TECHNICAL MEMORANDUM

DATE: February 11, 2025
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JOB NO: 14324-03 Technical Memo

SUBJECT: PEPPER 210 COMMERCE CENTER COMPARATIVE HEALTH IMPACT, ZERO-EMISSION TRUCK FEASIBILITY, GHG MITIGATION, AND ENERGY CUMULATIVE IMPACT ANALYSIS

The purpose of this memorandum is to provide additional analysis of the Pepper 210 Commerce Center (proposed Project) in the following areas:

- A comparative analysis of air quality impacts and health risks for the proposed Project by leveraging the conclusions from similar projects such as the Friant Ranch Community Development Project (Friant Ranch Project) and the California State University Dominguez Hills (CSUDH) Campus Master Plan (CSUDH Project);
- The feasibility of air quality mitigation measures, specifically the availability and viability of zero-emission trucks;
- The enforceability of GHG mitigation measures; and
- The proposed Project's use of renewable energy sources and how this relates to energy impacts.

COMPARATIVE HEALTH IMPACT ANALYSIS: FRIANT RANCH AND CSUDH

This section presents a comparative analysis of air quality impacts and health risk assessments for the Pepper 210 Commerce Center (proposed Project), leveraging the conclusions from similar projects such as the Friant Ranch Project and the CSUDH Project. These projects underwent comprehensive health impact modeling to evaluate the potential health effects of increased ozone and $PM_{2.5}$ concentrations due to emissions from these projects. These analyses concluded that emissions from these projects would not result in significantly higher concentrations of ozone and PM2.5 in the region, and that these increased pollutant concentrations would not result in meaningful health effects in the region. This memorandum demonstrates that the proposed Project's emissions would similarly not result in a meaningful increase in health effects due to increased concentrations of ozone and $PM_{2.5}$ in the region.

The comparison focuses primarily on emissions of Nitrogen Oxides (NOx), Particulate Matter ($PM_{2.5}$ and PM_{10}), and Reactive Organic Gases (ROG)/Volatile Organic Compounds (VOC)—key pollutants for evaluating potential adverse health effects and ozone precursor formation. The findings of the Friant Ranch and CSUDH health impacts analyses serve as a foundation to support the conclusions for the proposed Project.

BACKGROUND

National and California Ambient Air Quality Standards

The National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) are air quality regulations designed to define clean air in such a way that even the most sensitive individuals are protected. The NAAQS were established by the United States Environmental Protection Agency (US EPA) under the Clean Air Act. The NAAQS includes standards for six criteria air pollutants, including ozone, particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb).

The CAAQS were established by the California Air Resources Board (CARB) and set stricter standards for criteria pollutants compared to the NAAQS. Additionally, the CAAQS include additional standards for pollutants not covered under the NAAQS, including hydrogen sulfide, vinyl chloride, sulfites, and visibility-reducing particles.

Criteria Pollutant Health Effects

Carbon Monoxide (CO): CO is a colorless, odorless gas produced by the incomplete combustion of carbon-containing fuels, such as gasoline or wood. CO concentrations tend to be the highest during the winter morning, when little to no wind and surface-based inversions trap the pollutant at ground levels. Because CO is emitted directly from internal combustion engines, unlike ozone (O_3), motor vehicles operating at slow speeds are the primary source of CO in the SCAB. The highest ambient CO concentrations are generally found near congested transportation corridors and intersections.

Individuals with a deficient blood supply to the heart are the most susceptible to the adverse effects of CO exposure. The effects observed include earlier onset of chest pain with exercise, and electrocardiograph changes indicative of decreased oxygen supply to the heart. Inhaled CO has no direct toxic effect on the lungs but exerts its effect on tissues by interfering with O_2 transport and competing with O_2 to combine with hemoglobin present in the blood to form carboxyhemoglobin. Hence, conditions with an increased demand for O_2 supply can be adversely affected by exposure to CO. Individuals most at risk include fetuses, patients with diseases involving heart and blood vessels, and patients with chronic hypoxemia (oxygen deficiency) as seen at high altitudes.

Sulfur Dioxide (SO_2): SO_2 is a colorless, extremely irritating gas or liquid. It enters the atmosphere as a pollutant mainly as a result of burning high sulfur-content fuel oils and coal and from chemical processes occurring at chemical plants and refineries. When SO_2 oxidizes in the atmosphere, it forms SO_4. Collectively, these pollutants are referred to as sulfur oxides (SO_X).

A few minutes of exposure to low levels of SO_2 can result in airway constriction in some asthmatics, all of whom are sensitive to its effects. In asthmatics, increase in resistance to air flow, as well as reduction in breathing capacity leading to severe breathing difficulties, are observed after acute exposure to SO_2. In contrast, healthy individuals do not exhibit similar acute responses even after exposure to higher concentrations of SO_2.

Animal studies suggest that despite SO_2 being a respiratory irritant, it does not cause substantial lung injury at ambient concentrations. However, very high levels of exposure can cause lung edema (fluid accumulation), lung tissue damage, and sloughing off of cells lining the respiratory tract.

Some population-based studies indicate that the mortality and morbidity effects associated with fine particles show a similar association with ambient SO_2 levels. In these studies, efforts to separate

the effects of SO_2 from those of fine particles have not been successful. It is not clear whether the two pollutants act synergistically, or one pollutant alone is the predominant factor.

Oxides of Nitrogen (NO_X): NO_X consist of nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) and are formed when nitrogen (N_2) combines with O_2. Their lifespan in the atmosphere ranges from one to seven days for nitric oxide and nitrogen dioxide, to 170 years for nitrous oxide. NO_X is typically created during combustion processes and are major contributors to smog formation and acid deposition. NO_2 is a criteria air pollutant and may result in numerous adverse health effects; it absorbs blue light, resulting in a brownish-red cast to the atmosphere and reduced visibility. Of the seven types of nitrogen oxide compounds, NO_2 is the most abundant in the atmosphere. As ambient concentrations of NO_2 are related to traffic density, commuters in heavy traffic may be exposed to higher concentrations of NO_2 than those indicated by a regional monitoring station.

Population-based studies suggest that an increase in acute respiratory illness, including infections and respiratory symptoms in children (not infants), is associated with long-term exposure to NO_2 at levels found in homes with gas stoves, which are higher than ambient levels found in Southern California. Increase in resistance to air flow and airway contraction is observed after short-term exposure to NO_2 in healthy subjects. Larger decreases in lung functions are observed in individuals with asthma or chronic obstructive pulmonary disease (e.g., chronic bronchitis, emphysema) than in healthy individuals, indicating a greater susceptibility of these sub-groups.

In animals, exposure to levels of NO_2 considerably higher than ambient concentrations result in increased susceptibility to infections, possibly due to the observed changes in cells involved in maintaining immune functions. The severity of lung tissue damage associated with high levels of O_3 exposure increases when animals are exposed to a combination of O_3 and NO_2.

Ozone (O_3): O_3 is a highly reactive and unstable gas that is formed when VOCs and NO_X, both byproducts of internal combustion engine exhaust, undergo slow photochemical reactions in the presence of sunlight. O_3 concentrations are generally highest during the summer months when direct sunlight, light wind, and warm temperature conditions are favorable to the formation of this pollutant.

Individuals exercising outdoors, children, and people with pre-existing lung disease, such as asthma and chronic pulmonary lung disease, are considered to be the most susceptible sub-groups for O_3 effects. Short-term exposure (lasting for a few hours) to O_3 at levels typically observed in Southern California can result in breathing pattern changes, reduction of breathing capacity, increased susceptibility to infections, inflammation of the lung tissue, and some immunological changes. Elevated O_3 levels are associated with increased school absences. In recent years, a correlation between elevated ambient O_3 levels and increases in daily hospital admission rates, as well as mortality, has also been reported. An increased risk for asthma has been found in children who participate in multiple outdoor sports and live in communities with high O_3 levels.

O_3 exposure under exercising conditions is known to increase the severity of the responses described above. Animal studies suggest that exposure to a combination of pollutants that includes O_3 may be more toxic than exposure to O_3 alone. Although lung volume and resistance changes observed after a single exposure diminish with repeated exposures, biochemical and cellular changes appear to persist, which can lead to subsequent lung structural changes.

Particulate Matter (PM_{10} and $PM_{2.5}$): PM_{10} is a major air pollutant consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and aerosols. Particulate matter pollution is a major cause of

reduced visibility (haze) which is caused by the scattering of light and consequently the significant reduction in air clarity. The size of the particles (10 microns or smaller, about 0.0004 inches or less) allows them to easily enter the lungs where they may be deposited, resulting in adverse health effects. Additionally, it should be noted that PM_{10} is considered a criteria air pollutant.

$PM_{2.5}$ is a similar air pollutant to PM_{10} consisting of tiny solid or liquid particles which are 2.5 microns or smaller (which is often referred to as fine particles). These particles are formed in the atmosphere from primary gaseous emissions that include SO_4 formed from SO_2 release from power plants and industrial facilities and nitrates that are formed from NO_X release from power plants, automobiles, and other types of combustion sources. The chemical composition of fine particles highly depends on location, time of year, and weather conditions. $PM_{2.5}$ is a criteria air pollutant.

A consistent correlation between elevated ambient fine particulate matter (PM_{10} and $PM_{2.5}$) levels and an increase in mortality rates, respiratory infections, number and severity of asthma attacks and the number of hospital admissions has been observed in different parts of the United States and various areas around the world. In recent years, some studies have reported an association between long-term exposure to air pollution dominated by fine particles and increased mortality, reduction in lifespan, and an increased mortality from lung cancer.

Daily fluctuations in $PM_{2.5}$ concentration levels have also been related to hospital admissions for acute respiratory conditions in children, to school and kindergarten absences, to a decrease in respiratory lung volumes in children without asthma, and to increased medication use in children and adults with asthma. Recent studies show lung function growth in children is reduced with long term exposure to particulate matter.

The elderly, people with pre-existing respiratory or cardiovascular disease, and children appear to be more susceptible to the effects of high levels of PM_{10} and $PM_{2.5}$.

Volatile Organic Compounds (VOCs): VOCs are hydrocarbon compounds (any compound containing various combinations of hydrogen and carbon atoms) that exist in the ambient air. VOCs contribute to the formation of smog through atmospheric photochemical reactions and/or may be toxic. Compounds of carbon (also known as organic compounds) have different levels of reactivity; that is, they do not react at the same speed or do not form O_3 to the same extent when exposed to photochemical processes. VOCs often have an odor, and some examples include gasoline, alcohol, and the solvents used in paints. Exceptions to the VOC designation include CO, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate. VOCs are a criteria pollutant since they are a precursor to O_3, which is a criteria pollutant. The terms VOC and ROG (see below) are used interchangeably.

Breathing VOCs can irritate the eyes, nose, and throat, can cause difficulty breathing and nausea, and can damage the central nervous system as well as other organs. Some VOCs can cause cancer. Not all VOCs have all these health effects, though many have several.

Reactive Organic Gases (ROGs): Similar to VOCs, ROGs are also precursors in forming O_3 and consist of compounds containing methane, ethane, propane, butane, and longer chain hydrocarbons, which are typically the result of some type of combustion/decomposition process. Smog is formed when ROG and NO_X react in the presence of sunlight. ROGs are a criteria pollutant since they are a precursor to O_3, which is a criteria pollutant. The terms ROG and VOC (see previous) are used interchangeably. The health effects of ROGs are similar to those of VOCs.

San Joaquin Valley APCD and SCAQMD Briefs

Both the San Joaquin Valley Air Pollution Control District (SJVAPCD) and the South Coast Air Quality Management District (SCAQMD) submitted amicus briefs during the Friant Ranch judicial proceedings, emphasizing the difficulty of linking individual project emissions to specific health impacts. Their briefs argued that the available air quality modeling tools are primarily designed for regional assessments rather than project-specific evaluations, given the complexities involved in the formation and dispersion of secondary pollutants. These points bolster the argument that the proposed Project, with emissions well below those that occur at the regional level, will not result in significant regional health impacts.

Sacramento Metropolitan Air Quality Management District Interim Recommendations

The Sacramento Metropolitan Air Quality Management District (SMAQMD) issued interim recommendations in response to the Friant Ranch decision, stating that there is no reliable quantitative methodology to correlate emissions from individual projects with specific health consequences. The proposed Project follows these recommendations by relying on established regional analyses and using health impact conclusions drawn from other large projects such as the Friant Ranch project, where no significant health impacts were identified at similar emission levels.

Bay Area Air Quality Management District Recommendations

In its updated 2022 CEQA Guidelines, the Bay Area Air Quality Management District (BAAQMD) released additional guidance for demonstrating compliance with the 2018 Friant Ranch decision. Per the BAAQMD Guidelines, lead agencies should explain the nature and magnitude of any health impacts that may result from criteria air pollutants and "make a reasonable effort to connect a project's emissions, where significant, to foreseeable health impacts or provide evidence as to why such an analysis is not scientifically possible."

Scientific and Modeling Approaches

Criteria Air Pollutants Versus Toxic Air Contaminants

Toxic Air Contaminants (TACs) are pollutants which may cause or contribute to an increase in illness or death, and are identified by CARB. It should be noted that TACs are subject to a different regulatory process than criteria pollutants, which are subject to the NAAQS and CAAQS. It should be noted that health impacts may result from exposure to relatively small quantities of TACs, and it is often not possible to definitively quantify acceptable levels of TAC exposures that would be considered safe and health protective. However, for criteria air pollutants, acceptable levels of exposure have been established, and are the general basis for the NAAQS and CAAQS levels. As SJVAPCD noted in their amicus brief[1]:

> "Although criteria air pollutants can also be harmful to human health, they are distinguishable from toxic air contaminants and are regulated separately. The most relevant difference between criteria pollutants and TACs for purposes of this case is the manner in which human health impacts are accounted for. While it is common practice to analyze the correlation between an individual facility's TAC emissions and the expected localized human

[1] https://www.courts.ca.gov/documents/7-s219783-ac-san-joaquin-valley-unified-air-pollution-control-dist-041315.pdf

health impacts, such is not the case for criteria pollutants. Instead, the human health impacts associated with criteria air pollutants are analyzed and taken into consideration when EPA sets the NAAQS for each criteria air pollutant."

The SJVAPCD concluded that although it is possible to evaluate the health impacts for TACs, it is not feasible to conduct a similar analysis for criteria air pollutants due to the lack of currently available computer modeling tools equipped for the task.

Air Quality and Health Impact Modeling

Community Multiscale Air Quality Modeling System and Comprehensive Air Quality Model with Extensions: The Community Multiscale Air Quality modeling system (CMAQ) and the Comprehensive Air Quality Model with Extensions (CAMx) are both photochemical air quality models used to simulate air quality at scales ranging from the local to regional levels. These models are often used in health impact analyses to estimate the potential increases in pollutant concentrations over a large geographic area as a result of criteria and precursor pollutant emissions generated by a project. These models are able to fully characterize the physical processes that occur in the atmosphere and can predict concentrations of ozone, $PM_{2.5}$, and other pollutants based on mass emissions of precursor pollutants.

Environmental Benefits Mapping and Analysis Program-Community Edition: The Environmental Benefits Mapping and Analysis Program-Community Edition (BenMAP-CE) is a modeling program that estimates the number of air pollution-related deaths and illnesses, as well as the associated economic impacts. The program utilizes population data as well as health and economic data to evaluate the potential health impacts that may result from increased pollutant concentrations in a given area. As such, emissions that occur in a heavily populated area would result in greater health impacts compared to those that would occur in a sparsely populated area. BenMAP-CE focuses on the impacts associated with increased ozone and $PM_{2.5}$ concentrations.

Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool: The Co-Benefits Risk Assessment Health Impact Screening and Mapping Tool (COBRA) is a tool published by the United States Environmental Protection Agency (U.S. EPA) that is designed to estimate the impacts to human health that may occur as a result of changes in ozone and $PM_{2.5}$ concentrations. COBRA includes a built-in air quality model for estimating ozone and $PM_{2.5}$ concentrations based on precursor pollutant mass emissions. As such, while BenMAP-CE requires the use of a model such as CMAQ or CAMx to calculate pollutant concentrations, this function is built into the COBRA model.

Similar to BenMAP-CE, COBRA evaluates how concentrations of precursor pollutants result in ozone and $PM_{2.5}$ health impacts, including premature mortality, asthma, heart attacks, and lost work and school days. The model also estimates the monetary impacts that arise from these health outcomes. It should be noted that COBRA takes into account the population density of a given area when calculating potential health impacts, and as a result emissions that occur in a more population-dense area would result in greater health impacts.

In short, COBRA is intended for use by state and local governments to explore how changes in air pollution from clean energy policies and programs can affect human health at the county, state, regional, and national levels, to estimate the economic value of the health benefits associated with clean energy policies and programs to compare against program costs, and to map the air quality

and health related benefits from reductions in emissions of $PM_{2.5}$, SO_2, NO_X, and VOCs that result from clean energy policies and programs[2].

Summary of Friant Ranch and CSUDH Health Impact Analyses

Friant Ranch Analysis

The Friant Ranch Project underwent a comprehensive health impact assessment using CAMx and BenMAP-CE to quantify the potential health impacts of NOx, $PM_{2.5}$, and PM_{10} emissions. Key findings from the Friant Ranch analysis include:

- Peak Daily Emissions: The estimated peak daily emissions for the Friant Ranch Project were estimated at 342 pounds per day of ROG/VOC, 438 pounds per day of NO_X, 174.7 pounds per day of PM_{10}, and 70.7 pounds per day of $PM_{2.5}$. Despite these emissions, the health impact modeling concluded that health risks from these pollutants were not significant or were within a margin of error, even under worst-case scenario assumptions.
- Modeling Approach: The CAMx model was used in order to model the potential incremental increase in ozone and PM2.5 concentrations in the region as a result of project emissions. This modeling indicated that project emissions would result in a maximum increase in pollutant concentration of 0.019% for ozone and 0.41% for $PM_{2.5}$ at the most impacted grid cell compared to baseline 2020 background concentrations. The BenMAP model was used to estimate health effects in the region that would be expected as a result of these increased pollutant concentrations. Even with these stringent parameters, the health impacts—quantified in terms of mortality—were minimal. The findings emphasized that the potential increase in health incidences was negligible, particularly compared to the background health conditions of the region.

CSUDH Analysis

The CSUDH Campus Master Plan also underwent a similar air quality impact analysis using CAMx and BenMAP-CE to estimate changes in ambient $PM_{2.5}$, PM_{10}, and ozone concentrations due to project-related emissions:

- Peak Daily Emissions: The estimated peak daily emissions for the CSUDH Project were estimated at 482.6 pounds per day of ROG/VOC, 240.1 pounds per day of NO_X, and 79.5 pounds per day of $PM_{2.5}$. Despite these emissions, the health impact modeling concluded that health risks from these pollutants were not significant or were within a margin of error.
- Health Impact Findings: The results of the health impact modeling for CSUDH indicated a very small increase in health incidences, including mortality, asthma-related emergency room visits and respiratory-related hospital admissions, all of which were considered negligible. For all endpoints, the number of estimated incidences was less than 0.0058% of the background health incidences, indicating that health impacts were well within the margin of error.
- Conservative Emissions Estimates: The analysis utilized peak operational emissions, and these were modeled across the entire operational year, further emphasizing the conservative nature of the health impact conclusions. Even with this conservative approach, the resulting health impacts were deemed negligible.

Geographic and Dispersion Considerations

The proposed Project benefits from favorable dispersion characteristics in the South Coast Air Basin (SCAB):

- Stronger Wind Patterns: Coastal winds, including Santa Ana winds, enhance the dispersal of pollutants, reducing the likelihood of pollutant accumulation near the project site.
- Marine Inversion Layers: SCAB benefits from marine inversion layers that aid in the dilution and transport of pollutants like NOx, $PM_{2.5}$, PM_{10}, and ROG/VOC, reducing potential health impacts.

[2] https://www.epa.gov/cobra/what-cobra

Given these favorable conditions, the SCAB's meteorology will likely enhance the dispersal of the proposed Project's emissions, mitigating any localized health impacts.

Health Effects of Criteria Air Pollutants and Their Precursors

Health effects associated with criteria air pollutants are diverse, including premature mortality, cardiovascular effects, increased healthcare utilization, respiratory illnesses, and reduced lung function. These impacts are particularly acute in sensitive receptors, such as children, the elderly, and those with preexisting respiratory conditions. The proposed Project's emissions for ROG/VOC, NOx, PM_{10}, and $PM_{2.5}$ are significantly lower than those observed for Friant Ranch and CSUDH. As a result, the potential health impacts are expected to be less than these projects, resulting in minimal increases in pollutant concentrations and health risk that is considered negligible.

Scientific and Technological Complexities

The Friant Ranch decision emphasized the need to correlate project-specific emissions to health outcomes, a task complicated by the scientific and technological challenges inherent in modeling secondary pollutants such as ozone and $PM_{2.5}$. Secondary pollutants are formed via complex chemical reactions involving multiple precursor emissions, influenced by atmospheric conditions, which makes the direct correlation of emissions to health outcomes challenging. The SJVAPCD and SCAQMD briefs described above highlight these complexities, asserting that currently available modeling tools are not equipped to provide reliable project-level health impact analyses. This underscores the lack of reliability in calculating regional health impacts, as emissions at an individual project level are often insufficient to affect regional pollutant concentrations and thus health impacts in a meaningful way.

Proposed Project Health Effects

In order to estimate regional health impacts that may result from criteria and precursor pollutants emitted by the proposed Project, the peak daily emissions for each Project scenario were utilized in the COBRA model. Table 1 below presents the estimated health effects for the proposed Project at the regional level (Riverside, San Bernardino, Los Angeles, and Orange Counties). Table 2 presents the incremental increase in mortality from all causes that is estimated to occur as a result of emissions generated by the proposed Project, as well as a comparison to the 2020-2022 mortality for the region based on data published by the California Department of Public Health for 2024[3]. It should be noted that the mortality incidence values presented in Table 2 conservatively utilize the high estimates output from the model.

[3] https://www.cdph.ca.gov/Programs/CHSI/Pages/County-Health-Status-Profiles.aspx

TABLE 1: PROPOSED PROJECT HEALTH INDICATORS

Health Indicator	
Total Mortality (low – high estimate)	0.059 – 0.102
Total Asthma Symptoms	51.524
Total Incidence, Asthma	0.306
Total Incidence, Hay Fever/Rhinitis	1.974
Total ER Visits, Respiratory	0.086
Total Hospital Admits, All Respiratory	0.008

TABLE 2: PROPOSED PROJECT MORTALITY INDICATORS

Mortality (all cause)		
Project Incremental Incidence	Baseline	% Increase
0.102	145,092.4	0.00007%

As shown in Table 2, based on the COBRA model the proposed Project is estimated to result in an incremental increase in mortality of 0.102 due to increased concentrations of ozone and $PM_{2.5}$ in the region due to Project emissions. Compared to baseline mortality estimates for the region, this represents an increase of approximately 0.00007%.

It should be noted that this incremental increase in mortality is significantly lower when compared to other large projects. The incremental incidence increase in mortality from all causes for the Friant Ranch project was estimated at 0.000014% for ozone and 0.00039% for $PM_{2.5}$, for a total incremental increase of 0.00041, which is higher than what would be expected from the proposed Project. For the CSUDH project, the project's emissions were estimated to result in an increase in mortality from all causes of 0.0032% attributable to ozone and $PM_{2.5}$ combined, which is significantly higher than would be expected for the proposed Project. As such, emissions associated with the proposed Project would not result in significant health impacts due to increases in ozone and $PM_{2.5}$ concentrations in the region.

CONCLUSION

The comparative analysis of emissions and health impacts for the proposed Project relative to the Friant Ranch and CSUDH projects supports the conclusion that the proposed Project's emissions are similar to those reported in these two sample projects, and thus emissions from the proposed Project would be expected to result in similarly negligible health impacts. Additionally, modeling performed using EPA's COBRA model indicates that health risks would not differ significantly from what was reported for these projects and remains negligible.

FEASIBILITY OF ZERO-EMISSION TRUCKS

BACKGROUND

In response to a strong political push to utilize all-electric commercial trucks in the logistics industry, the California State Assembly passed the Advanced Clean Fleets (ACF) legislation with the goal of

phasing out sales of internal combustion heavy-duty trucks in favor of zero emission trucks, such as those powered by battery-electric technologies or hydrogen, with a complete phase-out of internal combustion-powered trucks by 2045[4]. Under the ACF legislation, any new medium heavy-duty (MHD)_truck purchased after January 2024 is required to be a zero-emission vehicle (ZEV). However, before the program could take effect in early 2024, CARB issued a notice that it would not enforce the ACF regulations, pending the approval of a preemption waiver from the U.S. Environmental Protection Agency (EPA). In 2025, with the election of President Donald Trump, CARB withdrew its pending waiver given that it would be unlikely to be granted under the Trump administration[5].

Currently the use of zero-emission heavy-duty trucks in support of uses such as the proposed Project remains infeasible given the extremely limited commercial availability of zero-emission trucks, as well as infrastructure limitations, including limited truck-accessible charging/refueling stations and electrical grid capacity. Recent actions such as California's withdrawal of the preemption waiver for the ACF in response to potential challenges from the incoming Trump administration add additional challenges to the adoption of ZEV trucks for logistics uses.

Commercial Availability of Zero-Emission Trucks

There are currently less than 10 manufacturers with long-haul electric trucks available on the market, however these vehicles have yet to reach large scale production and their use remains extremely limited. Tesla first revealed the Tesla Semi in 2017, and an initial order for 100 trucks was placed by PepsiCo. However, the Tesla Semi did not enter production until 2022, and as of April 2024 only 36 trucks have been delivered to PepsiCo, with additional orders placed by UPS, Walmart, Sysco, Schneider, and ASKO Norway remaining unfulfilled. Although the Tesla Semi was initially slated to begin production in 2019, with production expected to hit 50,000 units in 2024, battery production constraints have severely limited production, and it is uncertain at this time when these orders may be expected to be fulfilled.[6]

Facing delays with the Tesla Semi, several companies have turned to other vehicle manufacturers, including Daimler's eCascadia. However, with a significantly shorter range of approximately 230 miles compared to the 500-mile range of the Tesla Semi, the eCascadia's use case is significantly limited in comparison. As of late 2023, Schneider has taken delivery of 92 eCascadias[7], representing 0.9% of the company's fleet of 10,600 tractors.[8]

The limited availability of zero-emission medium- and heavy-duty vehicles is borne out in CARB's Emission Factor (EMFAC) Model, as well as data published by California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). The EMFAC model outputs provide detailed information as to the vehicle fleet in California, including fuel types for various vehicle classes and vehicle populations. Per EMFAC data, in 2024 battery electric trucks made up 0.01% of California's

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[4] McNamara, Marie; *Understanding California's Advanced Clean Fleet Regulation* (July 3, 2023) https://rmi.org/understanding-californias-advanced-clean-fleet-regulation/

[5] Lazo, Alejandro; *California abandons diesel truck ban and 3 other clean-air rules before Trump is sworn in* (January 14, 2025) https://calmatters.org/environment/2025/01/trump-california-withdraws-diesel-clean-air-rules/

[6] https://www.reuters.com/business/autos-transportation/tesla-semi-trucks-short-supply-pepsico-its-rivals-use-competing-ev-big-rigs-2024-04-19/

[7] https://electrek.co/2023/11/20/schneider-1-million-emission-free-miles-freightliner-ecascadia-electric-trucks/

[8] https://schneider.com/resources/infographic/schneider-by-the-numbers

medium-duty truck fleet, and 0.21% of the heavy-duty truck fleet.[9] Similarly, based on HVIP's Zero-Emission Vehicle Population Dashboard,[10] as of October 2024 there are currently 226 medium-duty and 197 heavy-duty zero-emission vehicles within SCAQMD jurisdiction, which includes Orange, Riverside, and San Bernardino Counties, as well as much of Los Angeles County. In 2023, statewide deliveries totaled 183 medium-duty vehicles and 121 heavy-duty vehicles, while in 2024 there have been no medium-duty truck vehicle deliveries and 13 heavy-duty truck deliveries. The adoption of zero emission trucks at the national scale has been similarly slow. As of January 2024, the national fleet of heavy-duty trucks is estimated at approximately 12.2 million. Of these, only 13,000 were electric, representing approximately 0.1% of the overall fleet[11].

Electric Truck Operational Constraints

Even if electric trucks were widely available on the market, operational constraints such as limited battery capacity, low operational range, and long charge times would severely limit their usefulness in the logistics industry. Compared to diesel-powered heavy-duty trucks, which can travel up to 2,000 miles before refueling, few electric trucks have a range exceeding 275 miles, with notable exceptions being the Tesla Semi and the Nikola Tre BEV. However, as discussed previously these models have yet to enter widespread production, and availability remains extremely limited.

In addition to limited range, current electric trucks suffer from slow charging times. Compared to a conventionally-powered truck, which can typically be refueled in less than 15 minutes, the Tesla Semi, currently among the fastest-charging electric trucks, requires 30 minutes to reach a 70% charge. Similarly, Freightliner's eCascadia requires approximately 90 minutes to reach an 80% charge. Like other electric vehicles, charge times slow significantly and battery longevity may be negatively impacted as the battery is charged beyond 80%. As such, trips utilizing electric trucks would require significantly longer stops, with the potential to disrupt the movement of goods, particularly for perishable and other time-sensitive loads, as well as require additional drivers in order to meet current transportation needs.

Charging and Refueling Infrastructure

Further, the availability of truck accessible vehicle charging stations and hydrogen refueling stations in California and the United States as a whole severely limits the feasibility of zero-emission trucks. Although the California Energy Commission estimates that there are over 11,000 DC fast charging stations in California,[12] the vast majority of these are intended to accommodate light duty passenger vehicles and lack the accessibility for medium- and heavy-duty trucks. California's first publicly accessible DC fast charging station for medium- and heavy-duty trucks opened in March 2023 in Otay Mesa.[13] In addition, based on data provided by the U.S. Department of Energy Alternative Fuels Data Center, there are currently only 12 publicly accessible DC fast charging stations with a total of 21 EV

[9] https://arb.ca.gov/emfac/
[10] https://californiahvip.org/industryinitiatives/#cazevdashboard
[11] Lazo, Alejandro; *California abandons diesel truck ban and 3 other clean-air rules before Trump is sworn in* (January 14, 2025) https://calmatters.org/environment/2025/01/trump-california-withdraws-diesel-clean-air-rules/
[12] https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/electric-vehicle
[13] https://www.sempra.com/cas-first-public-dc-fast-chargers-electric-medium-and-heavy-duty-vehicles-truck-stop-open-public

charging ports across the United States and Canada that are capable of accommodating heavy-duty (class 6-8) trucks.[14]

As of early 2024, medium- and heavy-duty truck DC fast charging depots are planned for three locations along Interstate 5 in the Central Valley as well as in Blythe[15], however the lack of charging stations severely limits the useful range of battery electric trucks, effectively restricting their use to local routes only.

Adoption and implementation of hydrogen fuel cell trucks face similar challenges. Based on data provided by the California Energy Commission, there are currently 68 light-duty vehicle hydrogen refueling stations in California.[16] However, similar to DC fast chargers, these stations are intended for use by light duty passenger vehicles and would not be capable of accommodating medium- and heavy-duty trucks. According to the United States Department of Energy Alternative Fuels Data Center, there are five hydrogen refueling stations across the United States and Canada that are capable of accommodating heavy-duty (class 6-8) trucks.[17]

Although infrastructure improvements and the installation of medium- and heavy-duty truck capable DC fast chargers and hydrogen fueling stations are currently in progress, the current state of charging and refueling infrastructure severely limits the feasibility of ZEV trucks beyond local routes where charging or hydrogen refueling would not be necessary outside of the location where trucks would be domiciled.

While charging for shorter routes may ideally occur at distribution and warehouse facilities while trucks are being loaded or unloaded at building loading docks, the installation of chargers at these locations represents an additional hurdle, as many of these locations are typically leased rather than owned by the facility operator. As a result, the cost of installation for fast chargers and the necessary electrical infrastructure improvements required to support them would fall to the owner of the facility, presenting an additional hurdle in obtaining the necessary infrastructure required to support the adoption of electric trucks.

Additionally, local zoning rules and regulations can pose significant hurdles for the installation of charging infrastructure. In many areas, zoning codes for EV chargers as the primary use do not exist, and most regulatory focus has been on EV charging as a secondary use. This can lead to delays as municipalities work to update their regulations to accommodate the new infrastructure.

Electrical Grid Infrastructure

Based on the current state of the electrical grid and the increasing adoption of electric vehicles in California, significant investments in the grid will need to occur in the coming decades to keep pace. However, these upgrades will be spread out over a period of decades such that the costs of infrastructure upgrades in any given year may be kept reasonable. Additionally, technologies such as battery integrated DC fast chargers[18] may be used to reduce strain on the grid and limit the need for expensive utility upgrades. At the local level, there is not sufficient grid capacity at this time to

[14] https://afdc.energy.gov/stations#/find/nearest
[15] https://www.canarymedia.com/articles/ev-charging/big-electric-truck-charging-depots-are-coming-soon-to-california
https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/hydrogen-refueling
[17] https://afdc.energy.gov/stations#/find/nearest
[18] https://freewiretech.com/pro-series/

support electrification of a significant portion of the proposed Project's truck fleet. Based on the U.S. Department of Energy, lead times for electrical transformers have increased substantially in the past few years, with lead times for some transformers and electrical equipment stretching to years.[19]

The electric grid needs to be enhanced to support the rapid charging of batteries with capacities nearing 1,000 kWh20. According to a Roland Berger study commissioned by the Clean Freight Coalition, electrifying the commercial truck fleet in the United States will require a $1 trillion investment (Schremmer, Mark)[21]. This investment includes $620 billion for charging infrastructure and $370 billion for power grid upgrades. Another study by the utility company National Grid found that by 2035, the power demands of a large truck stop will be comparable to those of a small town (Randall, Tom). Establishing a grid connection capable of handling over 5 megawatts can take up to eight years and cost tens of millions of dollars.

To electrify all long-haul trucks in the US, approximately 504 TWh of energy would be needed annually (Sierzchula, Will)[22]. Terawatt Infrastructure has been exploring potential charging station sites in California (St. John & Medina, supra). However, 95% of these sites lack the required power capacity (Id.). To support the proposed charging hubs in California's Inland Empire, Southern California Edison has indicated that it will need to either expand existing substations, which takes four to five years, or construct a new substation, which takes at least eight years.

GHG MITIGATION MEASURES

The proposed Project is located in the County of San Bernardino, which adopted its latest GHG Emissions Reduction Plan in September 2011. As detailed in the GHG Emissions Reduction Plan, a screening threshold of 3,000 $MTCO_2e$/yr is used to determine if additional analysis is required. Projects that exceed the 3,000 $MTCO_2e$/yr threshold are required to either achieve a minimum 100 points per the Plan's Screening Tables, or a 31% reduction over 2007 emission levels. As discussed in the proposed Project GHG Analysis, the proposed Project's emissions would exceed the 3,000 $MTCO_2e$/yr threshold. As such, the proposed Project would achieve 100 Screening Table points in order to be consistent with the requirements of the plan.

ENERGY IMPACTS

The energy analysis that was prepared for the proposed Project found that the Project would not result in energy usage that would be wasteful, inefficient, or unnecessary, and thus concluded that the proposed Project would result in a less than significant impact with regard to energy.

As discussed in the Energy Analysis, the Project would be subject to the applicable Title 24 energy efficiency standards in place at the time plan check submittals are made. Under Title 24, the Project would be required to implement measures aimed at reducing building energy usage through the use of energy efficient lighting, increased insulation, and the use of energy efficient HVAC systems and

[19] https://www.energy.gov/oe/articles/doe-and-industry-team-keep-lights-america
[20] Ramos, Alex; *6 Problems with Electric Semi Trucks* (March 30, 2023) https://www.makeuseof.com/problems-with-electric-semi-trucks/
[21] Schremmer, Mark; *Move toward electric trucks 'ignores operational realities'* (April 30, 2024) https://landline.media/move-toward-electric-trucks-ignores-operational-realities/
[22] Sierzchula, Will; *Electrifying US long haul trucks will require 504 TWh a year. But that won't be the hardest part* (December 1, 2022) https://www.utilitydive.com/news/electrifying-us-long-haul-trucks-will-require-504-twh-a-year-but-that-won/636684/

other appliances. Further, Title 24 requires that the Project include dedicated EV charging spaces, which would encourage the use of alternative fueled vehicles and reduce the Project's transportation energy demand. The Project would also be required to install electrical panels and conduit in order to facilitate the future installation of EV truck chargers once EV trucks reach viability.

The GHG Reduction Plan checklist includes several energy and water efficiency measures that go beyond the requirements of Title 24. These measures also encourage the use of carpooling, and zero-emission transportation alternatives, including walking, biking, and electric vehicles. Implementation of these measures would serve to reduce the Project's energy consumption to levels below what would otherwise be attained based on Title 24 standards alone. Additionally, MM AQ-2 would reduce gasoline consumption in landscape maintenance equipment by requiring the use of electric landscape maintenance equipment to the extent feasible, to be enforced through lease agreements with building tenants.

It should be noted that the end user of the proposed Project is not known at this time. As such, the precise building energy usage estimates, as well as the extent to which on-site renewable energy sources may offset the building's energy consumption is unknown as well. However, buildings would be designed solar-ready, and the Project will be design and built in such a manner as to facilitate the installation of solar photovoltaics in the future. At the time an end user is selected, an analysis of the expected energy needs will be performed to determine the appropriate type and quantity of renewable energy appropriate for the end use. However, it should be noted that as of 2022, approximately one third of the power generated by Southern California Edison is from renewable sources, and this is anticipated to continue to increase under the State's Renewable Portfolio Standard, which requires retail sellers of electric services to increase procurement from eligible renewable resources to 44% of total retail sales by 2024. The amount of retail electricity provided from renewable sources is expected to further increase significantly to meet the state goal of carbon neutrality by 2045.

APPENDIX 1:

FRIANT ANALYSES

AIR EMISSIONS REPORT

for the

FRIANT RANCH COMMUNITY DEVELOPMENT PROJECT

***Prepared for*:**

Friant Ranch LP
Fresno, California

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BLUESCAPE ENVIRONMENTAL

March 4, 2021

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APPENDICES

Appendix A: Supporting Tables

Appendix B: CalEEMod Files (Provided Electronically)

GLOSSARY OF TERMS AND ACRONYMS

Acronym	Description
AE	Alternative Energy
BE	Building Energy
CalEEMod	California Emissions Estimator Model
Cal/EPA	California Environmental Protection Agency
CAMx	Comprehensive Air Quality Model with Extensions
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CEUS	California Commercial End Use Survey
CO	Carbon Monoxide
csv	Comma Separated Value
DEIR	Draft Environmental Impact Report
DPM	Diesel particulate matter
DU	Dwelling Unit
EMFAC	EMission FACtor Model
FEIR	Final Environmental Impact Report
HIA	Health Impact Analysis
ISR	Indirect Source Review
ITE	Institute of Transportation Engineers
kg	Kilograms
km	Kilometers
kWh	Kilowatt hour
lb/day	Pounds per Day
lb/yr	Pounds per Year
LE	Lighting Energy
LUT	Land Use Transportation
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
O_3	Ozone
PM	Particulate Matter
PM_{10}	Particulate Matter 10 Micrometers or less in diameter
$PM_{2.5}$	Particulate Matter 2.5 Micrometers or less in diameter
ppm	Parts per million
RASS	Residential Appliance Saturation Survey
ROG	Reactive Organic Gases
SAFE	Safer Affordable Fuel-Efficient Vehicles Rule
SDT	Site Design Transportation
SJVAPCD	San Joaquin Valley Air Pollution Control District
SO_2	Sulfur Dioxide
SO_x	Oxides of Sulfur
sqft	Square Feet
SW	Solid Waste
TPY	Tons Per Year
TRT	Trip Reduction Transportation
USEPA	US Environmental Protection Agency
VOC	Volatile Organic Compounds

1.0 INTRODUCTION

At the request of Friant Ranch LP, BlueScape Environmental (BlueScape) prepared this Air Emissions Report for pollutant emissions from the Friant Ranch Development Project (Project), including criteria pollutants. The Project consists of the Friant Ranch Specific Plan, an update to the Friant Ranch Community Plan, a new wastewater treatment facility, and improvements at such locations as the Depot Parcel. The purpose of the report is to provide the Project air quality modeling emissions inputs for the regional Health Impact Analysis (HIA). A discussion on the baseline regional emissions inputs used in the HIA is provided in a separate report (BlueScape 2021).

The Air Emissions Report is organized into the following sections:

- **Section 2.0 – Project Description:** The Friant Ranch Development Project is described in this section, including details that were used to complete the emission calculations.

- **Section 3.0 – Air Emissions Calculation Methods:** The methods used to calculate criteria pollutant emissions are described in this section, for the Specific Plan and Community Plan, for each phase of Project construction and for operations. Emissions from a proposed new wastewater treatment plant were evaluated and determined to be negligible for regional impact analysis modeling, but were included in the HRA. This section also provides a discussion on non-mitigated and mitigated emission scenarios.

- **Section 4.0 – Air Emissions Estimates:** The emission calculations are summarized in this section.

- **Section 5.0 – Evaluation of Mitigation Measures:** A brief discussion of construction and operational mitigation measures used in emissions modeling are described in this section.

- **Section 6.0 – Peak Daily Emissions for Health Impact Modeling**: This section presents the peak daily criteria pollutant estimates that were used in HIA modeling.

- **Section 7.0 – References:** includes a list of references cited in this report.

2.0 PROJECT DESCRIPTION

The Project is located in Friant, California, in Fresno County, approximately five miles north of the Fresno city limits and 21 miles east of the city of Madera, within the Friant Community Plan Area and the Friant Specific Plan Area. In February 2011, the County of Fresno approved the Friant Ranch Project, a master planned community incorporating age-restricted (ages 55+) and non-age restricted family and multi-family residential units, a commercial village center, a recreation center, trails, open spaces, parks and parkways. The county's approvals included a new Specific Plan called the Friant Ranch Specific Plan and an update to the pre-existing Friant Community Plan.

The proposed Project is a mixed-use development proposed by Friant Ranch LP (Project sponsor). The Project would develop retail, residential, and open space uses on a 942-acre site in Friant, California. The Project will be primarily residential, with up to 2,270 dwelling units age restricted to over 55, and up to 230 dwelling units without age restriction.

The site is in a mostly rural area, with scattered neighborhoods and houses surrounding it to the northwest, northeast, and southwest. Off-site roads near the Project site include North Friant Road, which runs in a northwest/southwest direction directly along the eastern property line of the Project. North Friant Road becomes Millerton Road at the northern tip of the Project site where the direction changes to mostly an east/west direction. North Fork Road / Road 206 branches off at the N. Friant Rd. / Millerton Rd. transition, and runs in an east/west direction.

The Project also includes a land use designation and zone change for the Depot Parcel, which is outside of the Friant Ranch Specific Plan area, but within the boundaries of the 1983 Friant Community Plan area.

Table 2-1 defines the land use types and total square footage for the proposed development at full-build-out, including both the Specific Plan and the Community Plan land use types.

TABLE 2-1
FRIANT RANCH LAND USE TYPES: SPECIFIC PLAN AND COMMUNITY PLAN

Land Use		Specific Plan			Community Plan		
Type	**Subtype**	**Amount**	**Size Metric**	**Population**	**Amount**	**Size Metric**	**Population**
Commercial	Medical Office Building	10	1000sqft	--	--	--	--
Commercial	Office Park	100	1000sqft	--	--	--	--
Recreational	Fast Food Restaurant w/Drive Thru	5.0	1000sqft	--	10	1000sqft	--
Recreational	Health Club	42	1000sqft	--	--	--	--
Recreational	High Turnover (Sit Down Restaurant)	10	1000sqft	--	80	1000sqft	--
Residential	Apartments Low Rise	230	Dwelling Unit	658	146	Dwelling Unit	418
Residential	Condo/Townhouse	166	Dwelling Unit	475	--	--	--
Residential	Retirement Community/Single Family Housing	2,104	Dwelling Unit	4,158	419	Dwelling Unit	1,198
Retail	Regional Shopping Center	125	1000sqft	--	74	1000sqft	--
Commercial	Pharmacy/Drugstore with Drive Thru	--	--	--	50	1000sqft	--
Recreational	City Park	--	--	--	6.1	Acre	--
Recreational	Hotel	--	--	--	200	Room	--
Recreational	Motel	--	--	--	25	Room	--
Recreational	Quality Restaurant	--	--	--	40	1000sqft	--
Retail	Convenience Market (24-hr)	--	--	--	10	1000sqft	--
Retail	Gasoline/Service Station	--	--	--	10	Pump	--
Retail	Strip Mall	--	--	--	100	1000sqft	--

3.0 EMISSION CALCULATION METHODS

Emissions of criteria pollutants were estimated for the Friant Ranch Specific Plan, as well as the Community Plan and new wastewater treatment plant discussed in the DEIR. Emissions are revised relative to the Draft Environmental Impact Report (DEIR, County of Fresno, 2009) for two reasons:

1) The DEIR used URBEMIS, an emissions model that is currently outdated, to estimate operational emissions for the Project. Currently, most air districts in California recommend the use of CalEEMod (CAPCOA, 2017), a more recently developed land use emissions model.
2) The DEIR estimated emissions for the Community Plan and the full Specific Plan at build-out, which was projected to be in year 2020. Based on an updated construction start date of 2022, operational Project emissions are estimated for full-build out in 2031.

This section describes the calculation of the Friant Ranch Project estimated emissions using CalEEMod and preparation of the model-ready Project emissions for regional Health Impact Analysis (HIA) modeling. Emissions of reactive organic gases (ROG), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter 10 micrometers or less in diameter (PM_{10}), and particulate matter 2.5 micrometers or less in diameter ($PM_{2.5}$) were estimated. There are minor differences between volatile organic compounds (VOC) and ROG that define each term, however for purposes of this study we will assume they are equivalent due to the fact that air quality models directly calculate ROG in place of VOC. The development of Friant Ranch Project emissions is provided in Section 3.1. The annual unmitigated Friant Ranch Project emissions are summarized in Section 4.0.

The highest peak daily Project emission rate for each pollutant was applied to the 2020 and 2031 background regional emissions data that is discussed further in the HIA report (BlueScape 2021). The 2020 scenario year represents the CEQA baseline for existing conditions prior to Project development. The 2031 scenario year represents the "no project" conditions that account for reasonably foreseeable development that will have occurred by that year, and is adequate as a cumulative CEQA baseline. The 2031 year full-buildout Project impacts were then added to these two CEQA baseline years, to understand the potential specific health impacts above baseline.

There are conservative assumptions and methodologies that were used during the development of Friant Ranch Project emissions, which result in conservatively high estimates of Project emissions and associated health effects. This includes a conservatively high estimate of land use areas and an overlap of all emissions that may happen in any given year. The operational emissions associated with the Specific Plan and the Community Plan were combined with the construction emissions to determine the highest emission rates for modeling.

First, the emissions were determined using the land use described in Section 2 of this report, for operational year 2031. Some of the land use types proposed for the Community Plan in the DEIR have been adjusted based on more recent and accurate information. The land use was revised to remove the light industrial building type and more realistic estimates of the sizes of hotels, motels, and park areas were applied.

Second, Friant Ranch Project emissions are estimated for each year of the development, from 2022 through 2031. Although 2031 is shown to be the full build-out year, with the highest Specific Plan and Community Plan operational emissions, the emissions from construction of the development were applied to each individual year to predict the worst-case year for health effects.

Third, both annual and peak daily emissions are estimated for all Friant Ranch Project sources; however, in order to be conservative, peak daily emissions for each emission source are selected for modeling and are modeled throughout the full annual air quality model simulation. Thus, the modeled annual impacts and the health effects that are dependent on annual concentrations have incorporated layers of conservatism:

1. Peak daily emissions for all activities occur concurrently;

2. Peak daily emissions would occur over a full year;

3. The highest unmitigated peak daily emissions for NO_x occur in 2023, but the highest peak daily emissions for ROG, PM_{10}, and $PM_{2.5}$ occur in 2029. Highest emissions are combined and overlayed onto the 2020 existing conditions baseline and the 2031 Project full build-out baseline to predict conservative health effects; and

4. Similarly, the highest mitigated peak daily emissions for NO_x occur in 2022, but the highest peak daily emissions for ROG, PM_{10}, and $PM_{2.5}$ occur in 2029. Highest emissions are combined and overlayed onto the 2020 existing conditions baseline and the 2031 Project full build-out baseline to demonstrate more likely, but still conservative, health effects after mitigation strategies are implemented.

Therefore, the estimated emissions utilized for health impacts modeling should be considered as worst-case scenarios.

3.1 Calculation Methodology for Friant Ranch Emissions

Emissions associated with construction and operation of the proposed Project and existing development were estimated using the California Emissions Estimator Model (CalEEMod) version 2016.3.2. Emission estimates are based on CalEEMod land use types and total square feet (as shown in Table 2-1), as well as population.

Default values used in CalEEMod version 2016.3.2 are based on the California Energy Commission (CEC), sponsored California Commercial End Use Survey (CEUS), and Residential Appliance Saturation Survey (RASS) studies. CalEEMod provides both construction-related and operational emissions of air pollutants. This methodology has been subjected to peer review by numerous public and private stakeholders, and in particular by the CEC; and therefore, is considered reasonable and reliable for use in estimating air emissions for development projects in California. CalEEMod is considered a conservative tool because many of the default parameters used to calculate emissions are based on conservative assumptions for land use developments throughout the State of California to be protective of the environment and air quality standards.

3.1.1 Construction Emissions Methodology

Construction of the proposed Project would generate temporary air emissions, primarily associated with the operation of construction equipment and truck trips. These impacts are associated with fugitive dust (PM_{10} and $PM_{2.5}$) from soil disturbance, and exhaust emissions, such as ROG, NO_x, CO, SO_2, and DPM from heavy diesel-fueled construction vehicles.

Site preparation and grading typically generate the highest emission quantities because the use of heavy equipment is greatest during this phase of construction. Emissions associated with the construction phases were estimated based on the projected maximum amount of equipment that would be used onsite at one time, in each given year.

The development schedule for the Specific Plan and Depot Parcel is based on the annual phased schedule in Table 2-2 of the DEIR and the duration and sequence of construction activities presented in the DEIR. Construction emissions are developed for the Specific Plan, phases 1 through 5 and the Depot Parcel. Each year of active construction in a development phase is run separately in CalEEMod and results for overlapping phases in the same year are added together to yield worst-case annual and daily emissions.

The duration and timing of construction activities are phased in 3-year increments, as presented in the FEIR. The following example shows the construction duration for phase 1 through phase 5.

- The first year of each phase includes grading that will occur from January 1 through May 2 and building construction from April 16 through December 31.
- The second year of each phase includes building construction from January 1 through December 31.
- The third year of each phase includes building construction from January 1 through December 31, architectural coating from June 28 through October 7, and paving from October 21 through December 3.
- In addition, the next phase of construction will begin in the second year of the previous phase, so construction activities occur in different locations, but emissions will overlap.

The construction equipment and activities are in accordance with CalEEMod defaults, with slight adjustments in equipment load factors, based on those discussed in the FEIR. Worker, vendor, and haul trips are also based on CalEEMod defaults. The silt loading factor is from the California Air Resources Board (CARB) 2018 Miscellaneous Process Methodology 7.9 for Entrained Road Travel, Paved Road Dust using Fresno County data. Construction mitigation strategies will be discussed in a subsequent section of this report.

After construction is complete, three types of sources will generate emissions at the proposed Project site. These are area sources, energy use, and Project-generated traffic, which are defined as operational emissions. The emission calculation methodologies of these sources are discussed below.

3.1.2 Operational Emissions Methodology

Operational emissions include emissions from electricity consumption (energy sources), vehicle trips (mobile sources), and area sources (landscape equipment and consumer products use or reapplication of paint). The majority of operational emissions are associated with vehicle trips to and from the Project site.

Area Sources

All direct area source emissions were based on CalEEMod defaults for the designated land use category with the exception of consumer product emissions and fireplaces. For consumer products, a (VOC) emission factor was derived using methodology consistent with CalEEMod, but with updated statewide parameters. The CalEEMod default emission factor assumes 2008 statewide VOC inventory and building square footage. An updated VOC inventory for 2017 was taken from CARB (CARB, 2017), and 2017 population estimates based on the State of California's Department of Finance demographic projections (DOF, 2017) were used to estimate a statewide VOC EF of 1.62×10^{-5} lb/sf/day for consumer products use, for 2017 going forward. Residential dwellings within the Specific Plan do not include wood burning fireplaces. However, residential dwellings within the Community Plan may have already been built with existing wood burning fireplaces. So, it was estimated that 12.4% of multi-family dwellings and 10% of single-family dwellings would include wood burning fireplaces. In addition, 55% of all dwelling types in the Specific Plan and Community Plan are assumed to have a natural gas hearth, consistent with CalEEMod defaults, and the remaining units have no fireplace. Reapplication of architectural coatings assumes 10% of each building interior and exterior surface area, which incorporates low VOC paints.

Energy Use

Residences and other land uses will use natural gas and the associated emissions were estimated using CalEEMod. Electricity use would contribute indirectly to criteria air pollutant emissions; however, the emissions from electricity use are only quantified for GHGs in CalEEMod. Natural gas use was based on CalEEMod defaults.

Project Traffic

The Project would generate criteria pollutant and DPM emissions from mobile sources (vehicular traffic), as a result of the residents and workers associated with the Project. The daily vehicle miles traveled were estimated using the CalEEMod calculation methodology for each land use type. The daily trip rates are based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th edition, which are incorporated into CalEEMod as average trip rates for each respective land use category. However, trip lengths were adjusted to account for mixed-use development criteria. Under the mixed-use design criteria, the community is planned to create working and shopping opportunity within the residential development design. Therefore, trip lengths for residential land uses traveling for work, shopping, or other activities are assumed to be mainly originating from the community, with destinations within the community. Using a weighted average of default trip lengths and a general layout of the development roads, the trip lengths were adjusted. It was assumed that 80% of the vehicle trips would travel an average of 2 miles for on-community destinations and 20% of the vehicle trips would use default trip lengths in CalEEMod, for off-community destinations (likely to the Fresno area).

Project-related traffic was assumed to include a mixture of vehicles in accordance with the fleet mix distribution values defined by CARB's EMission FACtor Model (EMFAC) (CARB 2017). Emission factors representing the vehicle mix and emissions for each year were adjusted using EMFAC2017 emission factors for the Fresno/San Joaquin Valley region, with the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule emission factor adjustment. A comma-separated value (csv) file was generated for each year of the development Project duration, from 2022 through 2031 and imported into the CalEEMod model for the calculation of vehicle emissions.

4.0 AIR EMISSIONS ESTIMATES

Full Project build-out emissions are presented, consistent with the Friant Community Plan Update & Friant Ranch Specific Plan DEIR (County of Fresno 2009). Emissions were calculated assuming full Project build-out of residential and commercial areas in 2031 noting that, according to the Project sponsor, the Project will be developed in phases over multiple years. The Depot Parcel will be developed after the full build-out year in 2032 or 2033 in a much smaller area than previous Project phases, and construction-related emissions will be much less than in the 2031 full build-out year. Operational emissions will be slightly less in 2022 and 2023 and the Depot Parcel will add little to operational emissions. Therefore, the Depot Parcel was not included in the operational air emissions estimates. The unmitigated annual construction emissions for the Friant Ranch Specific Plan are presented in Table 4-1. Emissions are shown for each of the phases for Project build-out, from 2022 through 2031.

TABLE 4-1
ANNUAL UNMITIGATED CONSTRUCTION EMISSIONS

	Friant Ranch - Annual Construction Emissions - Unmitigated (tons/year)										
Year	Phase	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
Total 2022	**P1**	**0.551**	**4.92**	**5.11**	**0.010**	**0.778**	**0.220**	**0.997**	**0.206**	**0.203**	**0.410**
Total 2023	**P1, P2**	**0.987**	**8.73**	**9.63**	**0.019**	**1.20**	**0.375**	**1.57**	**0.320**	**0.347**	**0.667**
2023	P1	0.390	3.11	3.91	0.008	0.182	0.129	0.311	0.049	0.120	0.170
2023	P2	0.597	5.62	5.72	0.011	1.01	0.245	1.26	0.271	0.227	0.498
Total 2024	**P1, P2**	**3.13**	**6.07**	**7.83**	**0.016**	**0.285**	**0.245**	**0.529**	**0.077**	**0.228**	**0.305**
2024	P1	2.779	3.14	4.11	0.008	0.161	0.129	0.290	0.044	0.120	0.163
2024	P2	0.347	2.93	3.73	0.007	0.123	0.116	0.239	0.033	0.108	0.141
Total 2025	**P2, P3**	**0.767**	**6.51**	**8.33**	**0.017**	**0.916**	**0.251**	**1.17**	**0.254**	**0.233**	**0.487**
2025	P2	0.345	2.83	3.78	0.008	0.185	0.101	0.285	0.050	0.094	0.144
2025	P3	0.422	3.69	4.54	0.009	0.731	0.151	0.882	0.204	0.139	0.343
Total 2026	**P2, P3**	**5.07**	**5.67**	**7.63**	**0.016**	**0.267**	**0.212**	**0.479**	**0.072**	**0.198**	**0.270**
2026	P2	4.74	2.91	3.95	0.008	0.119	0.112	0.231	0.032	0.104	0.136
2026	P3	0.329	2.76	3.68	0.008	0.148	0.100	0.249	0.040	0.093	0.134
Total 2027	**P3, P4**	**3.88**	**6.96**	**8.87**	**0.018**	**1.14**	**0.271**	**1.41**	**0.281**	**0.251**	**0.532**
2027	P3	3.42	2.96	3.97	0.008	0.143	0.112	0.255	0.039	0.104	0.143
2027	P4	0.460	4.00	4.90	0.010	0.996	0.159	1.15	0.242	0.147	0.389
Total 2028	**P4**	**0.354**	**2.95**	**3.82**	**0.009**	**0.251**	**0.101**	**0.351**	**0.068**	**0.094**	**0.161**
Total 2029	**P4, P5**	**4.63**	**7.64**	**9.70**	**0.020**	**0.960**	**0.295**	**1.26**	**0.265**	**0.274**	**0.539**
2029	P4	4.08	2.85	3.83	0.007	0.073	0.112	0.185	0.020	0.104	0.124
2029	P5	0.553	4.78	5.88	0.013	0.887	0.183	1.07	0.245	0.170	0.415
Total 2030	**P5**	**0.312**	**1.59**	**3.41**	**0.008**	**0.113**	**0.029**	**0.142**	**0.031**	**0.029**	**0.060**
Total 2031	**P5**	**3.49**	**1.66**	**3.64**	**0.008**	**0.057**	**0.037**	**0.093**	**0.015**	**0.037**	**0.052**
Depot 2032	**P6**	**0.191**	**0.955**	**1.804**	**0.004**	**0.230**	**0.024**	**0.254**	**0.116**	**0.024**	**0.140**
Depot 2033	**P6**	**0.247**	**0.430**	**0.822**	**0.002**	**0.022**	**0.010**	**0.032**	**0.006**	**0.010**	**0.016**

Note: Fug PM_{10}/$PM_{2.5}$ represents fugitive (dust) particulate matter and Exh PM_{10}/$PM_{2.5}$ represents exhaust particulate matter.

The unmitigated annual operational emissions for the Friant Ranch Specific Plan and the Friant Community Plan are presented in Table 4-2.

TABLE 4-2
ANNUAL UNMITIGATED OPERATIONAL CRITERIA POLLUTANT EMISSIONS

Friant Ranch Specific Plan						
	2031					
	ROG	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Category	**Tons/Year**					
Area (Total)	**10.7**	**1.15**	**18.9**	**0.007**	**0.179**	**0.179**
Architectural Coatings	1.36	0	0	0	0	0
Consumer Products	8.65	0	0	0	0	0
Hearth	0.109	0.935	0.398	0.006	0.076	0.076
Landscaping	0.554	0.214	18.5	0.001	0.103	0.103
Energy (Natural Gas)	**0.247**	**2.13**	**1.07**	**0.014**	**0.171**	**0.171**
Mobile (Total)	**4.90**	**4.00**	**27.0**	**0.062**	**7.86**	**2.13**
Specific Plan Total	**15.8**	**7.28**	**46.9**	**0.083**	**8.21**	**2.48**
Friant Community Plan						
Category	**2031**					
	ROG	**NO_x**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
	Tons/Year					
Area (Total)	**6.36**	**0.350**	**9.83**	**0.020**	**0.946**	**0.946**
Architectural Coatings	0.846	0	0	0	0	0
Consumer Products	4.75	0	0	0	0	0
Hearth	0.636	0.302	5.64	0.020	0.923	0.923
Landscaping	0.126	0.048	4.19	0.0002	0.023	0.023
Energy (Natural Gas)	**0.277**	**2.48**	**1.84**	**0.015**	**0.192**	**0.192**
Mobile (Total)	**11.7**	**39.6**	**69.4**	**0.182**	**13.4**	**3.78**
Community Plan Total	**18.3**	**42.4**	**81.0**	**0.217**	**14.5**	**4.91**
Friant Ranch Specific Plan and Community Plan						
Unmitigated Project Total	**34.2**	**49.7**	**128**	**0.300**	**22.8**	**7.40**

A summary of the total annual emissions for each year of the development Project are shown below in Table 4-3 for the Specific Plan, Community Plan, and Construction.

TABLE 4-3
UNMITIGATED ANNUAL OPERATION AND CONSTRUCTION

	Specific Plan - Total Operational Emissions - Unmitigated (tons/year)									
Year	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	1.91	0.99	5.97	0.010	0.784	0.043	0.827	0.210	0.043	0.253
2023	3.70	1.81	11.4	0.020	1.57	0.082	1.65	0.420	0.081	0.501
2024	5.41	2.60	16.5	0.029	2.35	0.121	2.47	0.630	0.120	0.750
2025	7.04	3.34	21.4	0.038	3.13	0.161	3.29	0.839	0.160	1.00
2026	8.62	4.05	26.0	0.046	3.92	0.201	4.12	1.05	0.199	1.25
2027	10.2	4.91	30.5	0.055	4.70	0.254	4.95	1.26	0.252	1.51
2028	11.8	5.37	34.7	0.061	5.48	0.277	5.76	1.47	0.275	1.74
2029	13.1	6.02	38.8	0.069	6.26	0.315	6.58	1.68	0.312	1.99
2030	14.5	6.65	42.9	0.076	7.04	0.352	7.40	1.89	0.350	2.24
2031	15.8	7.28	46.9	0.083	7.82	0.389	8.21	2.10	0.387	2.48

	Community Plan - Total Operational Emissions - Unmitigated (tons/year)									
Year	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	25.5	51.7	104	0.266	13.2	1.47	14.7	3.58	1.45	5.03
2023	24.0	46.9	100	0.258	13.2	1.38	14.6	3.58	1.37	4.95
2024	23.0	46.1	96.6	0.253	13.2	1.38	14.6	3.58	1.37	4.95
2025	22.1	45.3	93.2	0.246	13.2	1.38	14.6	3.58	1.36	4.94
2026	21.4	44.6	90.6	0.241	13.2	1.37	14.6	3.58	1.36	4.94
2027	20.7	44.0	88.1	0.235	13.2	1.37	14.6	3.58	1.36	4.93
2028	20.0	43.5	85.9	0.230	13.2	1.36	14.6	3.58	1.35	4.93
2029	19.4	43.0	84.0	0.225	13.2	1.36	14.6	3.58	1.35	4.92
2030	18.9	42.7	82.4	0.221	13.2	1.35	14.5	3.58	1.34	4.92
2031	18.3	42.4	81.0	0.217	13.2	1.35	14.5	3.58	1.34	4.91

	Friant Ranch - Total Annual Construction Emissions - Unmitigated (tons/year)									
Year	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	0.551	4.92	5.11	0.010	0.778	0.220	1.00	0.206	0.203	0.410
2023	0.987	8.73	9.63	0.019	1.20	0.375	1.57	0.320	0.347	0.667
2024	3.13	6.07	7.83	0.016	0.285	0.245	0.53	0.077	0.228	0.305
2025	0.767	6.51	8.33	0.017	0.92	0.251	1.17	0.254	0.233	0.487
2026	5.07	5.67	7.63	0.016	0.267	0.212	0.48	0.072	0.198	0.270
2027	3.88	6.96	8.87	0.018	1.14	0.271	1.41	0.281	0.251	0.532
2028	0.354	2.95	3.82	0.009	0.251	0.101	0.35	0.068	0.094	0.161
2029	4.63	7.64	9.70	0.020	0.960	0.295	1.26	0.265	0.274	0.539
2030	0.312	1.59	3.41	0.008	0.113	0.029	0.14	0.031	0.029	0.060
2031	3.49	1.66	3.64	0.008	0.057	0.037	0.09	0.015	0.037	0.052

	Friant Ranch - Total Annual Operational and Construction Emissions - Unmitigated (tons/year)									
Year	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	28.0	57.6	115	0.286	14.8	1.73	16.5	4.00	1.70	5.70
2023	28.7	57.4	121	0.297	16.0	1.84	17.8	4.32	1.80	6.12
2024	31.6	54.8	121	0.297	15.8	1.75	17.6	4.29	1.72	6.00
2025	30.0	55.1	123	0.301	17.2	1.79	19.0	4.67	1.76	6.43
2026	35.1	54.4	124	0.302	17.4	1.79	19.2	4.70	1.76	6.46
2027	34.7	55.9	127	0.308	19.0	1.89	20.9	5.12	1.86	6.98
2028	32.1	51.8	124	0.300	18.9	1.74	20.7	5.11	1.72	6.83
2029	37.1	56.7	133	0.314	20.4	1.97	22.4	5.52	1.93	7.45
2030	33.6	50.9	129	0.304	20.3	1.73	22.1	5.49	1.72	7.21
2031	37.6	51.3	132	0.308	21.1	1.77	22.8	5.69	1.76	7.45

5.0 EVALUATION OF MITIGATION STRATEGIES

Construction mitigation strategies would mainly rely on the use of construction equipment considered construction clean fleet, to comply with the emission reductions required by SJVAPCD District Rule 9510: Indirect Source Review (ISR). The rule requires construction equipment greater than fifty (50) horsepower to reduce construction equipment emissions by 20% of the total NO_x emissions and by 45% of the total PM_{10} exhaust emissions. Although the construction fleet will vary based on the phase and subphase of construction activity, a combination of Tier 3 and Tier 4 engines were modeled to demonstrate the overall emission reductions. Lower emitting equipment or add-on control technology may become more readily available in future construction years.

Construction mitigation measures to comply with SJVAPCD District Rule 8021 were also included to demonstrate the reduction of fugitive dust emissions associated with the Project. At a minimum, watering of disturbed areas at least 3 times per day or as necessary; and limiting vehicle travel speeds on unpaved roads within the construction areas to a maximum of 15 miles per hour were incorporated.

Operational mitigation strategies were incorporated to quantify the reduction in emissions due to the SJVAPCD District Rule 9510: Indirect Source Review (ISR) strategies. The CAPCOA traffic mitigation measures have been incorporated into CalEEMod and correlate well with the ISR mitigation measures.

LUT-1 / Mitigation Measure 2a: Increase Density was applied as 2,000 dwelling units (du) within ½-mile radius (3.98 du/acre) and 1,500 jobs within ½-mile radius (2.9 jobs/acre).

LUT-3 / Mitigation Measure 2b: *Increase Diversity* can be included if the Project contains various land uses, such as office, commercial, institutional, and residential land uses present within ¼ mile.

LUT-9 / Mitigation Measure 2c: *Improve Walkability Design* included a calculation of 3-way and 4-way intersections compared to the distance from the center of the Project to its farthest boundary. This value was calculated to be 5.62 intersections per square mile.

LUT-4 / Mitigation Measure 2d: *Improve Destination Accessibility* was applied as the distance to downtown per job center is within ¼ mile.

LUT-5 / Mitigation Measure 2e: *Increase Transit Accessibility* was applied as the distance to a transit station is within ¼ mile.

SDT-1 / Mitigation Measure 3a: *Improve Pedestrian Network* was applied as providing a pedestrian access network within the Project site and connecting off-site.

SDT-2 / Mitigation Measure 3b: *Provide Traffic Calming Measures* was applied as 100% of streets containing improvements within ½ mile of the Project site and 25% of intersections improved within ½ mile of the Project site.

SDT-3 / Mitigation Measure 3c: *Implement Neighborhood Electric Vehicle (NEV) Network* was included for the Project.

TRT-6 / Mitigation Measure 5c: *Encourage Telecommuting and Alternative Work Schedules* included 25% of employees to participate in telecommuting 1.5 days per week.

A-1 / Mitigation Measure 7b: *Landscape Equipment* included 3% electric lawnmower, leaf blower, and chainsaws.

BE-1 / Mitigation Measure 7a: *Exceed Title 24* included as a minimum of 7% improvement over the 2016 building standards as applied by CalEEMod.

LE-1 / Mitigation Measure 7a: *Install High Efficiency Lighting* applied as a 20% reduction in energy use.

AE-1, AE-2, AE-3 / Mitigation Measure 8: *Solar Panels* are incorporated as 3 kW times the number of dwelling units, or a maximum of 7,500 kWh for 2031.

SW-1 would institute recycling and composting services to provide a reduction of 50% to 75% of the total waste disposed.

Use of low VOC paints will be included in the baseline scenario, but additional mitigation is considered for SJV Rule 4601, which requires a VOC limit of 50 g/L for flat and non-flat coatings, effective after 1/1/2022.

These mitigation strategies were quantified to demonstrate emission reductions, using the CalEEMod model. Mitigation strategies that were defined in the FEIR are now considered outdated, but are shown with the newer ISR reduction strategies, submitted in 2019. The comparison of FEIR mitigation strategies and those applied based on the ISR application is shown in Table A-1 in Appendix A.

The mitigated annual construction emissions for the Friant Ranch Specific Plan are presented in Table 5-1. Emissions are shown for each of the phases of Project build-out, from 2022 through 2031.

TABLE 5-1
ANNUAL MITIGATED CONSTRUCTION EMISSIONS

	Friant Ranch - Annual Construction Emissions - Mitigated (tons/year)										
Year	Phase	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
Total 2022	**P1**	**0.293**	**3.86**	**5.42**	**0.010**	**0.086**	**0.190**	**0.475**	**0.104**	**0.085**	**0.189**
Total 2023	**P1, P2**	**0.483**	**5.07**	**10.6**	**0.019**	**0.610**	**0.209**	**0.819**	**0.163**	**0.209**	**0.373**
2023	P1	0.210	1.01	4.19	0.008	0.182	0.027	0.209	0.049	0.027	0.076
2023	P2	0.273	4.06	6.37	0.011	0.428	0.183	0.611	0.114	0.183	0.297
Total 2024	**P1, P2**	**2.77**	**2.92**	**8.50**	**0.016**	**0.285**	**0.121**	**0.405**	**0.077**	**0.120**	**0.197**
2024	P1	2.60	1.18	4.43	0.008	0.161	0.039	0.200	0.044	0.038	0.082
2024	P2	0.170	1.74	4.06	0.007	0.123	0.082	0.205	0.033	0.082	0.115
Total 2025	**P2, P3**	**0.368**	**4.16**	**9.26**	**0.017**	**0.506**	**0.195**	**0.700**	**0.139**	**0.194**	**0.334**
2025	P2	0.187	1.85	4.16	0.008	0.185	0.081	0.266	0.050	0.081	0.131
2025	P3	0.181	2.31	5.09	0.009	0.321	0.113	0.434	0.089	0.113	0.203
Total 2026	**P2, P3**	**4.73**	**2.84**	**8.41**	**0.016**	**0.267**	**0.111**	**0.378**	**0.072**	**0.111**	**0.183**
2026	P2	4.55	1.05	4.34	0.008	0.119	0.030	0.149	0.032	0.030	0.062
2026	P3	0.171	1.79	4.06	0.008	0.148	0.081	0.229	0.040	0.081	0.121
Total 2027	**P3, P4**	**3.44**	**3.68**	**9.84**	**0.018**	**0.603**	**0.149**	**0.752**	**0.153**	**0.149**	**0.302**
2027	P3	3.25	1.99	4.36	0.008	0.143	0.096	0.239	0.039	0.096	0.135
2027	P4	0.188	1.70	5.48	0.010	0.460	0.053	0.513	0.114	0.053	0.167
Total 2028	**P4**	**0.197**	**1.98**	**4.20**	**0.009**	**0.251**	**0.081**	**0.332**	**0.068**	**0.081**	**0.149**
Total 2029	**P4, P5**	**4.17**	**4.98**	**10.8**	**0.020**	**0.551**	**0.236**	**0.788**	**0.151**	**0.236**	**0.388**
2029	P4	3.91	1.88	4.22	0.007	0.073	0.097	0.170	0.020	0.097	0.116
2029	P5	0.261	3.10	6.55	0.013	0.478	0.140	0.618	0.132	0.140	0.271
Total 2030	**P5**	**0.122**	**0.878**	**3.93**	**0.008**	**0.113**	**0.011**	**0.125**	**0.031**	**0.011**	**0.042**
Total 2031	**P5**	**3.28**	**0.985**	**4.16**	**0.008**	**0.057**	**0.026**	**0.082**	**0.015**	**0.026**	**0.041**
Depot 2032	**P6**	**0.063**	**0.671**	**2.22**	**0.004**	**0.111**	**0.018**	**0.129**	**0.051**	**0.018**	**0.069**
Depot 2033	**P6**	**0.202**	**0.318**	**0.943**	**0.002**	**0.022**	**0.009**	**0.031**	**0.006**	**0.009**	**0.015**

Note: Fug PM_{10}/$PM_{2.5}$ represents fugitive (dust) particulate matter and Exh PM_{10}/$PM_{2.5}$ represents exhaust particulate matter.

Mitigated Specific Plan and Community Plan operational emissions for 2031 are shown in Table 5-2, which demonstrates the annual reduction in each pollutant by using the mitigation strategies defined above.

TABLE 5-2
ANNUAL MITIGATED OPERATIONAL CRITERIA POLLUTANT EMISSIONS

Friant Ranch Community: Operational Criteria Pollutant Emissions (tons/year)						
Friant Ranch Specific Plan						
Category	**2031**					
	ROG	**NOx**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
	tons					
Area (Total)	**10.2**	**1.15**	**18.8**	**0.007**	**0.178**	**0.178**
Architectural Coatings	0.892	0	0	0	0	0
Consumer Products	8.65	0	0	0	0	0
Hearth	0.109	0.935	0.398	0.006	0.076	0.076
Landscaping	0.546	0.212	18.4	0.001	0.102	0.102
Energy (Natural Gas)	**0.234**	**2.02**	**1.01**	**0.013**	**0.162**	**0.162**
Mobile (Total)	**4.84**	**3.60**	**24.7**	**0.052**	**6.45**	**1.75**
Specific Plan Total	**15.3**	**6.77**	**44.5**	**0.071**	**6.79**	**2.09**
Mitigation Reduction %	**3.51**	**6.96**	**5.17**	**13.6**	**17.4**	**15.8**
Friant Community Plan						
Category	**2031**					
	ROG	**NOx**	**CO**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
	tons					
Area (Total)	**5.34**	**0.259**	**4.25**	**0.002**	**0.040**	**0.040**
Architectural Coatings	0.445	0	0	0	0	0
Consumer Products	4.75	0	0	0	0	0
Hearth	0.025	0.211	0.090	0.001	0.017	0.017
Landscaping	0.124	0.048	4.16	0.0002	0.023	0.023
Energy (Natural Gas)	**0.277**	**2.48**	**1.84**	**0.015**	**0.192**	**0.192**
Mobile (Total)	**11.6**	**37.7**	**66.8**	**0.165**	**11.8**	**3.33**
Community Plan Total	**17.2**	**40.5**	**72.9**	**0.181**	**12.1**	**3.56**
Mitigation Reduction %	**5.99**	**4.58**	**9.99**	**16.5**	**17.1**	**27.5**
Friant Ranch Specific Plan and Community Plan						
Project Total	**32.5**	**47.2**	**117**	**0.253**	**18.8**	**5.65**

A summary of the total annual mitigated emissions for each year of the development Project are shown below in Table 5-3 for the Specific Plan, Community Plan, and Construction.

TABLE 5-3
MITIGATED ANNUAL OPERATION AND CONSTRUCTION EMISSIONS

Year	Specific Plan - Total Operational Emissions - Mitigated (tons/year)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	1.85	0.90	5.59	0.009	0.642	0.041	0.683	0.172	0.041	0.213
2023	3.58	1.67	10.7	0.017	1.28	0.078	1.36	0.344	0.077	0.421
2024	5.23	2.40	15.6	0.025	1.93	0.116	2.04	0.516	0.115	0.631
2025	6.81	3.09	20.1	0.032	2.57	0.154	2.72	0.688	0.153	0.841
2026	8.34	3.75	24.6	0.039	3.21	0.192	3.40	0.860	0.191	1.05
2027	9.83	4.57	28.8	0.047	3.85	0.245	4.09	1.03	0.243	1.27
2028	11.3	4.98	32.8	0.053	4.49	0.266	4.76	1.20	0.264	1.47
2029	12.6	5.59	36.8	0.059	5.13	0.303	5.43	1.37	0.300	1.67
2030	14.0	6.18	40.7	0.065	5.77	0.339	6.11	1.55	0.336	1.88
2031	15.3	6.77	44.5	0.071	6.41	0.374	6.79	1.72	0.372	2.09

Year	Community Plan - Total Operational Emissions - Mitigated (tons/year)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	24.3	49.0	94.5	0.225	11.6	0.531	12.2	3.16	0.515	3.67
2023	22.9	44.6	91.1	0.218	11.6	0.454	12.1	3.16	0.442	3.60
2024	21.9	43.9	87.6	0.213	11.6	0.451	12.1	3.16	0.439	3.60
2025	21.0	43.1	84.5	0.207	11.6	0.447	12.1	3.16	0.436	3.59
2026	20.2	42.5	82.0	0.203	11.6	0.444	12.1	3.16	0.432	3.59
2027	19.5	41.9	79.6	0.198	11.6	0.439	12.1	3.16	0.428	3.58
2028	18.9	41.5	77.6	0.193	11.6	0.434	12.1	3.16	0.423	3.58
2029	18.3	41.0	75.7	0.188	11.6	0.429	12.1	3.15	0.419	3.57
2030	17.8	41.0	74.6	0.187	11.9	0.428	12.3	3.22	0.418	3.64
2031	17.2	40.5	72.9	0.181	11.6	0.421	12.1	3.15	0.411	3.56

Year	Friant Ranch - Total Annual Construction Emissions - Mitigated (tons/year)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	0.293	3.86	5.42	0.010	0.086	0.190	0.475	0.104	0.085	0.189
2023	0.483	5.07	10.6	0.019	0.610	0.209	0.819	0.163	0.209	0.373
2024	2.77	2.92	8.50	0.016	0.285	0.121	0.405	0.077	0.120	0.197
2025	0.368	4.16	9.26	0.017	0.506	0.195	0.700	0.139	0.194	0.334
2026	4.73	2.84	8.41	0.016	0.267	0.111	0.378	0.072	0.111	0.183
2027	3.44	3.68	9.84	0.018	0.603	0.149	0.752	0.153	0.149	0.302
2028	0.197	1.98	4.20	0.009	0.251	0.081	0.332	0.068	0.081	0.149
2029	4.17	4.98	10.8	0.020	0.551	0.236	0.788	0.151	0.236	0.388
2030	0.122	0.878	3.93	0.008	0.113	0.011	0.125	0.031	0.011	0.042
2031	3.28	0.985	4.16	0.008	0.057	0.026	0.082	0.015	0.026	0.041

Year	Friant Ranch - Total Annual Operational and Construction Emissions - Mitigated (tons/year)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	26.5	53.7	106	0.244	12.4	0.761	13.3	3.43	0.64	4.07
2023	27.0	51.3	112	0.254	13.5	0.741	14.3	3.67	0.73	4.39
2024	29.9	49.2	112	0.254	13.9	0.688	14.5	3.75	0.67	4.42
2025	28.2	50.4	114	0.257	14.7	0.796	15.5	3.98	0.78	4.77
2026	33.3	49.1	115	0.257	15.1	0.747	15.9	4.09	0.73	4.82
2027	32.8	50.2	118	0.263	16.1	0.833	16.9	4.34	0.82	5.16
2028	30.4	48.4	115	0.254	16.4	0.781	17.2	4.43	0.77	5.19
2029	35.1	51.6	123	0.267	17.3	0.968	18.3	4.68	0.96	5.64
2030	31.9	48.0	119	0.261	17.8	0.778	18.5	4.80	0.77	5.56
2031	35.8	48.2	122	0.260	18.1	0.821	18.9	4.89	0.81	5.69

6.0 PEAK DAILY EMISSIONS FOR HEALTH IMPACT MODELING

Peak daily emissions are required for regional Health Impact Analysis (HIA) modeling. To determine the highest peak daily emissions, the combined operational plus construction emissions for each year were evaluated. The highest peak daily emission rate for each pollutant was applied to the 2020 and 2031 background regional emissions data to demonstrate the most conservative health impacts. The 2020 and 2031 regional emissions data inputs used for the HIA were developed from modeling information obtained from CARB, as developed for the San Joaquin Valley 2018 $PM_{2.5}$ State Implementation Plan (SJVAPCD 2018). A discussion on the regional emissions inputs to the HIA is provided in the separate HIA report (BlueScape 2021).

Without the Project emissions included, the 2020 scenario year represents the CEQA baseline for existing conditions prior to Project development. The 2031 scenario year represents the "no project" conditions that account for reasonably foreseeable development that will have occurred by that year, and is adequate as a cumulative CEQA baseline. The 2031 year full-buildout Project impacts were then added to these two CEQA baseline years, to understand the potential specific health impacts above baseline.

The following tables show unmitigated and mitigated peak daily emissions for operational and construction emissions combined. Table 6-1 shows the unmitigated peak daily emissions and then the mitigated peak daily emissions that were applied to the regional health impact model, for the Project. Construction emissions and operational emissions are defined separately, by source category. Peak daily NO_x emissions occur in year 2023 for the unmitigated scenario and year 2022 for the mitigated scenario. Peak daily ROG and PM emissions occur in year 2029 for both the unmitigated and mitigated scenarios. Although operational emissions associated with the Specific Plan and Community Plan are highest at Project build-out, year 2031, the combination of construction emissions with operational emissions in these years (2022, 2023 and 2029) represents a worst-case peak day scenario for those pollutants.

TABLE 6-1
PEAK DAILY OPERATION AND CONSTRUCTION EMISSIONS

Category	Peak Day Unmitigated Emissions (lb/day)					
	ROG	NO_x	Fugitive PM_{10}	Exhaust PM_{10}	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$
	Construction					
On-Road Mobile	0.773	3.13	2.59	0.014	0.699	0.013
Off-Road Mobile	9.36	111	15.6	4.10	4.34	3.79
Area/Energy	104	0	0	0	0	0
	Operational (Specific Plan plus Community Plan)					
On-Road Mobile	127	294	124	1.59	33.4	1.51
Off-Road Mobile	0	0	0	0	0	0
Area/Energy	101	28.9	0	27.0	0	27.0
Total	**342**	**438**	**142**	**32.7**	**38.4**	**32.3**

Category	Peak Day Mitigated Emissions (lb/day)					
	ROG	NO_x	Fugitive PM_{10}	Exhaust PM_{10}	Fugitive $PM_{2.5}$	Exhaust $PM_{2.5}$
	Construction					
On-Road Mobile	0.773	2.63	2.59	0.014	0.699	0.013
Off-Road Mobile	3.83	60.4	6.08	3.49	1.69	3.49
Area/Energy	104	0	0	0	0	0
	Operational (Specific Plan plus Community Plan)					
On-Road Mobile	126	304	107	1.42	28.8	1.35
Off-Road Mobile	0	0	0	0	0	0
Area/Energy	81.8	22.9	0	4.82	0	4.82
Total	**316**	**389**	**115**	**9.74**	**31.2**	**9.66**

Note: Area source exhaust PM originates from natural gas combustion and landscaping.

Table 6-2 shows the unmitigated peak daily emissions, on an annual basis from 2022 through 2031. The maximum daily emission rate for each pollutant was selected for the peak daily rate. Table 6-3 shows the mitigated peak daily emissions, on an annual basis from 2022 through 2031. These tables include all of the criteria pollutant emissions, but since contributions to regional ozone and fine particulate are minimal, CO and SO_2 were not included in the regional HIA modeling.

TABLE 6-2
UNMITIGATED PEAK DAILY OPERATION AND CONSTRUCTION

Year	Friant Ranch - Total Peak Daily Operational Emissions - Unmitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	199	346	869	2.13	89.0	26.3	115	24.1	26.2	50.3
2023	201	323	888	2.15	94.0	26.2	120	25.4	26.1	51.5
2024	205	325	905	2.18	99.0	26.6	126	26.7	26.5	53.3
2025	209	326	922	2.21	104	27.0	131	28.1	26.9	55.0
2026	213	328	943	2.24	109	27.4	136	29.4	27.3	56.7
2027	219	334	965	2.29	114	28.2	142	30.7	28.1	58.8
2028	224	332	985	2.29	119	28.2	147	32.1	28.1	60.2
2029	228	335	1,008	2.32	124	28.5	153	33.4	28.5	61.9
2030	233	338	1,032	2.34	129	28.9	158	34.7	28.8	63.6
2031	237	342	1,057	2.38	134	29.3	163	36.1	29.2	65.3

Year	Friant Ranch - Total Peak Daily Construction Emissions - Unmitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	9.09	83.2	83.0	0.155	16.5	3.76	20.3	4.38	3.47	7.84
2023	12.6	114	122	0.235	19.0	4.94	23.9	5.06	4.57	9.63
2024	72.2	56.2	72.5	0.138	2.36	2.41	4.74	0.636	2.24	2.87
2025	10.1	86.2	107	0.217	17.7	3.46	21.2	4.94	3.20	8.14
2026	127	53.7	71.6	0.140	2.19	2.16	4.36	0.591	2.01	2.60
2027	95.5	98.6	121	0.241	22.8	4.09	26.8	5.54	3.78	9.31
2028	2.78	22.7	30.0	0.070	1.98	0.773	2.75	0.535	0.719	1.25
2029	114	99.2	122	0.242	18.2	4.12	22.3	5.04	3.81	8.85
2030	2.41	12.2	26.3	0.062	0.89	0.223	1.11	0.241	0.223	0.463
2031	90.2	21.4	42.3	0.084	0.58	0.67	1.25	0.156	0.668	0.824

Year	Friant Ranch - Total Peak Daily Operational and Construction Emissions - Unmitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	209	429	952	2.28	105	30.1	136	28.4	29.7	58.1
2023	214	438	1,009	2.39	113	31.2	144	30.5	30.7	61.2
2024	277	381	977	2.32	101	29.0	130	27.4	28.8	56.1
2025	219	412	1,029	2.42	122	30.5	152	33.0	30.1	63.1
2026	341	382	1,015	2.38	111	29.6	141	30.0	29.3	59.3
2027	314	433	1,087	2.53	137	32.3	169	36.3	31.9	68.1
2028	226	355	1,015	2.36	121	28.9	150	32.6	28.8	61.4
2029	342	434	1,130	2.56	142	32.7	175	38.4	32.3	70.7
2030	235	350	1,058	2.41	130	29.2	159	35.0	29.1	64.0
2031	328	364	1,100	2.46	135	30.0	165	36.2	29.9	66.1

TABLE 6-3
MITIGATED PEAK DAILY OPERATION AND CONSTRUCTION

Year	Friant Ranch - Total Peak Daily Operational Emissions -Mitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	181	326	707	1.53	78.2	4.02	82.2	21.1	3.92	25.1
2023	182	306	725	1.55	82.3	3.95	86.2	22.2	3.87	26.1
2024	186	308	741	1.57	86.4	4.34	90.7	23.3	4.26	27.6
2025	190	309	759	1.60	90.5	4.73	95.2	24.4	4.65	29.1
2026	194	311	778	1.62	94.5	5.12	99.7	25.5	5.04	30.5
2027	199	317	800	1.67	98.6	5.86	105	26.6	5.78	32.4
2028	203	315	819	1.67	103	5.87	109	27.7	5.79	33.5
2029	208	318	841	1.69	107	6.24	113	28.8	6.16	34.9
2030	212	323	866	1.73	112	6.63	119	30.3	6.56	36.8
2031	217	325	888	1.75	115	6.99	122	31.0	6.91	37.9

Year	Friant Ranch - Total Peak Daily Construction Emissions - Mitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	4.55	63.0	87.0	0.155	7.48	1.50	8.98	1.99	1.47	3.45
2023	5.94	72.4	134.0	0.235	8.75	3.10	11.8	2.34	3.10	5.44
2024	69.5	31.5	78.4	0.138	2.36	1.57	3.90	0.64	1.57	2.20
2025	4.53	54.7	119	0.217	8.29	2.60	10.9	2.30	2.60	4.90
2026	125	32.1	78.4	0.140	2.19	1.59	3.78	0.59	1.59	2.18
2027	89.7	56.1	135	0.241	10.5	2.55	13.0	2.59	2.55	5.13
2028	1.57	15.2	32.9	0.070	1.98	0.624	2.60	0.53	0.62	1.16
2029	109	67.9	136	0.242	8.67	3.50	12.2	2.39	3.50	5.89
2030	0.955	6.7	30.3	0.062	0.890	0.088	0.978	0.241	0.087	0.328
2031	88.7	18.0	46.2	0.084	0.580	0.939	1.52	0.156	0.939	1.10

Year	Friant Ranch - Total Peak Daily Operational and Construction Emissions - Mitigated (lb/day)									
	ROG	NO_x	CO	SO_2	Fug PM_{10}	Exh PM_{10}	Total PM_{10}	Fug $PM_{2.5}$	Exh $PM_{2.5}$	Total $PM_{2.5}$
2022	185	389	794	1.68	85.6	5.52	91.2	23.1	5.39	28.5
2023	188	379	859	1.78	91.0	7.05	98.1	24.6	6.97	31.5
2024	255	340	820	1.71	88.7	5.91	94.6	24.0	5.83	29.8
2025	194	364	878	1.81	98.7	7.34	106	26.7	7.25	34.0
2026	319	343	857	1.76	96.7	6.71	103	26.1	6.62	32.7
2027	289	374	935	1.91	109	8.41	117	29.2	8.33	37.5
2028	205	330	852	1.74	105	6.49	111	28.2	6.41	34.6
2029	316	386	977	1.93	115	9.74	125	31.2	9.66	40.8
2030	213	330	896	1.80	113	6.72	120	30.5	6.64	37.2
2031	305	343	934	1.83	116	7.93	124	31.1	7.85	39.0

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APPENDIX A

TABLES

TABLE A-1
MITIGATION STRATEGIES FOR EMISSION REDUCTION

Mitigation Strategy	FEIR 3.3.1/3.3.2	ISR Application	CalEEMod Applied
Construction Clean Fleet	3.3.1: Diesel oxidation catalyst with 40% NO_x reduction (cranes/forklift 15%)	Mitigation Measure 1: District Rule 9510 (ISR requires the clean fleet data template to verify the NO_x and PM_{10} emission reductions)	CalEEMod can apply oxidation catalysts, diesel particulate filters, and upgraded engine Tier 2, 3, or 4, or alternate fuels (Bio, CNG, Electric)[1]
Increase Density		Mitigation Measure 2a: 2,000 DU within ½ mi radius of Project	Applied as 2,000 in CalEEMod
Increase Diversity		Mitigation Measure 2b: Mixed-Use development	Applied as increased diversity in CalEEMod
Increase Walkability Design		Mitigation Measure 2c: 7 intersections	Applied as intersections per square miles in CalEEMod
Improve Destination Accessibility		Mitigation Measure 2d: ¼ mile	Applied as ¼ mi to job center or downtown in CalEEMod
Increase Transit Accessibility	3.3.2 Transportation related mitigation measures	Mitigation Measure 2e: ¼ mi to transit station	Applied as ¼ mi to transit station in CalEEMod
Improve pedestrian network	Bicycle usage is considered a design strategy, not mitigation	Mitigation Measure 3a: Provide pedestrian access network within Project site and connecting offsite	Applied as pedestrian access network within Project site and connecting offsite in CalEEMod
Provide traffic calming measures		Mitigation Measure 3b: 100% of streets with improvement within ½ mile of Project site	Applied as 100% of streets with improvement within ½ mile of Project site in CalEEMod
Implement Neighborhood Electric Vehicle Network		Mitigation Measure 3c: Provide NEV Network	Applied as NEV network provided in CalEEMod
Encourage Telecommuting and Alt Work Schedules		Mitigation Measure 5c: 25% of employees to participate in telecommuting 1.5 days	Applied as 25% of employees to participate in telecommuting 1.5 days in CalEEMod
Hearth		Mitigation Measure 6: NG only hearth	Applied as NG only hearth
Exceed Title 24	3.3.2: Reduce residential energy consumption 10-20% from 2008 Title 24. (These energy efficiency standards are now considered design requirements and are outdated as mitigation.)	Mitigation Measure 7a: ISR states: TBD	Apply Title 24 reduction (see below)
			Single family homes built under 2019 Energy Standards use 7% less energy than 2016 Standards. Assume 7% reduction to 2031.
			Lighting energy reduction based on an average 29% for the lighting power density from 2016 to 2019 (non-residential buildings). Assume 20% reduction to 2031.
			Low-flow plumbing, toilets, sinks, showers in accordance with Title 24 as of 2019 and water efficient irrigation, in CalEEMod.
Landscape Equipment		Mitigation Measure 7b: ISR states "yes"	3% electric will be applied in CalEEMod, as noted to be the assumed statewide average

TABLE A-1
MITIGATION STRATEGIES FOR EMISSION REDUCTION

Mitigation Strategy	FEIR 3.3.1/3.3.2	ISR Application	CalEEMod Applied
Solar Panels		Mitigation Measure 8: ISR states "yes"	kW of total power output will be entered into CalEEMod
Electric Vehicle Charger		Mitigation Measure 9: ISR states "TBD"	Number of charging outlets to be entered into CalEEMod
Solid Waste Reduction			Fresno County is required to meet the state mandated 75% reduction in solid waste by 2020. CalEEMod will apply 75% recycling and composting.
Low VOC Paints	3.3.1: 45% ROG emission reduction compared to existing architectural coating rules (defined defaults were Res: 130 g/L and Non-res: 250 g/L)		The FEIR measure is outdated. SJV Rule 4601 requires VOC limit of 50 g/L for flat and non-flat coatings, effective after 1/1/2022. 50 g/L will be used in CalEEMod.
Fugitive Dust	SJV Reg VIII Control Measures		Apply 3x per day watering frequency (61% reduction in PM10/2.5), vehicle speed 15 mph
EMFAC 2017 and SAFE Factor Adjustment			Emission factors for mobiles sources will be adjusted in CalEEMod to update vehicle emissions

1. The ISR does not state specific measures, only the general clean fleet data, which is submitted to verify emission reductions meet the rule after each construction phase is completed. A combination of Tier 3 and Tier 4 engines was applied in CalEEMod to demonstrate the reductions, but they are not specified in the ISR or the EIR.

APPENDIX B

CALEEMOD FILES
(PROVIDED ELECTRONICALLY)

Appendix E

Regional Air Quality Modeling and Health Impact Analysis

REGIONAL AIR QUALITY MODELING & HEALTH IMPACT ANALYSIS

for the

FRIANT RANCH COMMUNITY DEVELOPMENT PROJECT

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APPENDICES

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GLOSSARY OF TERMS AND ACRONYMS

Acronym	Description
3D	Three-dimensional
AAQA	Ambient Air Quality Analysis
agl	Above ground level
AQMP	Air Quality Management Plan
Avg	Average
BAAQMD	Bay Area Air Quality Management District
BenMAP-CE	Benefits Mapping and Analysis Program – Community Edition
C-R	Concentration-Response function
CAAQS	California Ambient Air Quality Standards
CalEEMod	California Emissions Estimator Model
CAMx	Comprehensive Air Quality Model with Extensions
CARB	California Air Resources Board
CB06	Carbon Bond 06 chemical mechanism
CEPAM	California Standard Emission Tool
CEQA	California Environmental Quality Act
CI	Confidence Interval
CMAS	Community Modeling and Analysis System
CMAQ	Community Multiscale Air Quality Model
CO	Carbon Monoxide
CSV	Comma Separated Value
DPM	Diesel Particulate Matter
EBI	Euler Backward Iterative solver
EIR	Environmental Impact Report
EMFAC	California Air Resources Board's Mobile Source Emission Factor inventory
EPA	U.S. Environmental Protection Agency
ESMF	Earth System Modeling Framework software
GIS	Geographic Information System
GREASD	Greatly Reduced Execution and Simplified Dynamics Submodel
GRIB	Gridded Binary form
HARP2	Hotspots Analysis and Reporting Program Version 2
HDF	Hierarchical Data Format
HIA	Health Impact Analysis
HRA	Health Risk Assessment
ISA	Integrated Science Assessments
km	Kilometers
lb/day	Pounds per day
LP	Limited Partnership
MDA8	Maximum Daily 8-hour Average Ozone
MPE	Model Performance Evaluation
NAAQS	National Ambient Air Quality Standards
NAM	North American Mesoscale

GLOSSARY OF TERMS AND ACRONYMS

Acronym	Description
NCEP	National Centers for Environmental Protection
NCL	NCAR Command Language
netCDF	Network Common Data form
NO_x	Oxides of Nitrogen
OFFROAD	California Air Resources Board's Offroad Source Emission Factor Inventory
PBL	Planetary Boundary Layer
PGM	Photochemical Grid model
$PM_{2.5}$	Particulate Matter 2.5 Micrometers or less in aerodynamic diameter
PM_{10}	Particulate Matter 10 Micrometers or less in aerodynamic diameter
ppb	Parts per billion
ppbv	Parts per billion by volume
PopGrid	EPA gridded population data for BenMAP
PPM	Piecewise Parabolic Model
ROG	Reactive Organic Gases
SAPRC07	Chemical Mechanism Model 2007
SIL	Significant Impact Level
SIP	State Implementation Plan
SMAQMD	Sacramento Metropolitan Air Quality Management District
SMOKE	Sparse Matrix Operator Kerner Emissions modeling system
SCAQMD	South Coast Air Quality Management District
SJV	San Joaquin Valley
SJVAPCD	San Joaquin Valley Air Pollution Control District
SO_x	Oxides of Sulfur
TOG	Total Organic Gases
$\mu g/m^3$	Micrograms per Cubic Meter
UTM	Universal Transverse Mercator
VERDI	Visual Environment for Rich Data Interpretation program
VOC	Volatile Organic Compounds
WRF	Weather Research and Forecasting model

EXECUTIVE SUMMARY

In the California Supreme Court decision in Sierra Club versus County of Fresno (S219783, December 24, 2018), or the "Friant Ranch" Case, the Court found the Environmental Impact Report (EIR) to be inadequate because it failed to make a reasonable effort to include an analysis that correlates Project emissions to impacts on human health. In particular, the Court focused on air quality impact analysis for the Project's significant emissions of oxides of nitrogen (NO_x) and Reactive Organic Gases (ROG), which are precursors to ozone formation, and of particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) emissions. The Court concluded that an EIR should meet evidentiary requirements, such as: 1) including sufficient detail to enable reviewers to understand and to consider meaningfully the issues the project raises, and 2) making a reasonable effort to connect a project's air quality impacts to likely health consequences, or explain why such air quality analysis is not scientifically feasible at the time of drafting the analysis.

This technical study describes the work completed to satisfy the Supreme Court's EIR evidentiary requirements as applied to the Friant Ranch Community Development Project (or "the Project"). BlueScape completed photochemical modeling work to support the Project Health Impact Analysis (HIA) as described in this technical study. BlueScape generally followed the California Air Resources Board's (CARB's) 2018 $PM_{2.5}$ State Implementation (SIP) study methods (CARB 2018), to develop regional ozone and $PM_{2.5}$ air quality concentration predictions that were then entered into the U.S. Environmental Protection Agency (EPA) Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE, EPA 2019a) to estimate Project health impacts. CARB used 2013 emissions and modeling files as the base case year for its photochemical modeling effort. In order to determine that the entire modeling system and supporting data bases adequately replicated observed conditions for 2013, CARB compared the 2013 air quality modeling concentration predictions to available 2013 observed air quality concentrations and determined that the modeling system was performant. CARB then projected emissions from 2013 to the 2020 future year, and the modeling system was applied in order to predict 2020 air quality concentrations. In the Project HIA study, it was deemed prudent to set 2020 as the Existing Baseline year for the regional emissions, and use the 2013 meteorological data year to complete the modeling, to ensure consistent and valid model performance with the work CARB performed.

The electronic meteorological and emissions data files used by CARB for the San Joaquin Valley (SJV) for photochemical modeling completed with the Community Multiscale Air Quality (CMAQ) model were initially obtained by Ramboll Corporation (Ramboll) and processed prior to BlueScape obtaining the files and using them to complete the HIA. The 2020 CMAQ files obtained by Ramboll from CARB, which included speciated NO_x, Total Organic Gases (TOG), particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}), and $PM_{2.5}$

emissions, were converted for use in the Comprehensive Air Quality Model with Extensions (CAMx) model (Ramboll ENVIRON 2017) with appropriate CMAQ-to-CAMx conversion tools. CARB also provided its 2013 Weather Research and Forecasting Model (WRF v3.8 or later) meteorological data files to Ramboll, which were also converted for use in CAMx using appropriate tools. BlueScape obtained these files prepared by Ramboll from the Project proponent and further developed them for use in the HIA discussed in this report.

Using the 2013 WRF meteorological data coupled with the converted CMAQ input files, CAMx (v.6.5) photochemical modeling was performed for six (6) scenarios:

1) 2020 Existing Baseline year without Project emissions;

2) 2020 Existing Baseline year with unmitigated Project emissions;

3) 2020 Existing Baseline year with mitigated Project emissions;

4) 2031 Future Baseline year without Project emissions;

5) 2031 Future Baseline year with unmitigated Project emissions; and

6) 2031 Future Baseline year with mitigated Project emissions.

The intent of including a 2020 Existing Baseline year is to describe environmental conditions in 2020 and then to add Project emissions to this baseline. The Project emissions include construction emissions, as well as operational emissions from prior completion of Project work, that will occur in the same year. The Future Baseline year describes 2031 environmental conditions without the Project to which Project emissions at full Project buildout are added for a cumulative result. For the 2031 Future Baseline year, the 2020 CAMx regional emissions inventory was "grown" to a 2031 regional emissions inventory based upon growth factors developed using the CARB 2016 SIP - Standard Emission Tool (CEPAM, CARB 2018). The 2031 regional emissions inventory thus accounts for reasonably foreseeable population growth in the affected region by 2031.

A Model Performance Evaluation (MPE) of the 2020 CAMx air quality modeled results was completed. The CAMx model was run for the entire 2020 Existing Baseline year. The MPE was conducted as a comparison of the hourly CAMx model predictions for the Project study, to CARB's original hourly CMAQ model predictions for 2020, using CMAQ modeling output files obtained from CARB. The Environmental Protection Agency (EPA) has issued guidance on how air quality simulation models are to be judged to be adequately performing in order to be used for studies such as conducted here (EPA 2018a). Two statistics that are used to judge such model performance are mean gross error and mean bias. If the gross error is less than 15% and bias is within +/-5%, it is an indicator that the model is adequately performing (Emery et. al. 2017). Average gross error and bias statistics were estimated at the county-level for ozone and $PM_{2.5}$ for each month of 2020 between the base case modeling results supplied to our team and the base case modeling results that we ran. Because the

gross error and bias values that resulted were less than 5% for gross error and were near zero for bias (i.e., a few tenths of a part per billion (ppb) for ozone and a few hundredths of a $\mu g/m^3$ for $PM_{2.5}$), the CAMx modeling system results for 2020 and 2031 were deemed suitable for use in the Friant Ranch Project HIA.

For the six modeling scenarios, maximum daily 8-hour average (MDA8) ozone concentrations and maximum annual 24-hour average $PM_{2.5}$ concentrations were developed using CAMx for import into EPA's BenMAP-CE model. BenMAP-CE is open-source software that can be configured to relate the human health impacts and/or benefits to air quality changes. The latest version of BenMAP-CE is Version 1.5, which the EPA released in March 2019. The program includes a subset of air quality monitoring data in preloaded databases for areas within the Continental United States, with recent and projected demographic and baseline health data, concentration-response (C-R) relationships drawn from the published epidemiological literature, and economic value estimates based on the published economics literature. The principal function of the software is to apply the findings of epidemiological and economics studies to estimate the health impacts and economic value of air pollution changes.

To estimate human health effects, BenMAP-CE first determines the change in ambient air pollution using user-specified air quality data for the baseline and controlled scenarios. The software then applies the relationship between the air pollution with certain health effects (also known as health endpoints) using health impact function or the C-R functions that were derived from epidemiology studies. BenMAP-CE applies that relationship to the exposed population to calculate health impacts based on baseline health incidence data.

The Project maximum estimated change in ozone concentration above both the 2020 Existing Baseline and the 2031 Future Baseline does not exceed the EPA's Significant Impact Level (SIL) for ozone of 1 ppb, 8-hour average. The Project maximum estimated change in $PM_{2.5}$ concentration impacts above baseline levels does not exceed the EPA's and San Joaquin Valley Air Pollution Control District's (SJVAPCD) SIL of 0.2 $\mu g/m^3$, annual average. As discussed in Section 2.0, concentration results that do not exceed a SIL can be used by Fresno County, the lead agency for this Project, as one indicator that the Project concentration impacts, and therefore the related specific health impacts, are likely not meaningful.

The Project-related specific health incidences estimated using BenMAP for ozone and $PM_{2.5}$ concentration changes above baseline, as compared with regional background health incidences, are very small relative to background incidences. For example, for ozone asthma-related emergency room visits for children aged 0 to 17, the Project-related health incidences per year were estimated to be 0.0427, or about 0.00026% of regional background occurrences. For $PM_{2.5}$ and mortality, the Project-related health incidences per year were estimated to be 0.35, or about 0.00054% of regional background occurrences. As the health incidence values estimated for Friant Ranch Project emissions are less than one, and a negligible fraction of the background incidence values, it is not expected that the Project will result in any meaningful health impact greater than zero, that can be established with any certainty.

1.0 INTRODUCTION

This HIA study provides a description of the methodologies used to develop concentration data for ozone and $PM_{2.5}$ for potential health impacts from Friant Ranch Project emissions. The intent of the HIA is to provide quantitative photochemical modeling and specific health impact information that meets the EIR evidentiary requirements for HIAs, as stated by the California Supreme Court in the Friant Ranch Case decision.

The proposed Project is located within the jurisdiction of the San Joaquin Valley Air Pollution Control District (SJVAPCD). CARB conducts photochemical modeling studies for the San Joaquin Valley to address attainment of the ozone and $PM_{2.5}$ state and federal ambient air quality standards. To review regional impacts from these pollutants, CARB recently completed photochemical modeling for the 2018 $PM_{2.5}$ SIP study using the CMAQ model for 2020 emissions (SJVAPCD 2018). As presented in this report, BlueScape obtained electronic files from Ramboll that were developed using CARB's CMAQ files, to run another photochemical model, the CAMx model. Using the CAMx files, BlueScape developed the HIA study to review potential ozone and $PM_{2.5}$ impacts from the Project. As addressed in the HIA, the primary emissions precursors to ozone formation are NO_x and Volatile Organic Compounds (VOC). VOC includes ROG, which is included within the larger category of TOG that is included in CAMx for complete photochemistry calculations. Air quality modeling concentration data developed with the CAMx model were used in health impact calculations completed with BenMAP-CE software.

The following discussion provides the background on California air district guidance, as response to the Friant Ranch Case decision. At the time the decision was released, the SJVAPCD did not develop general guidance to be used for California Environmental Quality Act (CEQA) review, and more specifically, the SJVAPCD did not develop procedures on how to evaluate specific health impacts from a project's ozone precursor and $PM_{2.5}$ emissions. However, the SJVAPCD and the South Coast Air Quality Management District (SCAQMD) did release legal positions on the Friant Ranch case. During the litigation before the California Supreme Court, SJVAPCD submitted an *Amicus Curiae* brief stating that models are not available to conduct an appropriate analysis (SJVAPCD 2015a). In its brief, SJVAPCD acknowledged that while health risk assessments (HRAs) for localized air toxics impacts, such as diesel particulate matter (DPM), are commonly prepared, "*it is not feasible to conduct a similar analysis for criteria air pollutants because currently available computer modeling tools are not equipped for this task*." The SJVAPCD further noted that an analysis of health impacts solely from the Friant Ranch Project emissions (which equate to less than one-tenth of one percent of the total NO_x and VOC emissions in the San Joaquin Valley) is not likely to yield valid information, and that any such information should not be "*accurate when applied at the local level*."

SJVAPCD has followed up the brief with general guidance to project developers to make "*a reasonable effort to discuss relevant specifics regarding the connection between potential adverse air quality impacts from the Project with the likely nature and magnitude of the potential health impacts. If the potential health impacts from*

the project cannot be specifically correlated, explain what is known and why, given scientific constraints, potential health impacts cannot be translated (SJVAPCD 2020)."

The SCAQMD also submitted an *Amicus Curiae* brief to the California Supreme Court (SCAQMD 2015). Its brief stated the difficulty of quantifying a project's health impacts for such pollutants as ozone, due to the need to consider the impact of a relatively small amount of emissions on overall regional pollution impacts. However, the SCAQMD did conclude that such regional impact modeling could be feasible for larger projects, considered to be much larger in terms of total emissions, than the Friant Ranch Project. The SCAQMD has demonstrated the typical use of a photochemical modeling concentration analysis for regional (not source-specific) ozone and $PM_{2.5}$ emissions impacts, connecting the results to specific predicted health impacts, in the *2016 Air Quality Management Plan* (AQMP, SCAQMD 2017) and related reports.

In late 2019, the Sacramento Metropolitan Air Quality Management District (SMAQMD 2019) released Interim Guidance suggesting that, where air quality emission impacts are deemed to be significant under CEQA, project applicants should provide a technical (or quantitative) analysis and make a finding on whether specific health impact review of ozone and $PM_{2.5}$ is feasible. If such a health impact analysis (for example using a photochemical model with BenMAP) is not feasible, the guidance suggests that the CEQA documents explain why the analysis is not feasible. Such an explanation could include review and discussion of models typically used currently for health impact analysis, including CalEEMod, EMFAC, OFFROAD, BenMAP-CE and HARP2, combined with an explanation of the extent to which these and any other tools identified could assist in describing the project's health impacts from ozone and $PM_{2.5}$ emissions.

Since releasing the Interim Guidance, the SMAQMD has released the *Guidance to Address the Friant Ranch Ruling for CEQA Projects in the Sac Metro Air District*, which replaces the Interim Guidance (SMAQMD 2020). The guidance document provides insight on potential ozone and $PM_{2.5}$ impacts that may occur due to project development in the Sacramento region, from a project's NO_x, VOC, carbon monoxide (CO) and oxides of sulfur (SO_x) emissions. The guidance provides screening look-up tables that can be used to estimate specific health effects in certain strategic growth areas. The screening look-up tables were developed using CAMx photochemical modeling. For projects with significant emissions outside of the strategic growth areas, the document provides guidance on the use of a photochemical model to develop quantitative estimates of ozone and $PM_{2.5}$ concentrations and health impacts from these pollutants.

This report describes the methodology used to complete the ozone and $PM_{2.5}$ concentration modeling for the Friant Ranch Project, including the CAMx modeling system, WRF model meteorological data inputs, CAMx model emission inputs and other input assumptions, and the output files prepared for BenMap-CE. The concentration results are described in tables and figures. A discussion regarding use of SILs for the HIA is provided in Section 2.0. The concentration impacts are discussed

in detail in Section 3.7. The health impacts calculated using BenMAP-CE are presented in Section 4.3.

2.0 SIGNIFICANT IMPACT LEVELS FOR REGIONAL AIR QUALITY MODELING AND HEALTH IMPACT ANALYSIS

The Friant Ranch Case decision did not establish, nor provide the means to develop, CEQA significance thresholds for regional air quality and health impact modeling. The Case only states that specific health impact information should be presented to the public in a reliable and meaningful way. This HIA analysis for the Friant Ranch Project has been prepared due to the finding that one or more of the pollutants, NO_x, ROG (or VOC), PM_{10} or $PM_{2.5}$ emitted by the Project may exceed the CEQA mass emissions significance thresholds listed by the SJVAPCD (SJVAPCD 2015b). This section provides a discussion on use of concentration significant impact levels (SILs) for consideration by Fresno County, should the county decide to complete further review on whether the specific health impacts described in the HIA are meaningful.

The EPA and CARB have set ambient health standards – the National Ambient Air Quality Standards (NAAQS) and the California Ambient Air Quality Standards (CAAQS) – for the purpose of meeting regional air pollution management goals. The ambient standards are based upon health impact studies, including health impact studies included in the BenMAP-CE model database and used in this HIA. For ozone and $PM_{2.5}$ health studies used to establish the NAAQS, see the Integrated Science Assessments (ISAs) (EPA 2019b). According to CARB, an ambient air quality standard is established to protect the health of the most sensitive groups in communities (CARB 2021a). The ambient standards represent an acceptable regional level of pollution for a specific compound. The federal and California state ambient health standards for ozone and $PM_{2.5}$ are listed in Table 1 below (CARB 2021b).

TABLE 1
AMBIENT HEALTH STANDARDS

Pollutant	Federal	California
Ozone	70 ppb 8-Hour Avg	90 ppb 1-Hour Avg 70 ppb 8-hour Avg
$PM_{2.5}$	35 $\mu g/m^3$ 24-Hour Avg 12.0 $\mu g/m^3$ Annual Avg	12 $\mu g/m^3$ Annual Avg

The SJVAPCD has established SILs as thresholds that are a small fraction of the ambient standards, to be used for ambient air quality analysis (AAQA) for air permitting, in APR 1925 *Policy for District Rule 2201 AAQA Modeling* (SJVAPCD 2019). The SILs are used to "*determine whether a proposed source's emissions will have a significant impact on air quality in an area*." In areas that are in nonattainment of the ambient standards, such as is the case for $PM_{2.5}$ within the San Joaquin Valley, the

SILs are thresholds that cannot be exceeded by an air permit applicant and still obtain an air permit authorization.

The SJVAPCD recommends use of ambient air quality analysis to determine whether impacts from development projects are significant under CEQA. The approach for development projects is provided in Section 8.4 of the *Guidance for Assessing and Mitigating Air Quality Impacts* (SJVAPCD 2015c) and refers to the APR 1925 AAQA modeling guidance. The $PM_{2.5}$ SILs for non-fugitive sources (or projects) were obtained by SJVAPCD from EPA, as described in the document *Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program* (EPA 2018b). In that EPA guidance document (pages 7, 13), the EPA addresses why, in its judgment, source concentration impacts below a SIL are insignificant: "*the EPA believes an insignificant impact is an impact on air quality concentrations that is small and not meaningful*." Thus, as related to the ambient health standards, a regulating authority can use the SILs as an indication that impacts below the SILs can be considered to be insignificant, or not causing a meaningful difference in a region's air quality as well as in any associated health impacts.

For $PM_{2.5}$, which is a nonattainment pollutant, the SJVAPCD considers project impacts on air quality to be insignificant if the $PM_{2.5}$ SILs are not exceeded. In that case, no further analysis of impacts is required. The SJVAPCD does not list a SIL for regional ozone impacts, because such analysis is not required by APR 1925. The SIL for regional ozone impacts from single projects, 1 ppb 8-hour average, can be obtained from EPA's Guidance on the SILs referenced above.

The air quality analysis SILs listed in the EPA SIL Guidance and SJVAPCD APR 1925 for ozone and $PM_{2.5}$ are shown in Table 2.

TABLE 2
EPA AND SJVAPCD SIGNIFICANT IMPACT LEVELS

Pollutant	EPA	SJVAPCD
Ozone	1 ppb, 8-Hour Avg	---
$PM_{2.5}$	<u>All sources:</u> 1.2 $\mu g/m^3$, 24-Hour Avg 0.2 $\mu g/m^3$, Annual Avg	<u>Non-Fugitive Sources:</u> 1.2 $\mu g/m^3$, 24-Hour Avg 0.2 $\mu g/m^3$, Annual Avg <u>Fugitive dust:</u> 2.5 $\mu g/m^3$, 24-Hour Avg 0.63 $\mu g/m^3$, Annual Avg

The ozone 8-hour average SIL of 1 ppb is about 1.4% of the 70 ppb federal and state 8-hour ozone standards. The most conservative $PM_{2.5}$ SIL listed in Table 2, which

would be associated with long-term health effects of 0.2 μg/m^3, is about 1.7% of the 12 μg/m^3 federal and state annual average $PM_{2.5}$ standard. While the purpose of an HIA is not to show compliance with ambient health standards as discussed above (rather to address specific health impacts of ozone and $PM_{2.5}$), if HIA concentration impacts due to a project above the existing regional baseline do not exceed these SIL thresholds, then Fresno County could use this finding as an indication that the project's concentration impacts on regional public health are likely not meaningful, because the SILs are related to regional health studies used to develop ambient health standards.

While this HIA report concludes that Friant Ranch Project concentration impacts (and therefore likely the related health impacts) are not meaningful, to provide Fresno County and the public with additional information, as well as meet the evidentiary requirements of the Friant Ranch Case, the report also provides specific health impact modeling results, as compared to baseline health impacts on the regional population from all of the emissions occurring in the region.

3.0 CAMX PHOTOCHEMICAL MODELING FOR THE FRIANT RANCH PROJECT

This section provides a discussion of regional photochemical modeling completed for ozone and $PM_{2.5}$ impacts using the CAMx model for the Friant Ranch Project. CAMx was used to develop regional air concentration data for the health impact analysis described in Section 4.0.

3.1 Summary of the Modeling System

Photochemical grid models (PGMs) are recognized and routinely utilized tools for regulatory analysis such as assessing emission control strategies in pursuit of attaining a particular ambient health standard. PGMs are large-scale mathematical air quality models that represent the physicochemical processes that occur in the atmosphere. PGMs simulate the changes of atmospheric pollutant concentrations due to changes in the constituent makeup of anthropogenic, biogenic, and geogenic emissions emitted into the atmosphere. PGMs are applied at multiple spatial scales from local, regional, national, and global over periods of time that span weekly, monthly, and annual scales.

Over the last five decades, EPA has devoted significant resources to develop PGMs for the assessment of air pollution issues, including health impact assessments and evaluation of emissions control strategies. The EPA's Air Quality Modeling Group has used photochemical models as part of its modeling analyses to support policy and regulatory decisions. Finally, EPA has developed guidance on the use of these models (EPA 2017).

CAMx is a state-of-the-art regional air quality modeling system developed by Ramboll that can be used to simulate the physical and chemical processes that govern the formation, transport, and deposition of gases and particulates in the atmosphere. The structure of the CAMx modeling system is shown in Figure 1 below.

The components shown in Figure 1 are:

- **WRF**: Weather Research and Forecasting Model, v3.8 or later. WRF was used by CARB on behalf of the SJVAPCD, to generate the meteorology data for CMAQ modeling completed for the San Joaquin Valley. WRF (year 2013) output files from CARB used for the SJVAPCD 2018 $PM_{2.5}$ SIP study 2020 model run were post-processed by Ramboll for use in CAMx. The 2013 meteorological data was used in this HIA for consistency with the CARB modeling study, thus ensuring valid CAMx model performance.

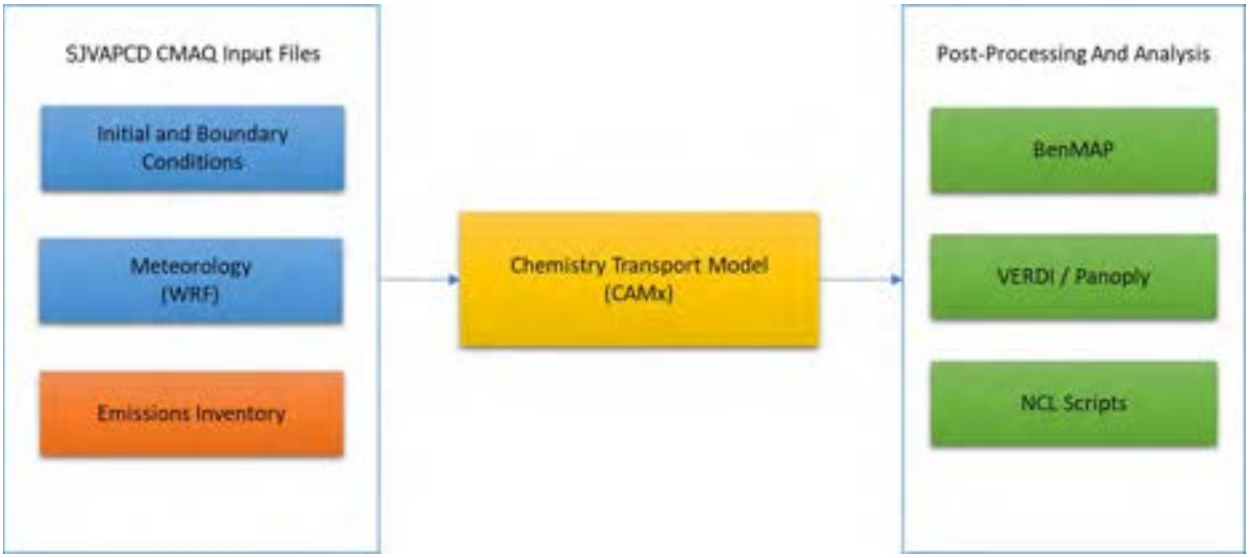


FIGURE 1. COMPONENTS OF THE CAMX MODELING SYSTEM

- **CAMx**: Comprehensive Air Quality Model with Extensions, v6.5. The CAMx model was run by Ramboll using converted CARB CMAQ input files and meteorology post-processed from CARB WRF output files.
- **Initial and Boundary Conditions**: Initial and boundary photochemical conditions for the spatial domain and the modeling time period. Initial conditions represent the state of the air quality of every grid cell of the domain and for every chemical species at the start of the simulation. The boundary conditions represent the estimated, incoming air quality of every chemical species at the north, south, east, and west lateral boundaries of the 4 km domain. The boundary conditions and initial conditions were derived based on modeling from the 12 km domain.
- **Emissions Inventory**: An emissions database for the scenario, spanning the time period, spatial domain, and species list required by CAMx. Generally, CAMx obtains its emissions inventories from the EPA's SMOKE (Sparse Matrix Operator Kernel Emissions) Modeling System (CMAS 2018). In this Project, a complete emissions inventory for Year 2020 in CMAQ-format files was provided

by CARB to Ramboll, then converted by Ramboll to CAMx format to be used in this analysis. BlueScape also obtained the CMAQ files from CARB and used them for model performance evaluation.

- **Post-Processing and Analysis**: The following software tools were available to post-process CAMx results for further analysis and data visualization:
    - **VERDI**: Java program for visualizing meteorology, emissions, and air quality modeling data. With options for overlaying GIS Shapefiles and observational data onto model output, VERDI offers a range of options for viewing atmospheric modeling data. VERDI was used in this Project to validate emissions re-gridding and output concentrations from CAMx.
    - **Panoply**: netCDF, HDF and GRIB Data Viewer. Used alongside VERDI to visualize CAMx output data and to extract CSV files from CAMx post-processed output files, stored in netCDF format.
    - **NCL Scripts**: The NCAR Command Language (NCL) is a free interpreted language designed specifically for scientific data processing and visualization. In this Project, NCL was not used to incorporate the Project's emissions model into the 2020 and 2031 Baseline emissions; rather the emissions were manually formatted and processed.
    - **BenMAP-CE**: EPA Benefits Mapping and Analysis Program – Community Edition, BenMAP-CE is an open-source software that calculates the number and economic value of air pollution-related deaths and illnesses. A component of BenMAP-CE is a tool called PopGrid which is used to estimate the population within each grid cell by gender, race, ethnicity, and age range.

3.2 Modeling Domain

The modeling domain chosen for the Project study was obtained from the domain used in the 2018 SJVAPCD $PM_{2.5}$ SIP modeling run completed by CARB. This modeling domain is comprised of three nested domains (i.e., 36 km, 12 km, and 4 km). For the current study, only the 4km domain was used for modeling. As the footprint of the Friant Ranch Project is wholly contained within the 4km domain, it was deemed unnecessary to conduct model simulations using the 36 km and 12 km domains. Further, it is well known that when additional emissions of small magnitude are inserted into a handful of grid cells of the 4 km domain, the modelled impact to air quality in the larger 12 km and 36 km are negligible if not imperceptible. Data from the final modeling grid subset used by CARB was used for the Project CAMx runs, as boundary and initial conditions from CARB for CMAQ already incorporated data from coarser grids. This final grid covered an area of 348 by 412 kilometers, using a 4-km grid size and 87 by 103 cells. Figure 2 shows this grid layout, used by both CARB for CMAQ model runs, and by BlueScape for Project CAMx model runs.

FIGURE 2. CARB CMAQ AND CAMX MODELING GRID



3.3 WRF – Weather Research and Forecasting Model Data

The WRF model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. The model generates three-dimensional (3D) wind fields for a specific domain, using telescopic grids to pass regional phenomena down to smaller areas. WRF is an integral part of both CMAQ and CAMx modeling systems.

CARB used WRF v3.8 to generate the meteorological fields needed for their 2020 CMAQ run used for the SJVAPCD $PM_{2.5}$ SIP Study. BlueScape obtained output files from this WRF run that were post-processed by Ramboll using the wrfcamx post-processing tool. Table 3 below contains the selected WRF modeling configuration used by CARB.

TABLE 3 **WRF MODELING CONFIGURATION**	
Grid Definition	CARB WRF data, final grid: • 4-km grid cell, 189 x 189 grid cells in size, total area: 756 x 756 kms
Initial and Boundary Conditions	NCEP North American Mesoscale (NAM) 12 km Analysis, Grid 218
Vertical Layers	50 Layers with the lowest layer at 18 m above ground level (agl).
Data Assimilation	Analysis nudging at every 6 hours for the outermost domain only. No temperature and moisture nudging within the Planetary Boundary Layer (PBL).

3.4 CAMx Model Setup

The CAMx model was set up to use the same grid as the final grid from the CARB 2020 CMAQ model run. Table 4 contains the general CAMx model configuration used, while Table 5 contains the grid configuration.

TABLE 4 **GENERAL CAMX CONFIGURATION**	
Chemical Mechanism	SAPRC07 with version "c" toluene updates gas-phase mechanism
Advection Solver	Piecewise Parabolic Method (PPM)
Chemical Solver	Euler Backward Iterative solver (EBI)
Plume-In-Grid Submodel	Greatly Reduced Execution and Simplified Dynamics Submodel (GREASD)
Dry Deposition Model	Zhang 2003
Photolysis	In-line Calculation

TABLE 5 **4-KM GRID CONFIGURATION**	
Grid Definition	4-km grid cell, 87 x 103 grid cells in size, total area: 348 x 412 kms

3.5 Emissions Inventories

The CAMx model requires input of hourly, gridded criteria pollutant emissions of both anthropogenic and biogenic sources that have been spatially allocated to the appropriate grid cells and chemically speciated for the model's applicable chemical mechanism.

Gridded area emissions, elevated point source emissions, boundary and initial conditions were converted by Ramboll from CARB CMAQ input files using the cmaq2camx conversion tool, changing the chemical mechanism from CB06 to SAPRC07. The input 2020 CMAQ files used 2013 emissions inventory files, that were updated by CARB for projected 2020 regional emissions. The gridded emission files include TOG, NO_x, PM_{10} and $PM_{2.5}$, to obtain the overall particulate concentration results. The TOG and particulate data were entered into CAMx by chemical species. Project SO_x and CO emissions were not included in the analysis, due to their small contribution to secondary $PM_{2.5}$ and ozone formation.

The Future Baseline year 2031 CAMx ROG, NO_x, PM_{10}, and $PM_{2.5}$ emissions were grown, or scaled, from 2020 emissions, using growth factors developed from the CEPAM 2016 SIP - Standard Emission Tool developed by CARB (CARB 2018). CEPAM lists emissions by source category: stationary sources, areawide sources, mobile sources, and natural sources. Each source category has subcategories, such as stationary source type, on-road and off-road subcategories. These CEPAM categories and subcategories were matched with the CARB CMAQ emission files source categories and subcategories. Note that should the Project development and full buildout be delayed past 2031, it is expected that of selection of 2031 emissions for CAMx modeling will be conservative.

The incremental Project emissions were incorporated into the Baseline year 2020 and Future year 2031 emissions. Tables 6 and 7 summarize the Project peak daily unmitigated and mitigated emissions in pounds per day (lb/day) by source category for any of the years between Project construction start in 2022 and the 2031 Buildout year. Note that for NO_x, 2022 emissions were used to represent Project peak daily emissions. This is due to the fact that Community Plan NO_x operational emissions and construction emissions are higher in 2022 than in 2031. This assumption for NO_x is expected to provide a conservative analysis. Further detail on the development of Project emissions for HIA modeling is presented in the *Air Emissions Report for the Friant Ranch Community Development Project* (BlueScape 2021).

TABLE 6 PROJECT PEAK DAILY UNMITIGATED OPERATION AND CONSTRUCTION EMISSIONS (LB/DAY)						
Category	**ROG**	**NO_x**	**Fugitive PM_{10}**	**Exhaust PM_{10}**	**Fugitive $PM_{2.5}$**	**Exhaust $PM_{2.5}$**
	Construction					
On-Road Mobile	0.773	3.13	2.59	0.014	0.699	0.013
Off-Road Mobile	9.36	111	15.6	4.10	4.34	3.79
Area/Energy	104	0	0	0	0	0
	Operational (Specific Plan plus Community Plan)					
On-Road Mobile	127	294	124	1.59	33.4	1.51
Off-Road Mobile	0	0	0	0	0	0
Area/Energy	101	28.9	0	27.0	0	27.0
Total	**342**	**438**	**142**	**32.7**	**38.4**	**32.3**

TABLE 7 PROJECT PEAK DAILY MITIGATED OPERATION AND CONSTRUCTION EMISSIONS (LB/DAY)						
Category	**ROG**	**NO_x**	**Fugitive PM_{10}**	**Exhaust PM_{10}**	**Fugitive $PM_{2.5}$**	**Exhaust $PM_{2.5}$**
	Construction					
On-Road Mobile	0.773	2.63	2.59	0.014	0.699	0.013
Off-Road Mobile	3.83	60.4	6.08	3.49	1.69	3.49
Area/Energy	104	0	0	0	0	0
	Operational (Specific Plan plus Community Plan)					
On-Road Mobile	126	304	107	1.42	28.8	1.35
Off-Road Mobile	0	0	0	0	0	0
Area/Energy	81.8	22.9	0	4.82	0	4.82
Total	**316**	**389**	**115**	**9.74**	**31.2**	**9.66**

For CAMx modeling, Project ROG emissions were converted to TOG emissions using conversion factors developed based upon SMOKE speciation profiles (CMAS 2018). For each Project scenario, in 2020 and 2031, in both unmitigated and mitigated scenarios, the following data was incorporated into the baseline gridded emission files:

- Temporal allocation of construction emissions by day-of-week and hour-of-day;

- Temporal profiles extracted by Ramboll from CARB CMAQ files for allocation of non-construction Project emissions, weekend-weekday and by time of day, for aggregated source categories;
- Spatial distribution of Project emissions from mobile sources, in ten grid cells near the Project site; and
- Speciation profiles of Project emissions for CAMx SAPRC07 specific gas and aerosol species.

Using this input data, new Project emissions were generated hour by hour for the entire simulation year. Per relevant CAMx species, incremental emissions were apportioned to the corresponding grid cells, and a complete Project emissions database was generated for each scenario. Figure 3 shows the Project site location and color-shading to represent emissions apportionment fractions by 4-km grid cell. The darker blue shaded grid cells are closest to the Project site, and have the highest emissions apportionment. No Project emissions were apportioned outside the grid cells shown in Figure 3.

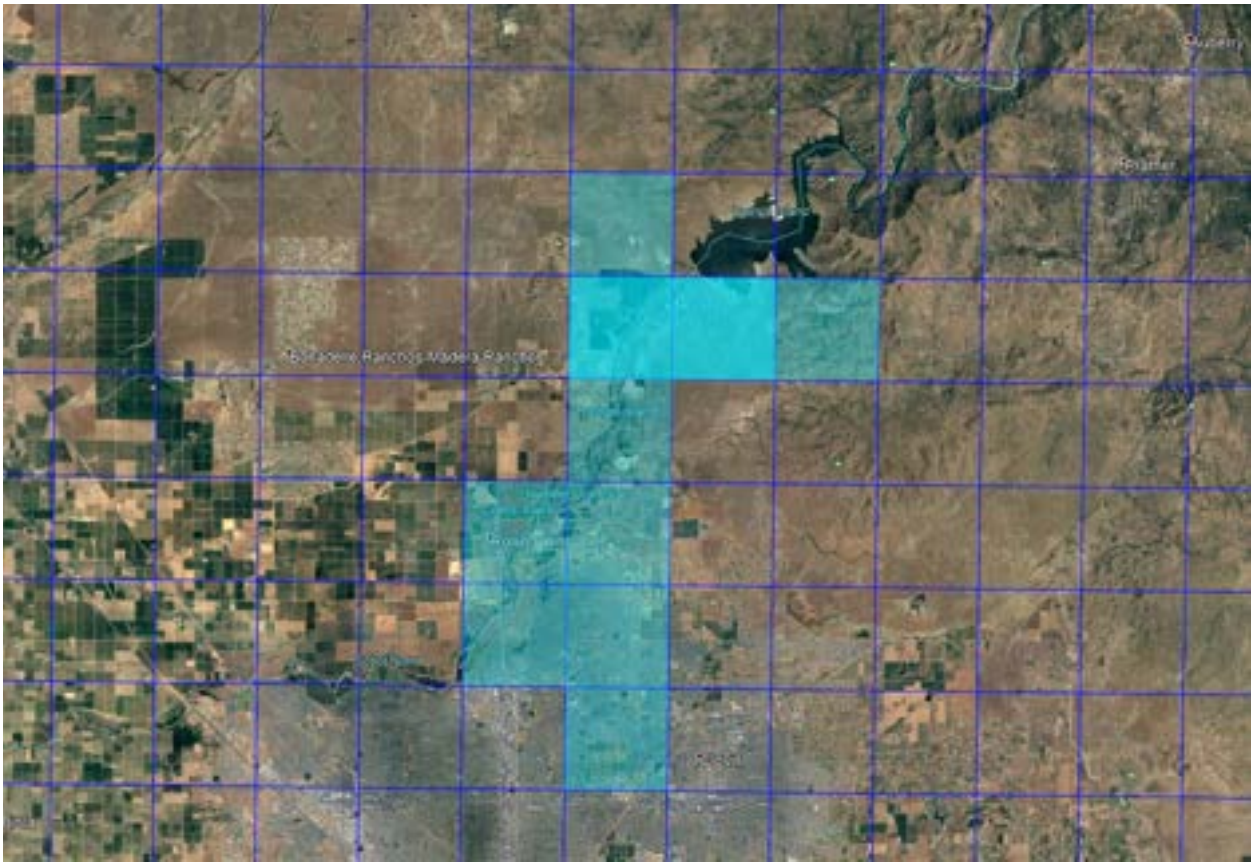


FIGURE 3. PROJECT EMISSIONS APPORTIONMENT TO GRID CELLS

3.6 Model Performance Evaluation

Air quality modeling studies are obliged to include efforts to assess the ability of an air quality modeling system to reliably recreate observed air quality events. In the current context of this study, the air quality modeling system is the combined meteorological modeling system (WRF), the photochemical modeling system (CAMx), and modeling input data sets. The air quality modeling system was derived from CARB's 2013 air quality modeling system used for the SJVAPCD $PM_{2.5}$ SIP Study to estimate regional ozone and $PM_{2.5}$ concentration impacts in 2020.

CARB performed a model performance evaluation (MPE) for the 2013 period and deemed its CMAQ-based air quality modeling system adequate for use in additional studies (SJVAPCD 2018) for future years. Therefore, it is sufficient that if the CAMx-based system, which was based on the CARB databases, replicates the CMAQ-based air quality modeling predictions, then the CAMx-based system is also adequate for use in further air quality studies.

The Environmental Protection Agency (EPA) has issued guidance on how air quality simulation models are to be judged to be adequately performing in order to be used for studies such as conducted here (EPA 2018a). Two statistics that are used to judge such model performance are mean gross error and mean bias. If the gross error is less than 15% and bias is within +/-5%, it is an indicator that the model is adequately performing (Emery et. al. 2017).

The average daily gross error and average daily bias for ozone and $PM_{2.5}$ between the CARB CMAQ-based predictions, and completed CAMx-based predictions that are the subject of this study were computed for each month of 2020 and each California County. The maximum CMAQ-to-CAMx difference for the ozone 8-hour average concentration in any grid cell was 0.24 ppbv. The maximum CMAQ-to-CAMx difference for the annual $PM_{2.5}$ 24-hour average was 0.091 $\mu g/m^3$. As the gross error values were less than 5% and the bias values near zero relative to the maximum concentrations calculated for 2020 for the same cells by both the CMAQ and CAMx models, it was deemed that the CAMx-based system was suitable, and performed well for use in this HIA.

3.7 CAMx Modeling Results

The CAMx modeling results are presented in this section. Section 3.7.1 compares the impact of Project TOG and NO_x emissions, unmitigated and mitigated, on regional ozone concentration changes, for the 2020 Existing Baseline and 2031 Future Baseline year scenarios. A comparison of the impact of Project $PM_{2.5}$ and PM_{10} emissions, unmitigated and mitigated, on regional $PM_{2.5}$ concentration changes is presented in Section 3.7.2.

3.7.1 Ozone Concentration Change Results

Ozone modeling concentration change results are presented in Tables 8 to 11, for the CAMx 4-km grid in parts per billion by volume (ppbv), maximum daily 8-hour average (MDA8) concentrations.

For the 2020 Existing Baseline year scenario, Tables 8 and 9 compare the Project concentration changes at the grid cell with the highest change, both unmitigated and mitigated scenarios, to the baseline concentration results. The maximum MDA8 Project concentration change for either scenario is 0.021%, for the unmitigated emissions scenario. The unmitigated emissions impact for this scenario, 0.01 ppbv is well below (1% of) the 1 ppb SIL.

TABLE 8
2020 CAMX MODELING RESULTS FOR THE BASELINE AND UNMITIGATED PROJECT SCENARIOS, MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, AT THE GRID CELL WITH THE HIGHEST CHANGE

Baseline Scenario (ppbv)	Project Scenario (ppbv)	Maximum Project Change (ppbv)	Maximum Project Change (%)
48.417	48.427	0.01	0.021

TABLE 9
2020 CAMX MODELING RESULTS FOR THE BASELINE AND MITIGATED PROJECT SCENARIOS, MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, AT THE GRID CELL WITH THE HIGHEST CHANGE

Baseline Scenario (ppbv)	Project Scenario (ppbv)	Maximum Project Change (ppbv)	Maximum Project Change (%)
48.417	48.426	0.009	0.019

For the 2031 Future Baseline year scenario, Tables 10 and 11 compare the Project concentration changes at the grid cell with the highest change, both unmitigated and mitigated scenarios, to the baseline concentration results. The maximum MDA8 Project concentration change for either scenario is 0.029%, for the unmitigated emissions scenario. The unmitigated emissions impact for this scenario, 0.013 ppbv is well below (1.3% of) the 1 ppb SIL.

TABLE 10
2031 CAMX MODELING RESULTS FOR THE FUTURE AND UNMITIGATED PROJECT SCENARIO, MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, AT THE GRID CELL WITH THE HIGHEST CHANGE

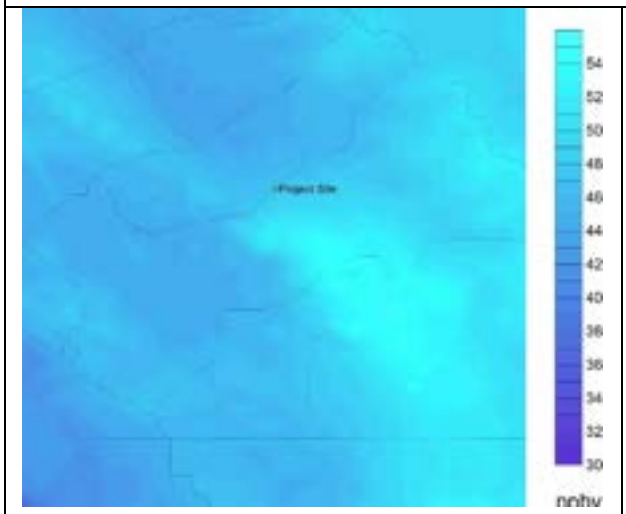
Future Scenario (ppbv)	Project Scenario (ppbv)	Maximum Project Change (ppbv)	Maximum Project Change (%)
44.357	44.370	0.013	0.029

TABLE 11
2031 CAMX MODELING RESULTS FOR THE FUTURE AND MITIGATED PROJECT SCENARIOUS, MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, AT THE GRID CELL WITH THE HIGHEST CHANGE

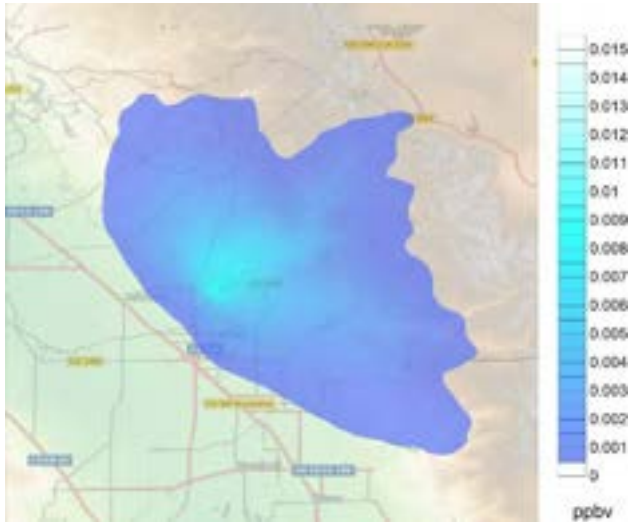
Future Scenario (ppbv)	Project Scenario (ppbv)	Maximum Project Change (ppbv)	Maximum Project Change (%)
44.357	44.369	0.012	0.027

Figures 4 and 5 display the modeled MDA8 ozone concentration results for the 2020 Existing Baseline year and 2031 Future Baseline year scenarios, comparing the difference from unmitigated (Figure 4 and 5 center panels) or mitigated (Figure 4 and 5 right panels) Project ozone impacts, to baseline concentrations, in units of ppbv.

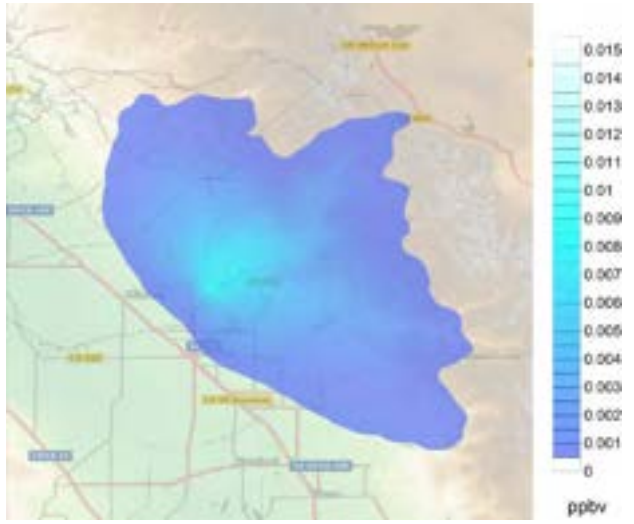
FIGURE 4. OZONE 2020 SCENARIO MAXIMUM DAILY 8-HOUR (MDA8) AVERAGE CONCENTRATIONS COMPARISON OF BASELINE TO UNMITIGATED PROJECT EMISSIONS AND PROJECT MITIGATED EMISSIONS



2020 Baseline Ozone MDA8 (ppbv)

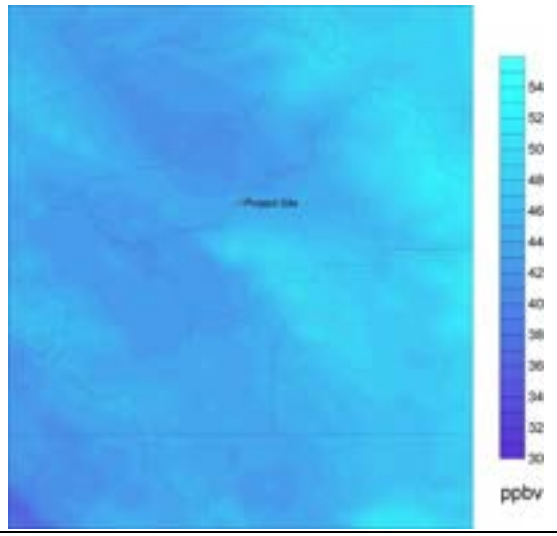


2020 Ozone MDA8 Unmitigated Project Emissions Difference from Baseline (ppbv)

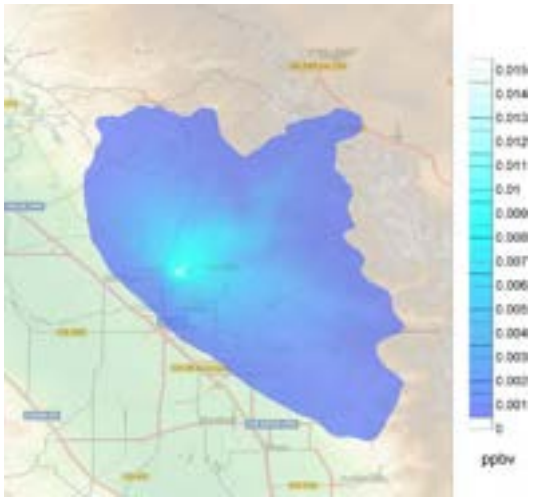


2020 Ozone MDA8 Mitigated Project Emissions Difference from Baseline (ppbv)

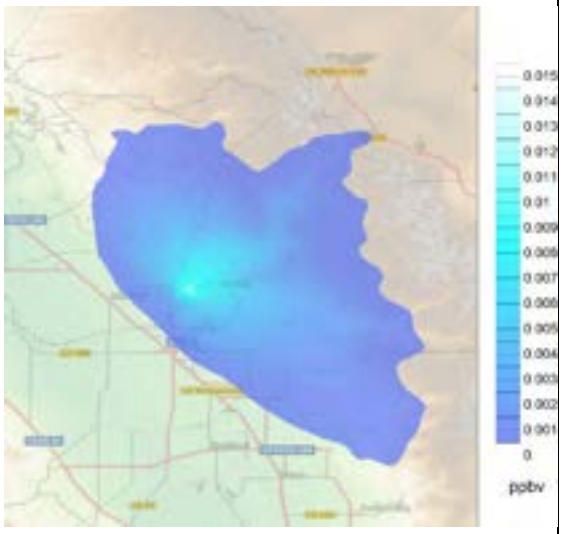
FIGURE 5. OZONE 2031 SCENARIO MAXIMUM DAILY 8-HOUR (MDA8) AVERAGE CONCENTRATIONS COMPARISON OF BASELINE TO UNMITIGATED PROJECT EMISSIONS AND PROJECT MITIGATED EMISSIONS



2031 Baseline Ozone MDA8 (ppbv)



2031 Ozone MDA8 Unmitigated Project Emissions Difference from Baseline (ppbv)



2031 Ozone MDA8 Mitigated Project Emissions Difference from Baseline (ppbv)

3.7.2 $PM_{2.5}$ Concentration Change Results

The $PM_{2.5}$ modeling concentration change results are presented in Tables 12 to 15, for the CAMx 4-km grid in micrograms per meters cubed ($\mu g/m^3$), annual 24-hour average $PM_{2.5}$ concentrations.

For the 2020 Existing Baseline year scenario, Tables 12 and 13 compare the Project concentration changes at the grid cell with the highest change, both unmitigated and mitigated scenarios, to the baseline concentration results. The maximum annual 24-hour $PM_{2.5}$ Project concentration change for either scenario is 0.55%, for the unmitigated emissions scenario. The unmitigated emissions impact for this scenario, 0.051 $\mu g/m^3$, is below (26% of) the 0.2 $\mu g/m^3$ SIL.

TABLE 12
2020 CAMX MODELING RESULTS FOR THE BASELINE AND UNMITIGATED PROJECT SCENARIOS, ANNUAL AVERAGE 24-HOUR $PM_{2.5}$, AT THE GRID CELL WITH THE HIGHEST CHANGE

Baseline Scenario ($\mu g/m^3$)	Project Scenario ($\mu g/m^3$)	Maximum Project Change ($\mu g/m^3$)	Maximum Project Change (%)
9.528	9.580	0.051	0.55

TABLE 13
2020 CAMX MODELING RESULTS FOR THE BASELINE AND MITIGATED PROJECT SCENARIOS, ANNUAL AVERAGE 24-HOUR $PM_{2.5}$, AT THE GRID CELL WITH THE HIGHEST CHANGE

Baseline Scenario ($\mu g/m^3$)	Project Scenario ($\mu g/m^3$)	Maximum Project Change ($\mu g/m^3$)	Maximum Project Change (%)
9.528	9.567	0.038	0.41

For the 2031 Future Baseline year scenario, Tables 14 and 15 compare the Project concentration changes at the grid cell with the highest change, both unmitigated and mitigated scenarios, to the baseline concentration results. The maximum annual daily $PM_{2.5}$ Project concentration change for either scenario is 0.56%, for the unmitigated emissions scenario. The unmitigated emissions impact for this scenario, 0.058 $\mu g/m^3$, is below (29% of) the 0.2 $\mu g/m^3$ SIL.

TABLE 14
2031 CAMX MODELING RESULTS FOR THE BASELINE AND UNMITIGATED PROJECT SCENARIOS, ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, AT THE GRID CELL WITH THE HIGHEST CHANGE

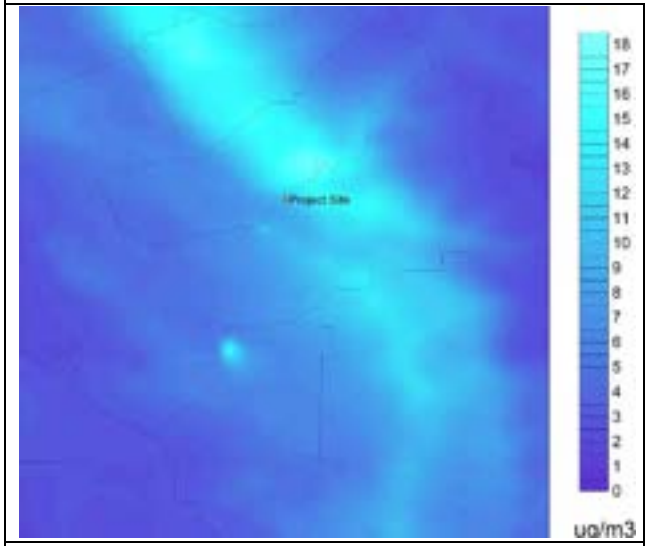
Baseline Scenario ($\mu g/m^3$)	Project Scenario ($\mu g/m^3$)	Maximum Project Change ($\mu g/m^3$)	Maximum Project Change (%)
10.111	10.168	0.058	0.56

TABLE 15
2031 CAMX MODELING RESULTS FOR THE BASELINE AND MITIGATED PROJECT SCENARIOS, ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, AT THE GRID CELL WITH THE HIGHEST CHANGE

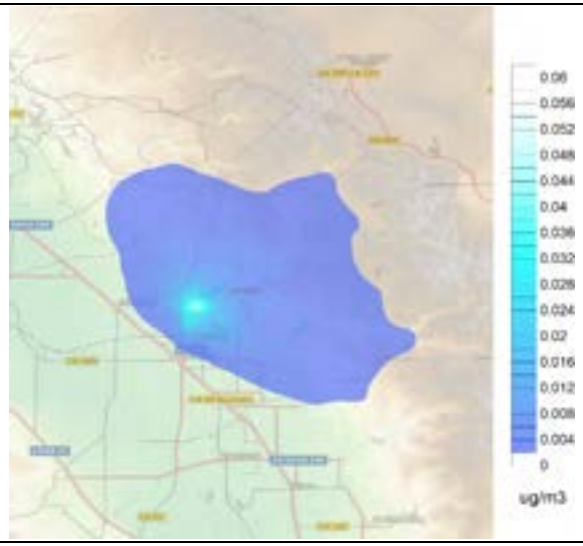
Baseline Scenario ($\mu g/m^3$)	Project Scenario ($\mu g/m^3$)	Maximum Project Change ($\mu g/m^3$)	Maximum Project Change (%)
10.111	10.155	0.044	0.44

Figures 6 and 7 display the modeled annual daily 24-hour $PM_{2.5}$ for the 2020 Existing Baseline and 2031 Future Baseline year scenarios, comparing the difference from unmitigated (Figure 6 and 7 center panels) or mitigated (Figure 6 and 7 right panels) Project $PM_{2.5}$ impacts, to the baseline concentrations, in units of ($\mu g/m^3$).

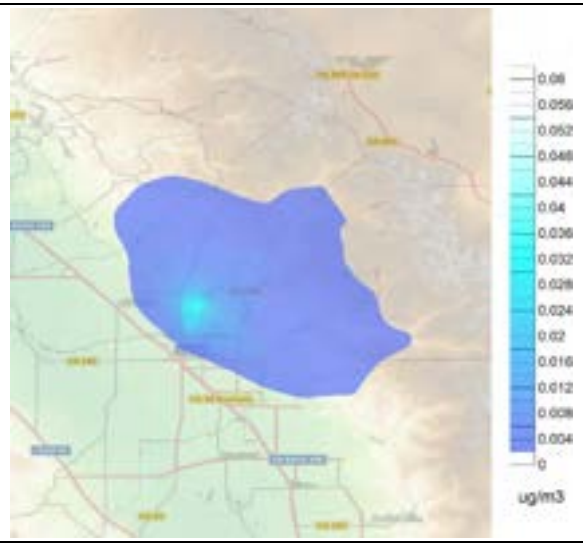
FIGURE 6. $PM_{2.5}$ 2020 SCENARIO ANNUAL 24-HOUR AVERAGE CONCENTRATIONS
COMPARISON OF BASELINE TO UNMITIGATED PROJECT EMISSIONS AND PROJECT MITIGATED EMISSIONS



2020 Baseline Annual 24-hour Average $PM_{2.5}$ ($\mu g/m^3$)

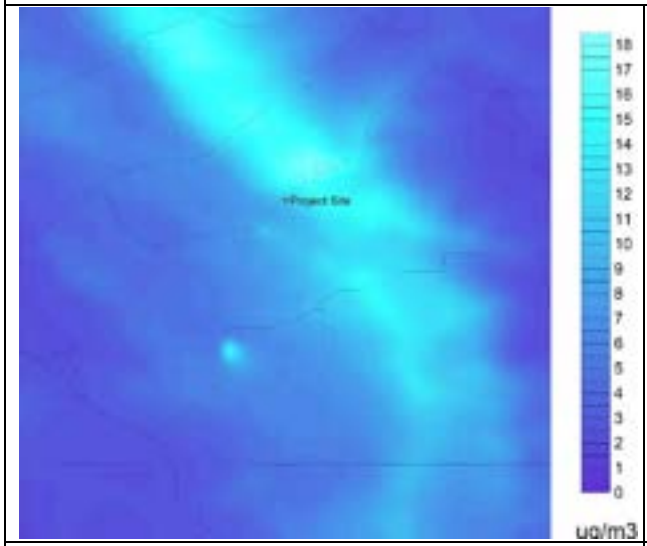


2020 $PM_{2.5}$ Unmitigated Project Emissions Difference from Baseline ($\mu g/m^3$)

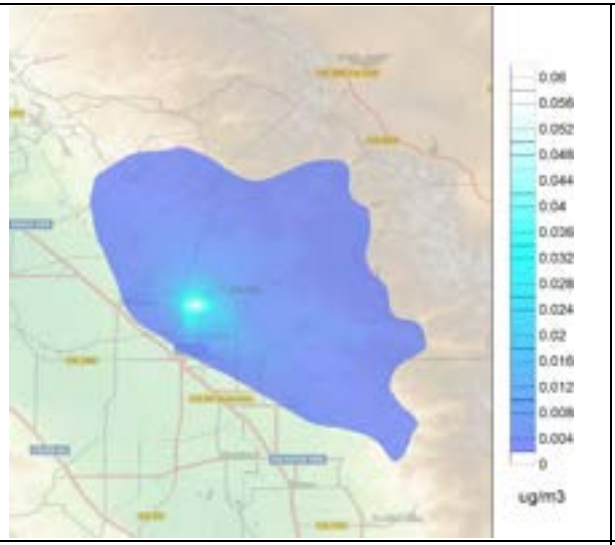


2020 $PM_{2.5}$ Mitigated Project Emissions Difference from Baseline ($\mu g/m^3$)

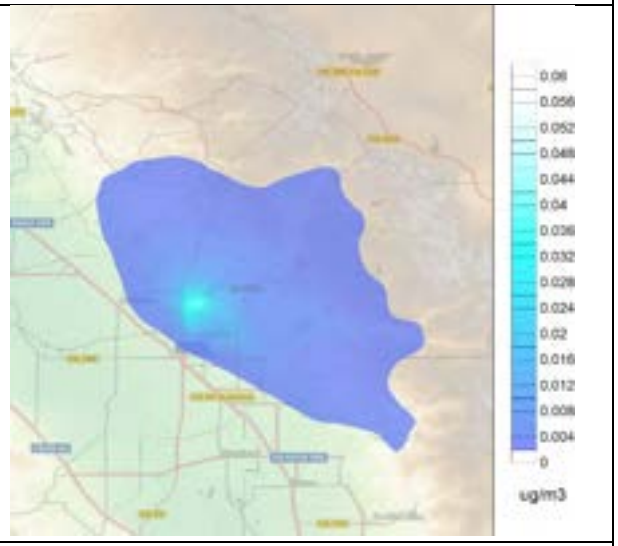
FIGURE 7 . $PM_{2.5}$ 2031 SCENARIO ANNUAL 24-HOUR AVERAGE CONCENTRATIONS
COMPARISON OF BASELINE TO UNMITIGATED PROJECT EMISSIONS AND PROJECT MITIGATED EMISSIONS



2031 Baseline Annual 24-hour Average $PM_{2.5}$ ($\mu g/m^3$)



2031 $PM_{2.5}$ Unmitigated Project Emissions Difference from Baseline ($\mu g/m^3$)



2031 $PM_{2.5}$ Mitigated Project Emissions Difference from Baseline ($\mu g/m^3$)

4.0 FRIANT RANCH REGIONAL HEALTH IMPACTS ANALYSIS

This section provides a discussion of the regional health impacts analysis for ozone and $PM_{2.5}$ concentration changes due to Friant Ranch Project emissions. The HIA was completed using the air concentration data developed from CAMx, as described in Section 3.0, and using the EPA's BenMAP-CE model. The results of the specific Project health impact analysis for ozone and $PM_{2.5}$ are provided in this section.

4.1 BenMAP-CE Overview

The U.S. Environmental Protection Agency (EPA) Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE) tool is a publicly available, PC-based open-source software that can be configured to relate the human health impacts and/or benefits to air quality changes. The program includes a subset of air quality monitoring data, recent and projected demographic and baseline health data, concentration-response relationships drawn from the published epidemiological literature, and economic value estimates based on the published economics literature. The principal function of the software is to apply the findings of epidemiological and economics studies to estimate the health impacts and economic value of air pollution changes.

The latest version of BenMAP-CE is Version 1.5, which the EPA released in March 2019. For analyses that are within the Continental United States, BenMAP-CE includes preloaded databases containing the concentration-response (C-R) relationships, population files, and health data needed to quantify the number and economic value of human health impacts resulting from changes in air quality - specifically, ground-level ozone and fine particles such as $PM_{2.5}$. Figure 8 summarizes the process that BenMAP-CE uses to calculate human health impacts.

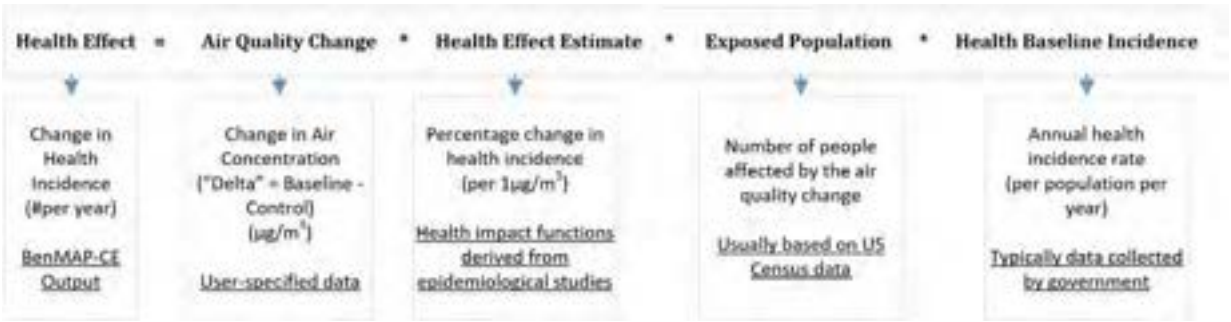


FIGURE 8. OVERVIEW OF THE PROCESS OF HEALTH IMPACT CALCULATIONS IN BENMAP-CE

To estimate human health effects, BenMAP-CE first determines the change in ambient air concentrations using user-specified air quality data for the baseline and controlled scenarios. The software then applies the relationship between the air concentrations with certain health effects (also known as health endpoints) using the health impact function or the C-R functions that were derived from epidemiology studies. BenMAP-CE applies that relationship to the exposed population to calculate health impacts based on baseline health incidence data.

4.2 Application of BenMAP-CE to the Friant Ranch Project

As part of an overall health impact analysis (HIA) for the proposed Friant Ranch Community Development Project, this analysis used BenMAP-CE (Version 1.5) to quantify the potential human health effects from the Project's emissions of ozone precursors and $PM_{2.5}$. The sections below summarize the data sources and specific BenMAP-CE input and method selections made for this Project-level analysis, covering five key pieces of information:

1. The ambient air quality data;
2. Population data representing the population exposed to the change in air pollution;
3. An analysis year;
4. Health endpoints (health effects) and health impact functions; and
5. The baseline rate of death and disease among the exposed population.

4.2.1 Air Quality Data

BenMAP-CE itself does not model changes in air pollutant emissions or the resultant concentrations. These data must be input into BenMAP-CE as dispersion modeling results or generated from air pollution monitoring data (some monitoring data is pre-loaded in BenMAP-CE). The potential ambient air concentrations of ozone and $PM_{2.5}$ in the region where the Project is located were estimated using the CAMx as discussed in Section 3.0 of this report. As detailed, for each pollutant (ozone or $PM_{2.5}$), each modeling year (Existing Baseline year 2020 or Future Baseline year 2031), and emissions for both unmitigated and mitigated conditions, each CAMx model run generated two sets of data:

1. The ambient air concentrations based on the 2020 emissions inventory provided by CARB, for the corresponding modeling year, 2020 or scaled to 2031 (referred to as the Existing Baseline year for 2020 and Future Baseline year for 2031); and

2. The resulting ambient air concentrations generated by adding the Project's emissions (unmitigated or mitigated) to the corresponding concentrations developed from the 2013 regional air emission inventory extrapolated by CARB to 2020 (as described in Section 3.5) and scaled for this HIA to 2031 (referred

to as the Existing Baseline plus Project scenarios for 2020, and the Future Baseline plus Project scenarios for 2031).

As detailed in Section 3.7 of this report, due to the orders-of-magnitude smaller emissions from the Project as compared to the 2020 and 2031 Baseline emissions inventories, the difference between the two sets of data (air concentration delta or "delta") was very small. This being the case, for informational purposes, even with the very small delta values between the two sets of concentration data and the inherent and unavoidable uncertainties associated with any CAMx modeling study, BenMAP-CE was used for this HIA to translate the potential Project-incurred changes in ambient air ozone and $PM_{2.5}$ concentrations into potential human health outcomes of the Project. This approach is consistent with the EPA's development and use of BenMAP-CE to understand potential regional health impact changes associated with concentration changes above baseline conditions.

For each BenMAP-CE run, the corresponding grid that matches the CAMx results were defined in the BenMAP-CE's Grid Definition database first. With the combination of pollutant and grid, a total of eight (8) BenMAP-CE model runs were conducted to determine the Project's potential health impacts, as summarized below:

- Ozone, Year 2020, Existing Baseline plus unmitigated Project emissions;
- Ozone, Year 2020, Existing Baseline plus mitigated Project emissions;
- Ozone, Year 2031, Future Baseline plus unmitigated Project emissions;
- Ozone, Year 2031, Future Baseline plus mitigated Project emissions;
- $PM_{2.5}$, Year 2020, Existing Baseline plus unmitigated Project emissions;
- $PM_{2.5}$, Year 2020, Existing Baseline plus mitigated Project emissions;
- $PM_{2.5}$, Year 2031, Future Baseline plus unmitigated Project emissions; and
- $PM_{2.5}$, Year 2031, Future Baseline plus mitigated Project emissions.

The CAMx-generated 2020 Existing Baseline and 2031 Future Baseline concentration datasets were imported into the BenMAP-CE program as base case Air Quality Data, and then post-Project (Baseline or Future plus Project, unmitigated and mitigated) concentration datasets were imported as "Control" Air Quality Data. Then BenMAP-CE calculates change (air concentration delta) using Control minus either the Existing Baseline or Future Baseline scenarios from the CAMx-generated input files.

4.2.2 Population Data

A customized population dataset matching the air quality grid definitions described above was generated using the EPA's PopGrid software for use in BenMAP-CE (EPA 2021). The PopGrid program allocates the 2010 block-level U.S. Census data for the defined air quality grids. When importing the population datasets into BenMAP-CE, the "Use Population Growth Weights" checkbox was checked, so that BenMAP-CE can use the population weights file in forecasting population levels for future years up to

2050. The projected Friant Community Plan and Specific Plan population projections for 2020 and 2031 were added to the population for two grid cells, to ensure that the local population growth is not under-counted.

4.2.3 Analysis Years

Years 2020 and 2031 were selected for the BenMAP-CE runs, which represents the Project's Existing Baseline year prior to start of construction in 2022, and the full build-out operational Future Baseline year 2031. In order to perform air quality modeling for this study, BlueScape obtained files processed from Ramboll, based upon air quality modeling from CARB, including the regional air quality emission inventory year 2020 from the SJVAPCD $PM_{2.5}$ SIP Study. The regional emissions inventory for 2020 was then scaled to 2031 using growth factors. For the 2020 analysis, the highest daily contribution of Project-related emissions for each pollutant was used in the photochemical modeling, from the construction to the full build-out year. Further, the most conservative emissions (in lb/day) for any Project development year from 2022 to 2031 were used in the model.

4.2.4 Baseline Health Incidence Data

This analysis used the health incidence dataset preloaded within BenMAP-CE. This includes the Mortality Incidence dataset for the mortality endpoint group (year 2020 dataset for analysis year 2020, and year 2030 dataset for analysis year 2031), and the Other Incidence dataset for all the morbidity endpoint groups.

Among the baseline health incidence datasets used, the 2020 BenMAP-CE endpoint groups match the Baseline scenario year (2020 for Existing Baseline year). The 2030 BenMAP-CE endpoint groups for 2031 were used for the Future Baseline year 2031. The mortality C-R functions offer datasets in 5-year increments, so the 2030 dataset preceding the 2031 Project year was assumed representative and conservative. From air quality related health effect perspective, since the ambient air quality is generally getting better (i.e., lower air pollutant concentrations) with more stringent regulations and technology advancement over time, the older years' datasets (i.e., using the 2030 mortality dataset for Project year 2031) will likely have greater health incidences; therefore, the results generated by this analysis are expected to be adequately conservative.

4.2.5 Health Endpoints and Health Impact Functions

The EPA-provided health endpoints functions contained in the BenMAP-CE software were used for this analyses. For the same pollutant-health endpoint (like acute respiratory symptoms or asthma exacerbation, for example), BenMAP-CE contains many different functions developed from different epidemiologic studies. This analysis selected the functions that were either studies conducted in California, and/or studies that were conducted for multiple cities and counties in the United States.

More detailed information regarding the BenMAP-CE setup for each model run can be found in the attached BenMAP-CE Audit Trial Reports (Appendix B).

4.3 BenMAP-CE Modeling Results and Results Interpretation

For each of the modeled grid cells, BenMAP-CE generates the health incidence value resulting from the Project's incremental increase in air pollutant concentrations that corresponds with each health endpoint and each C-R function. For many of the health endpoints (e.g., respiratory hospital admissions), the premade setups in BenMAP-CE contain many different C-R functions from different studies. To summarize the regional health incidence estimates, the incidence results were exported into an Access database and summed across all cells of the modeled geographic grid to generate one set of numerical values for each pollutant-health endpoint group combination.

Tables 16 through 23 summarize the BenMAP-CE results of ozone and $PM_{2.5}$ from the Project, for both the Existing Baseline year 2020 and Future Baseline year 2031 and unmitigated and mitigated Project emission inventories. Each table contains the following columns:

- Group – General grouping of health impact outcomes;
- Health Endpoint – Specific health endpoint in the Health Endpoint Group. Numbers in braces represent the age range for the specific health endpoints, and for specific health endpoints without a specified age range, the age range is for 0 to 99 years old;
- Mean – the mean number of health incidences estimated to occur due to Project-related emissions above the value reported in the column Baseline Incidence (# per year);
- 95% Confidence Interval – In statistics, a confidence interval (CI) provides a range of health incidences for which the true health incidence resides. The 95% CI is a common value reported by researchers. The interpretation of the 95% CI means that a researcher is 95% confident that the true health incidence falls within the associated range of health incidences;
- Baseline Incidence (# per year) – The BenMAP-CE baseline health incidences for the Health Endpoint; and
- Incremental Incidence / Existing Baseline Incidence (%) – The percent increase of health incidences above the baseline calculated as the "Mean" divided by the "Baseline Incidence (# per year)" times 100.

As the data shown in these tables demonstrate, the maximum regional health impacts associated with the emissions of ozone precursors and corresponding formation of ozone in the atmosphere associated with the construction and operation of the Project included incidences of respiratory-related hospital admissions (0.0047 maximum

incidences/year), mortality (0.012 maximum incidences/year), and asthma-related emergency room visits (0.0765 maximum incidences/year) for all studied age groups combined. The Project's incremental health incidences for ozone are less than 0.0003% for any of the baseline number of health endpoint occurrences. The baseline is the actual health effect occurrences measured in the regional population without the emissions produced by the Project.

The maximum regional health impacts associated with emissions of $PM_{2.5}$ resulting from the construction and operation of the Project included incidences of acute myocardial infarction (0.0254 maximum incidences/year), mortality (0.35 maximum incidences/year), hospital admissions (0.114 maximum incidences/year) and asthma-related emergency room visits (0.20 maximum incidences/year) for all studied age groups combined. The Project's incremental health incidences for $PM_{2.5}$ are less than 0.00054% for any of the baseline number of health endpoint occurrences. The baseline is the actual health effect occurrences measured in the regional population without the emissions produced by the Project.

The very small Project-related changes in health endpoint occurrences, relative to the substantially larger number of baseline health endpoint occurrences, demonstrates that the Project provides a negligible contribution to regional health impacts; therefore, Fresno County can consider the Project-related health impacts to not be meaningful. In other words, the Project impact is not likely discernible as different than zero, as discussed below.

The health incidences estimated for modeled Project changes in ozone and $PM_{2.5}$ concentrations are calculated within a range that is called the 95% confidence interval. The 95% confidence interval is a standard metric for statistical significance of an estimated unknown parameter from the observed data. It essentially means that 95% of the estimates of the health impact related to a change in concentration (estimated by 4 km grid cell) will include the most likely value within the distribution, but 5% won't (i.e., there is a 1-in-20 chance that the reported confidence intervals in Tables 16-23 do not include the true values). The health incidence values estimated for Tables 16-24 are the composite of values calculated for all the 4 km grid cells included within the modeling domain.

Based upon the wide range of Project incremental health incidence values calculated for the 95% CI shown in the tables, the reported positive mean Project incremental health incidence values are of high statistical uncertainty. In cases where there are negative health incidence values within the 95% confidence interval, meaning the interval includes zero, the result is highly uncertain and there is very low confidence that the result is statistically different than zero. In cases where the health incidence values within the 95% confidence interval are greater than zero but less than one, the values are also a negligible fraction of the background incidence values. In both cases, it is not expected that the Project will result in any meaningful health impact greater than zero that can be established with any certainty.

TABLE 16
BENMAP-CE MODELING RESULTS FOR MAXIMUM DAILY 8-HOUR (MDA8) AVERAGE OZONE, EXISTNG BASELINE YEAR 2020, UNMITIGATED

Human Health Endpoints		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Acute Respiratory Symptoms	Minor Restricted Activity Days	10.959	4.5235 - 17.3852	28,359,911	0.000039%
Asthma Exacerbation	One or More Symptoms	1.6894	-8.6578 - 12.0214	12,205,190	0.000014%
Emergency Room Visits -Respiratory	Emergency Room Visits Asthma [0-17]	0.0354	0.0064 - 0.0645	14,828	0.000239%
Emergency Room Visits -Respiratory	Emergency Room Visits Asthma [18-99]	0.0239	0.0066 - 0.0412	20,037	0.000119%
Hospital Admissions Respiratory	HA All Respiratory	0.0027	-0.0006 - 0.0061	24,743	0.000011%
Mortality	All Cause	0.0076	0.0036 - 0.0115	51,215	0.000015%
	Cardiopulmonary	0.0027	0.001 - 0.0044	17,114	0.000016%
	Non-Accidental	0.0019	-0.0005 - 0.0043	38,717	0.000005%
	Respiratory	0.0036	0.0012 - 0.006	4,213	0.000085%
School Loss Days	All Cause	9.0324	-1.0498 - 19.0997	7,988,290	0.000113%

TABLE 17
BENMAP-CE MODELING RESUTS FOR MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, EXISTING BASELINE YEAR 2020, MITIGATED

Human Health Endpoints		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Acute Respiratory Symptoms	Minor Restricted Activity Days	10.301	4.252 - 16.3417	28,359,911	0.000036%
Asthma Exacerbation	One or More Symptoms	1.5930	-8.1641 - 11.3359	12,205,190	0.000013%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [0-17]	0.0322	0.0058 - 0.0585	14,828	0.000217%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [18-99]	0.0225	0.0062 - 0.0388	20,037	0.000112%
Hospital Admissions Respiratory	HA All Respiratory	0.0026	-0.0006 - 0.0057	24,743	0.000010%
Mortality	All Cause	0.0070	0.0034 - 0.0107	51,215	0.000014%
	Cardiopulmonary	0.0025	0.001 - 0.0041	17,114	0.000015%
	Non-Accidental	0.0017	-0.0005 - 0.004	38,717	0.000005%
	Respiratory	0.0033	0.0011 - 0.0055	4,213	0.000079%
School Loss Days	All Cause	8.5184	-0.99 - 18.0129	7,988,290	0.000107%

TABLE 18
BENMAP-CE MODELING RESULTS FOR MAXIMUM DAILY 8-HOUR (MDA8) AVERAGE OZONE, FUTURE BASELINE YEAR 2031, UNMITIGATED

Human Health Endpoints		Aggregated Regional Results			
		Project Incremental Incidence (# per year)		Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval		
Acute Respiratory Symptoms	Minor Restricted Activity Days	14.5060	5.9875 - 23.0121	30,640,682	0.000047%
Asthma Exacerbation	One or More Symptoms	2.4333	-12.4705 - 17.3154	13,815,762	0.000018%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [0-17]	0.0427	0.0077 - 0.0777	16,541	0.000258%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [18-99]	0.0338	0.0093 - 0.0582	22,666	0.000149%
Hospital Admissions Respiratory	HA All Respiratory	0.0047	-0.0011 - 0.0104	34,277	0.000014%
Mortality	All Cause	0.0120	0.0057 - 0.0182	67,316	0.000018%
	Cardiopulmonary	0.0045	0.0017 - 0.0073	23,263	0.000019%
	Non-Accidental	0.0030	-0.0008 - 0.0068	51,566	0.000006%
	Respiratory	0.0058	0.002 - 0.0097	5,750	0.000101%
School Loss Days	All Cause	13.0657	-1.5185 - 27.6286	9,097,769	0.000144%

TABLE 19
BENMAP-CE MODELING RESULTS FOR MAXIMUM DAILY 8-HOUR AVERAGE (MDA8) OZONE, FUTURE BASELINE YEAR 2031, MITIGATED

Human Health Endpoints		Aggregated Regional Results			Incremental Incidence / Existing Baseline Incidence (%)
		Project Incremental Incidence (# per year)		Baseline Incidence (# per year)	
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval		
Acute Respiratory Symptoms	Minor Restricted Activity Days	13.7277	5.6663 - 21.7775	30,640,682	0.000045%
Asthma Exacerbation	One or More Symptoms	2.3068	-11.822 - 16.4149	13,815,762	0.000017%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [0-17]	0.0393	0.0071 - 0.0714	16,541	0.000237%
Emergency Room Visits - Respiratory	Emergency Room Visits Asthma [18-99]	0.0320	0.0088 - 0.0551	22,666	0.000141%
Hospital Admissions Respiratory	HA All Respiratory	0.0044	-0.001 - 0.0098	34,277	0.000013%
Mortality	All Cause	0.0112	0.0053 - 0.0171	67,316	0.000017%
	Cardiopulmonary	0.0042	0.0016 - 0.0068	23,263	0.000018%
	Non-Accidental	0.0028	-0.0008 - 0.0064	51,566	0.000005%
	Respiratory	0.0055	0.0018 - 0.0091	5,750	0.000095%
School Loss Days	All Cause	12.3866	-1.4396 - 26.1926	9,097,769	0.000136%

TABLE 20
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, EXISTING BASELINE YEAR 2020, UNMITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)		Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval		
Acute Myocardial Infarction	Acute Myocardial Infarction Nonfatal [18-24]	0.00001	0.000006 - 0.000018	9	0.000142%
	Acute Myocardial Infarction Nonfatal [25-44]	0.00085	0.000409 - 0.001281	462	0.000183%
	Acute Myocardial Infarction Nonfatal [45-54]	0.00179	0.000866 - 0.002715	1,047	0.000171%
	Acute Myocardial Infarction Nonfatal [55-64]	0.00396	0.001916 - 0.006004	2,152	0.000184%
	Acute Myocardial Infarction Nonfatal [65-99]	0.01032	0.004989 - 0.015636	5,353	0.000193%
Emergency Room Visits - Respiratory	Asthma	0.14501	0.038122 - 0.251735	34,865	0.000416%
Hospital Admissions	All Cardiovascular (less Myocardial Infarctions)	0.01930	0.014227 - 0.024364	28,261	0.000068%
	All Respiratory	0.03885	0.022404 - 0.055276	24,743	0.000157%
	Asthma	0.01182	0.004526 - 0.019101	4,381	0.000270%
Mortality	All Cause	0.21796	0.147276 - 0.288536	49,417	0.000441%

TABLE 21
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, EXISTING BASELINE YEAR 2020, MITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			Incremental Incidence / Existing Baseline Incidence (%)
		Project Incremental Incidence (# per year)		Baseline Incidence (# per year)	
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval		
Acute Myocardial Infarction	Acute Myocardial Infarction Nonfatal [18-24]	0.00001	0.000005 - 0.000017	9	0.000127%
	Acute Myocardial Infarction Nonfatal [25-44]	0.00075	0.000365 - 0.001144	462	0.000163%
	Acute Myocardial Infarction Nonfatal [45-54]	0.00160	0.000774 - 0.002426	1,047	0.000153%
	Acute Myocardial Infarction Nonfatal [55-64]	0.00354	0.001711 - 0.005362	2,152	0.000164%
	Acute Myocardial Infarction Nonfatal [65-99]	0.00918	0.004441 - 0.013917	5,353	0.000172%
Emergency Room Visits - Respiratory	Asthma	0.12804	0.033662 - 0.222282	34,865	0.000367%
Hospital Admissions	All Cardiovascular (less Myocardial Infarctions)	0.01718	0.012668 - 0.021695	28,261	0.000061%
	All Respiratory	0.03461	0.019959 - 0.049244	24,743	0.000140%

TABLE 21
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, EXISTING BASELINE YEAR 2020, MITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
	Asthma	0.01039	0.003977 - 0.016787	4,381	0.000237%
Mortality	All Cause	0.19398	0.131076 - 0.256798	49,417	0.000393%

TABLE 22
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, FUTURE BASELINE YEAR 2031, UNMITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Acute Myocardial Infarction	Acute Myocardial Infarction Nonfatal [18-24]	0.00002	0.000008 - 0.000024	9	0.000174%
	Acute Myocardial Infarction Nonfatal [25-44]	0.00120	0.00058 - 0.001817	548	0.000219%
	Acute Myocardial Infarction Nonfatal [45-54]	0.00259	0.001254 - 0.003931	1,187	0.000218%
	Acute Myocardial	0.00448	0.002165 - 0.006787	2,072	0.000216%

TABLE 22
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, FUTURE BASELINE YEAR 2031, UNMITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
	Infarction Nonfatal [55-64]				
	Acute Myocardial Infarction Nonfatal [65-99]	0.01711	0.008276 - 0.025939	7,348	0.000233%
Emergency Room Visits - Respiratory	Asthma	0.20129	0.05292 - 0.34944	39,207	0.000513%
Hospital Admissions	All Cardiovascular (less Myocardial Infarctions)	0.03239	0.023878 - 0.040894	39,203	0.000083%
	All Respiratory	0.06536	0.037689 - 0.092987	34,277	0.000191%
	Asthma	0.01597	0.006114 - 0.025805	4,762	0.000335%
Mortality	All Cause	0.35149	0.237503 - 0.465302	65,401	0.000537%

TABLE 23
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, FUTURE BASELINE YEAR 2031, MITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Acute Myocardial Infarction	Acute Myocardial Infarction Nonfatal [18-24]	0.00001	0.000007 - 0.000022	9	0.000157%
	Acute Myocardial Infarction Nonfatal [25-44]	0.00108	0.000523 - 0.001639	548	0.000197%
	Acute Myocardial Infarction Nonfatal [45-54]	0.00234	0.001131 - 0.003546	1,187	0.000197%
	Acute Myocardial Infarction Nonfatal [55-64]	0.00404	0.001955 - 0.006126	2,072	0.000195%
	Acute Myocardial Infarction Nonfatal [65-99]	0.01539	0.007441 - 0.023321	7,348	0.000209%
Emergency Room Visits - Respiratory	Asthma	0.17935	0.047151 - 0.31135	39,207	0.000457%

TABLE 23
BENMAP-CE MODELING RESULTS FOR MAXIMUM ANNUAL 24-HOUR AVERAGE $PM_{2.5}$, FUTURE BASELINE YEAR 2031, MITIGATED

Human Health Endpoints		Fine Modeling Grid			
		Aggregated Regional Results			
		Project Incremental Incidence (# per year)			
Health Endpoint Group	Health Endpoint	Mean	95% Confidence Interval	Baseline Incidence (# per year)	Incremental Incidence / Existing Baseline Incidence (%)
Hospital Admissions	All Cardiovascular (less Myocardial Infarctions)	0.02913	0.021476 - 0.036781	39,203	0.000074%
	All Respiratory	0.05879	0.033903 - 0.083645	34,277	0.000172%
	Asthma	0.01415	0.005419 - 0.02287	4,762	0.000297%
Mortality	All Cause	0.31574	0.213348 - 0.41798	65,401	0.000483%

5.0 UNCERTAINTY IN PHOTOCHEMICAL MODELING AND HEALTH IMPACT ANALYSIS

Air quality impact analysis and health impact studies and the results, as for any technical or scientific study, are subject to "uncertainty." Uncertainty means that there is a range of possible values for the inputs to the modeling studies in which exist the true values, and therefore, there is uncertainty as well in the modeling study outputs. Conclusions from these studies should be made with consideration of the uncertainty. Section 5.1 focuses on uncertainty related to photochemical modeling for air concentration results. Section 5.2 discusses the uncertainty involved in relating concentration data to specific health impact results.

5.1 Uncertainty in Photochemical Modeling

Uncertainty addresses the potential variability in photochemical modeling concentration results. Variability in a value is due to the differences in the value among different members of a population (e.g., ozone or $PM_{2.5}$ measurements from identical instruments over a common area, precipitation measured from identical rain gauges over a common area). Variability represents heterogeneity in a well-characterized population and is usually not reducible through further measurement.

Uncertainty in a value arises due to lack of knowledge regarding the true value of a quantity for a given member of a population (e.g., an emissions factor used to characterize emissions from automobiles, a speciation factor to split total organic gases into its constituent chemical species). Uncertainty represents lack of perfect knowledge about poorly characterized phenomena and is sometimes reducible through further measurement.

There has been much research on sensitivities and uncertainties regarding the evaluation of environmental models (Hanna et. al. 2001, Biswas and Rao 2001, Baker and Bash 2012). It is widely recognized that full and perfect validation of a chemical transport model against real, natural systems cannot be accomplished by computer modeling systems, because natural systems are never closed, and results are always unique. Thus, a model can be evaluated by comparisons with observations, but it can never be fully validated against natural systems because all possible scenarios cannot be anticipated nor included in modeling systems.

A computational photochemical model such as CAMx is used to describe through mathematical representation, the complex and dynamic physical and chemical processes occurring in the atmosphere, in order to calculate regional air pollutant concentration impacts due to anthropogenic and biogenic emissions (Leary 1976). As an attempt to mathematically represent physical reality, CAMx modeling is subject to uncertainty that can cause error in model outputs. These uncertainties must be understood to properly validate and interpret CAMx model results.

Uncertainty and error in CAMx predictions arise due to uncertainty and error in the data inputs to CAMx (e.g., emissions estimates, boundary conditions, meteorological predictions, chemistry, grid resolution, and model formulation) as well as the model formulation itself (Sathya et. al. 2000, Fine et. al. 2003).

Estimates of emissions are typically the most uncertain inputs to a photochemical model (NRC 1991). Emissions estimates include those from on- and off-road mobile sources (e.g., cars, trucks, agricultural equipment such as combines and tractors, airplanes and ocean-going vessels, lawnmowers), biogenics, stationary sources (e.g., power plants, large dairies), and area sources (e.g., restaurant charbroiling, gasoline stations), among others. A vast amount of data is necessary to estimate emissions from these sources (e.g., fuel consumption, number of lawnmowers, number of cows) utilizing other models (e.g., the Biogenic Emissions Inventory System (EPA 2018c), SMOKE (CMAS 2018) and tools. Given the suspect quality of some of these data, it is not surprising that there are large uncertainties in the resulting emissions estimates that are input into CAMx.

Observational data or attendant climate model predictions that are used to initialize the meteorological and photochemical models, provide boundary conditions, or evaluate model performance are uncertain due to limited characterization of their spatial and temporal variability. Observational data are variable and uncertain due to monitoring equipment, user error, monitoring network design, and issues with proper instrument calibration. Some pollutant species are easier to measure than others.

For example, measurements of NO_x may actually capture NO_y, which includes NO_x plus products of NO_x oxidation (CARB 1992).

WRF too is a mathematical representation of the atmospheric processes that drive weather; thus, it is also subject to uncertainties in model formulation and model inputs. The meteorological model relies on observations typically lacking in the spatial and temporal detail needed to initialize meteorological fields. The application of four-dimensional data assimilation dampens the temporal growth in errors by causing model results to conform to observations at regular intervals (Stauffer and Seaman 1990). Specifically, the three components of wind velocity calculated as a function of time are nudged toward measured values, and in so doing, reduce the amount of observational data remaining for performance evaluation. Thus, the WRF meteorological predictions that are input into CAMx are subject to uncertainty.

A complete understanding of atmospheric chemistry is unknown. The atmosphere has hundreds to thousands of chemical species that participate in thousands of chemical reactions. How fast these reactions take place and the products of these reactions are still not well known (EPRI 2000). Even if known completely, atmospheric chemistry cannot be represented in its entirety because it would impose excessive computational demands (Russell and Dennis 2000).

Additional uncertainty can be introduced due to the choice of grid resolution. It is well known that grid resolution can impact model predictions (Gillani and Pleim 1996). Further, studies have shown that the use of air quality model predictions at various grid resolutions can impact predicted health outcomes (Thompson and Noelle 2012).

Uncertainties associated with model formulation (e.g., representing atmospheric turbulence, processes that remove chemicals from the atmosphere, representation of aerosol formation and portioning to aerosol sizes [$PM_{2.5}$, PM_{10}], and the numerical techniques used to solve the mathematical equations) in the models described above can cause generally incomplete representations. Simplified representations are necessary when knowledge is incomplete, or when a more precise formulation excessively increases computational requirements. Further, there typically exists more than one formulation to represent a process; thus, choosing one inevitably means accepting some uncertainties over another (NRC 1991, Barchet et. al. 1994).

5.2 Uncertainty in Health Impact Analysis

As many regional-scale health impact assessments and this project-level analysis demonstrate, performing a quantitative HIA is complex and difficult, but it is possible to perform such analyses. Nevertheless, the limits of such analyses should be noted. The BenMAP-CE model outputs provide precise values. It would be inappropriate, however, to assume that these values, though seemingly precise, give an accurate understanding of the project's actual impacts. The imprecision of such analyses is inherent and unavoidable. Uncertainties associated with air quality modeling have been discussed above. Air quality models, including CAMx and BenMAP-CE, rely on assumptions that may not fully or accurately capture the complexity or dynamism of the physical world. Each step in the modeling process, and each assumption

incorporated into each model, adds a degree of uncertainty to the reported results. These inputs include air pollutant emission estimates, ambient air concentration modeling, and health impact calculations using various health impact functions.

The combination and compounding of the uncertainties from each step of the modeling analysis, in the context of the very small increments of change that are predicted associated with a single project, could result in large margins of error for the overall modeled outcomes. That does not necessarily mean the modeled results are invalid or meaningless. Rather, it means that one should not have undue confidence in the seeming precision of the reported outcome. In other words, the modeled results may be valid, but they should not be misinterpreted as an exact calculation of something as complex as criteria air pollutant dispersion modeling, or as correlating a given level of emissions with specific health effects. This is particularly true where, as in this study, regional models have been adapted for use at the Project-level. In this case, the calculated impact may be smaller than the reasonable margin of errors of such analyses.

Specific to the application of the BenMAP-CE model itself, although it can be a powerful tool, it has the following limitations which impact the precision of the generated results. These are especially relevant when applying this tool to a project-level analysis such as this study.

- In its current form, BenMAP–CE cannot conduct source-specific modeling without inputs from other modeling programs, such as CAMx. The differences among the mathematical and/or statistical algorithms used by these additional air quality modeling programs and those used by BenMAP-CE to process the air quality inputs and then correlate these inputs to specific health effects introduces layers of uncertainty into the generated results. In addition, the air pollutant concentrations that BenMAP–CE uses represent overall ambient concentrations of ozone and $PM_{2.5}$. Due to the fact that the estimated emissions from the Project are a very small fraction of the base case regional emission inventory, the incremental increase in concentrations and health incidences associated with the Project, as shown in this analysis, are very small, with very low confidence that the results represent any health impacts greater than zero. Therefore, the small incremental increase in concentrations generated by the Project in the context of regional-scale ambient air modeling should not be taken as a precise or meaningful representation of the Project-specific contributions.

- There are a number of conservative assumptions built into the analysis, which include but are not limited to the following:

    - Maximum annual average emissions were used in the modeling and were assumed to occur for the same year for each pollutant, as opposed to considering the potential variabilities in emissions from year to year; and

- Emissions from activities currently occurring on the project site were not removed from the model (although emissions from project-related VMT are net of existing mobile-source emissions in the traffic study area).

- The health impact functions that BenMAP-CE uses are based on findings from population-based epidemiological studies that develop statistical relationships between human health effects and air pollution exposures. Thus, each cause-and-effect relationship used by BenMAP-CE has some inherent uncertainty due to important limitations associated with the epidemiological studies including but not limited to (Sacks et. al. 2018):

  - The absence in the analysis of any linkage between predicted changes in ozone and $PM_{2.5}$ concentrations associated with project operations and any specific *individual* health impact; instead, the analysis uses studies that report *correlations* between health effects and exposure to ozone and $PM_{2.5}$, to estimate potential effects on the population in the modeling domain;

  - Difficulty in determining from epidemiological studies whether health effects are caused from exposure to the air pollutant of interest, or from other factors such as weather, other pollutants, or life style factors like smoking and diet;

  - Inconsistencies across different epidemiological studies regarding the cause-and-effect relationship for the same pollutant and health endpoint combination, as demonstrated by the multiple health impact functions preloaded in BenMAP-CE for the same pollutant and health endpoint combinations;

  - Limitations in application of concentration-response functions based on epidemiological studies. For example, estimates of all-cause mortality impacts from $PM_{2.5}$ are based on a single epidemiological study that found an association between $PM_{2.5}$ concentrations and mortality. Similar studies suggest that such an association exists, but uncertainty remains regarding a clear causal link. This uncertainty stems from the limitations of epidemiological studies, such as inadequate exposure estimates and the inability to control for many factors that could explain the association between $PM_{2.5}$ and mortality, such as lifestyle factors like smoking or exposures to other air pollutants;

  - The potential for overstating the overall impacts, since, for both the $PM_{2.5}$ and ozone health effects calculated, each pollutant may confound the other and both air pollutants could contribute to the health effect outcomes evaluated; and

  - The presumption in the estimate of health effects that impacts seen at large concentration differences can be linearly scaled down to small concentration differences, with no consideration of the potential thresholds

below which health effects may not occur. This method of linearly scaling impacts is broadly accepted for use in regulatory evaluations and is considered to be health protective.

- There is inherent uncertainty in the reporting of health effects. For example, asthma exacerbations may be reported as other conditions that fall under another endpoint group. This uncertainty in how health conditions are reported or categorized under various health studies not only increases the difficulty and uncertainty in the development of cause-and-effect relationships, but also increases the uncertainty of the reported baseline health incidence data.

- The estimated health impact by BenMAP-CE is based on people's assumed exposures to outdoor ambient air concentrations; however, these concentration values may be very different from the actual exposures that people experience. For example, ozone and $PM_{2.5}$ exposures may be significantly lower for those who spend much of their day indoors.

6.0 CONCLUSIONS

This Health Impact Analysis (HIA) reviewed the potential regional impacts from increased emissions due to the Friant Ranch Project, including the Community Plan and Specific Plan developments. The study included construction and operational emissions of the ozone precursors NO_x and ROG (or VOC, as a subset of TOG) and particulate matter (PM_{10} and $PM_{2.5}$). The HIA reviewed the Project's potential regional ozone and $PM_{2.5}$ concentration impacts, and specific health impacts, above expected baseline conditions.

Existing Baseline year and Future Baseline year (2020 and 2031) regional air quality modeling scenario databases were simulated using the CAMx modeling system. CAMx was used to apportion pollutant emission increases to Project emissions, including unmitigated and mitigated scenarios. The CAMx modeling estimated that the Project's emissions will increase the regional maximum daily 8-hour (MDA8) average ozone concentration by a maximum of 0.013 ppbv for the 2031 unmitigated scenario. Thus, the ozone concentration changes above baseline conditions for all modeled scenarios are expected to be less than 1.3% of the 1 ppb Significant Impact Level (SIL). The ozone concentration changes due to the Friant Ranch Project can be considered by Fresno County to contribute little to regional ozone formation, such that the specific health impacts due to the Project-related ozone concentration changes are not expected to be meaningful.

The maximum regional annual 24-hour average $PM_{2.5}$ concentration change due to the Project was estimated to be 0.058 $\mu g/m^3$ for the 2031 unmitigated scenario. The $PM_{2.5}$ concentration changes above baseline conditions for all modeled scenarios are expected to be less than 29% of the 0.2 $\mu g/m^3$ SIL. Thus, the changes in emissions

due to the Friant Ranch Project can be considered by Fresno County to contribute little to regional $PM_{2.5}$ concentrations, such that the specific health impacts due to the $PM_{2.5}$ concentration changes are not expected to be meaningful.

While the CAMx modeling results show that ozone and $PM_{2.5}$ concentration impacts from the Project above baseline conditions are not expected to be meaningful, BlueScape completed specific health impact modeling. The health impact modeling provides additional information that may be useful to Fresno County and the public, and is intended to meet the evidentiary requirements stated the Friant Ranch Case. The specific health impacts for these pollutants were estimated using the BenMAP-CE health assessment model. The ozone and $PM_{2.5}$ concentration changes above baseline modeled by CAMx were converted to effects (or incidences) on various health endpoints including premature mortality, hospitalizations, and emergency room visits, and others, and then compared to the "background health incidence." The background health incidence is the actual incidence of health effects as measured in the local population in the absence of additional emissions from the Project.

The results of the BenMAP-CE health incidence calculations for the Friant Ranch Project are shown in Section 4.3 of this report. For example, the analysis shows that for ozone-related health endpoints for the 2031 Project unmitigated scenario, asthma-related emergency room visits are: incidences/year = 0.0338 for adults ages 18 to 99, and incidences/year = 0.0427 for children ages 0 to 17. For the $PM_{2.5}$-related health endpoints, for the Project 2031 unmitigated scenario, the health effect on mortality is: incidences/year = 0.35.

When taken into context, the Project-related change in health incidences/year is very small relative to background health incidences. Using the example provided, the largest Project-related ozone health incidence calculated for any scenario for asthma related emergency room visits by children age 0-17 represents 0.00026% of the total of all regional emergency room visits due to asthma. The largest Project-related $PM_{2.5}$ health incidence for mortality calculated for any scenario represents 0.00054% of the total of all regional deaths. As the health incidence values estimated for Friant Ranch Project emissions are less than one, and a negligible fraction of the background incidence values, it is not expected that the Project will result in any meaningful health impact greater than zero, that can be established with any certainty.

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APPENDIX A

CAMx Modeling Input and Output (list of electronic files)

The input and output files used and generated by the CAMx models are detailed in the following table.

NOTE: An asterisk (*) indicates a wildcard, meant to indicate one or more files following that file naming pattern. Most filesets in this list contain one file per day for an entire year (modeled or meteorological).

TABLE A-1
MODELING INPUT AND OUTPUT FILES

Filename	Description
Input files	
input/camx/bcon/bc_gid555_vint.2013001.bin … input/camx/bcon/bc_gid555_vint.2013365.bin	CAMx boundary condition files. One file per day.
input/camx/icon/ic.*.const.bin	CAMx initial condition files. Monthly files.
input/camx/tuv/tuv.CEQA.FRanch.do_SAPRC07.20130101 … input/camx/tuv/tuv.CEQA.FRanch.do_SAPRC07.20131231	CAMx photolysis input files. One file per day.
input/camx/o3map/o3map.CEQA.FRanch.4km.2013001.txt … input/camx/o3map/o3map.CEQA.FRanch.4km.2013365.txt	CAMx ozone map input files. One file per day.
Input/camx/chem/CAMx6.5.chemparam.SAPRC07_CF_SOAP_ISORROPIA	CAMx SAPRC 2007 chemical parametrization file
input/camx/met/ camx.lu.4km.FRanch.bin	CAMx static surface geophysical parameters (land use, terrain).
input/camx/met/camx.3d.4km.20130101.FRanch.bin … input/camx/met/camx.3d.4km.20131231.FRanch.bin	CAMx meteorological 3D data files. One file per day.
input/camx/met/camx.2d.4km.20130101.FRanch.bin … input/camx/met/camx.2d.4km.20131231.FRanch.bin	CAMx meteorological 2D surface data files. One file per day.
input/camx/met/camx.kvpatch.YSU.OB70.4km.20130101.FRanch.bin … input/camx/met/camx.kvpatch.YSU.OB70.4km.20131231.FRanch.bin	CAMx meteorological vertical diffusivity data files. One file per day.
input/camx/met/camx.3d.4km.20130101.FRanch.bin … input/camx/met/camx.3d.4km.20131231.FRanch.bin	CAMx meteorological cloud/rain data files. One file per day.

TABLE A-1
MODELING INPUT AND OUTPUT FILES

Filename	Description
input/camx/met/camx.cr.2016010100 … input/camx/met/camx.cr.2016123100	CAMx meteorological cloud/rain data files. One file per day.
input/camx/emiss/2020/point/ point.camx.ceqa_FRanch.gid555.20130101.bin … input/camx/emiss/2020/point/ point.camx.ceqa_FRanch.gid555.20131231.bin	CAMx point source emissions files. All scenarios 2020. One file per day.
input/camx/emiss/2031/point/point.bluescape.20130101.2031.bin … input/camx/emiss/2031/point/point.bluescape.20130101.2031.bin	CAMx point source emissions files. All scenarios 2031. One file per day.
input/camx/emiss/2020/area/base/ camx_ar.ceqa_FRanch.wProj.2020proj.4km.20130101.bin … input/camx/emiss/2020/area/base/ camx_ar.ceqa_FRanch.wProj.2020proj.4km.20131231.bin	CAMx 3d gridded emissions files. Base scenario 2020. One file per day.
input/camx/emiss/2031/area/base/ area.bluescape.20130101.2031.base.bin … input/camx/emiss/2031/area/base/ area.bluescape.20131231.2031.base.bin	CAMx 3d gridded emissions files. Base scenario 2031. One file per day.
input/camx/emiss/2020/area/proj/ area.bluescape.20130101.2020.proj.bin … input/camx/emiss/2020/area/proj/ area.bluescape.20131231.2020.proj.bin	CAMx 3d gridded emissions files. Unmitigated project scenario 2020. One file per day.
input/camx/emiss/2020/area/pmit/ area.bluescape.20130101.2020.pmit.bin … input/camx/emiss/2020/area/pmit/ area.bluescape.20131231.2020.pmit.bin	CAMx 3d gridded emissions files. Mitigated project scenario 2020. One file per day.
input/camx/emiss/2031/area/proj/ area.bluescape.20130101.2031.proj.bin … input/camx/emiss/2031/area/proj/ area.bluescape.20131231.2031.proj.bin	CAMx 3d gridded emissions files. Unmitigated project scenario 2031. One file per day.
input/camx/emiss/2031/area/pmit/ area.bluescape.20130101.2031.pmit.bin … input/camx/emiss/2031/area/pmit/ area.bluescape.20131231.2031.pmit.bin	CAMx 3d gridded emissions files. Mitigated project scenario 2031. One file per day.
Output files	
output/all/2020/base/ camx65_SAPRC07.FRanch.4km_SA.2020.base.20130101.avrg.grd01.nc … output/all/2020/base/ camx65_SAPRC07.FRanch.4km_SA.2020.base.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Base scenario 2020. One file per day.
output/all/2031/base/ camx65_SAPRC07.FRanch.4km_SA.2031.base.20130101.avrg.grd01.nc … output/all/2031/base/ camx65_SAPRC07.FRanch.4km_SA.2031.base.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Base scenario 2031. One file per day.

TABLE A-1
MODELING INPUT AND OUTPUT FILES

Filename	Description
output/all/2020/proj/ camx65_SAPRC07.FRanch.4km_SA.2020.proj.20130101.avrg.grd01.nc … output/all/2020/proj/ camx65_SAPRC07.FRanch.4km_SA.2020.proj.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Unmitigated project scenario 2020. One file per day.
output/all/2020/pmit/ camx65_SAPRC07.FRanch.4km_SA.2020.pmit.20130101.avrg.grd01.nc … output/all/2020/pmit/ camx65_SAPRC07.FRanch.4km_SA.2020.pmit.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Mitigated project scenario 2020. One file per day.
output/all/2031/proj/ camx65_SAPRC07.FRanch.4km_SA.2031.proj.20130101.avrg.grd01.nc … output/all/2031/proj/ camx65_SAPRC07.FRanch.4km_SA.2031.proj.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Unmitigated project scenario 2031. One file per day.
output/all/2031/pmit/ camx65_SAPRC07.FRanch.4km_SA.2031.pmit.20130101.avrg.grd01.nc … output/all/2031/pmit/ camx65_SAPRC07.FRanch.4km_SA.2031.pmit.20131231.avrg.grd01.nc	CAMx output files. NetCDF format. Mitigated project scenario 2031. One file per day.

APPENDIX B
BenMAP-CE Audit Trial Reports

ATTACHMENT B-1

BENMAP-CE AUDIT TRAIL REPORT
O3.2020.PROJ.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 02:59:08
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2020
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-15 07:28:36
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2020.proj.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-15 07:29:27
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2020.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly

Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Start age:5
End age:17
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None

Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere
Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Start age:6
End age:18
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Prevalence dataset:Prevalence (2008)
Variable dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:

C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:17
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Start age:18
End age:64
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Baseline functional form:A*POP
Incidence dataset:
Prevalence dataset:
Variable dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>

<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:18
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Start age:0
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65

Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>
<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:0

End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.9>
</Selected.health.impact.functions>
<Log.And.Message>
Processing complete. HIF processing time: 0 hours 23 minutes 14 seconds.
</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>

Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Valuation.Aggregation>
<Incidence.Pooling.And.Aggregation.>
<MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Year:2005
Location:US & non-US
Other pollutants:
Geographic area:Everywhere
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:0
End age:99
Baseline functional form:
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Year:2005
Location:19 US cities
Other pollutants:
Geographic area:Everywhere
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:0
End age:99

Baseline functional form:
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Year:2009
Location:98 US cities
Other pollutants:PM10
Geographic area:Everywhere
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:0
End age:99
Baseline functional form:PM10
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Year:2009
Location:86 urban areas
Other pollutants:PM2.5

Geographic area:Everywhere
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:PM2.5
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality

Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0

NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Mortality>
Mortality
Bell:Pooling Method Type:None
Huang:Pooling Method Type:None
Smith:Pooling Method Type:None
Jerrett:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere

Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Start age:5
End age:17
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.School.Loss.Days>
School Loss Days
</Valuation.Pooling.Window.Name.School.Loss.Days>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Start age:6
End age:18
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Asthma.Exacerbation>
Asthma Exacerbation
</Valuation.Pooling.Window.Name.Asthma.Exacerbation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere

Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:0
End age:17
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma

Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:
End age:17
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:

C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
Mar:Pooling Method Type:None
Mar:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Start age:18
End age:64
Baseline functional form:A*POP
Incidence dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Acute Respiratory Symptoms
</Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-2

BENMAP-CE AUDIT TRAIL REPORT
O3.2020.PMIT.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 02:59:08
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2020
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-15 07:28:36
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2020.pmit.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-15 07:29:27
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2020.base.benmap.csv
<Grid.Definition>
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ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly

Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Start age:5
End age:17
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None

Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere
Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Start age:6
End age:18
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Prevalence dataset:Prevalence (2008)
Variable dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:

C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:17
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Start age:18
End age:64
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Baseline functional form:A*POP
Incidence dataset:
Prevalence dataset:
Variable dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>

<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:18
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Start age:0
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65

Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>
<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:0

End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
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</Selected.health.impact.functions>
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Processing complete. HIF processing time: 0 hours 23 minutes 14 seconds.
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Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
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Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>

Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
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<MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Year:2005
Location:US & non-US
Other pollutants:
Geographic area:Everywhere
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:0
End age:99
Baseline functional form:
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Year:2005
Location:19 US cities
Other pollutants:
Geographic area:Everywhere
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:0
End age:99

Baseline functional form:
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Year:2009
Location:98 US cities
Other pollutants:PM10
Geographic area:Everywhere
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:0
End age:99
Baseline functional form:PM10
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Year:2009
Location:86 urban areas
Other pollutants:PM2.5

Geographic area:Everywhere
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:PM2.5
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality

Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0

NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Mortality>
Mortality
Bell:Pooling Method Type:None
Huang:Pooling Method Type:None
Smith:Pooling Method Type:None
Jerrett:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere

Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Start age:5
End age:17
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
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School Loss Days
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<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Start age:6
End age:18
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Asthma.Exacerbation>
Asthma Exacerbation
</Valuation.Pooling.Window.Name.Asthma.Exacerbation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere

Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:0
End age:17
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma

Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:
End age:17
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:

C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
Mar:Pooling Method Type:None
Mar:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Start age:18
End age:64
Baseline functional form:A*POP
Incidence dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Acute Respiratory Symptoms
</Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-3

BENMAP-CE AUDIT TRAIL REPORT
O3.2031.PROJ.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 04:30:00
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2031
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 04:07:41
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2031.proj.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 04:07:19
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2031.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly

Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Start age:6
End age:18
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None

Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Prevalence dataset:Prevalence (2008)
Variable dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Start age:5
End age:17
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere
Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence

C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:17
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Start age:18
End age:64
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Baseline functional form:A*POP
Incidence dataset:
Prevalence dataset:
Variable dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>

<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:18
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.

Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>
<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental

Start age:0
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
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</Selected.health.impact.functions>
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</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
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ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>

Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Valuation.Aggregation>
<Incidence.Pooling.And.Aggregation.>
<MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Year:2005
Location:US & non-US
Other pollutants:
Geographic area:Everywhere
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:0
End age:99
Baseline functional form:
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Year:2005
Location:19 US cities
Other pollutants:
Geographic area:Everywhere
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:0
End age:99

Baseline functional form:
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Year:2009
Location:98 US cities
Other pollutants:PM10
Geographic area:Everywhere
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:0
End age:99
Baseline functional form:PM10
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Year:2009
Location:86 urban areas
Other pollutants:PM2.5

Geographic area:Everywhere
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:PM2.5
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality

Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0

NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Mortality>
Mortality
Bell:Pooling Method Type:None
Huang:Pooling Method Type:None
Smith:Pooling Method Type:None
Jerrett:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere

Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Start age:5
End age:17
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.School.Loss.Days>
School Loss Days
</Valuation.Pooling.Window.Name.School.Loss.Days>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Start age:6
End age:18
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Asthma.Exacerbation>
Asthma Exacerbation
</Valuation.Pooling.Window.Name.Asthma.Exacerbation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere

Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:0
End age:17
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma

Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:
End age:17
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:

C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
Mar:Pooling Method Type:None
Mar:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Start age:18
End age:64
Baseline functional form:A*POP
Incidence dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Acute Respiratory Symptoms
</Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-4

BENMAP-CE AUDIT TRAIL REPORT
O3.2031.PMIT.TEXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 05:35:30
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2031
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 05:14:11
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2031.pmit.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly
Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 04:07:19
Pollutant:Ozone
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\o3.2031.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:Ozone
Observation Type:Hourly

Season0:May 1-September 30
Metric0:D1HourMax
Metric1:D24HourMean
Metric2:D8HourMax
Metric3:D8HourMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Start age:6
End age:18
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None

Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Prevalence dataset:Prevalence (2008)
Variable dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Start age:5
End age:17
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere
Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence

C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:17
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Start age:18
End age:64
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Baseline functional form:A*POP
Incidence dataset:
Prevalence dataset:
Variable dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>

<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:18
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.

Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>
<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental

Start age:0
End age:99
Race:ALL
Ethnicity:ALL
Gender:ALL
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Prevalence dataset:
Variable dataset:
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.9>
</Selected.health.impact.functions>
<Log.And.Message>
Processing complete. HIF processing time: 0 hours 20 minutes 54 seconds.
</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>

Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Valuation.Aggregation>
<Incidence.Pooling.And.Aggregation.>
<MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Year:2005
Location:US & non-US
Other pollutants:
Geographic area:Everywhere
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:0
End age:99
Baseline functional form:
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Year:2005
Location:19 US cities
Other pollutants:
Geographic area:Everywhere
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:0
End age:99

Baseline functional form:
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Year:2009
Location:98 US cities
Other pollutants:PM10
Geographic area:Everywhere
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:0
End age:99
Baseline functional form:PM10
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Year:2009
Location:86 urban areas
Other pollutants:PM2.5

Geographic area:Everywhere
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:PM2.5
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</MortalityPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Bell et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L., F. Dominici, and J.M. Samet. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. Epidemiology, 2005. 16(4): p. 436-45.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2000)
Beta:0.000795
Beta distribution:Normal
P1Beta:0.00021227
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality

Endpoint:Mortality, Cardiopulmonary
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Huang et al.
Qualifier:Warm season. 8-hour max from 24-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2005
Geographic area:Everywhere
Other pollutants:
Reference:Huang, Y., F. Dominici and M. L. Bell. 2005. Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics. Vol. 16: 547?562.
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.0008125
Beta distribution:Normal
P1Beta:0.000258673
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Non-Accidental
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Smith et al.
Qualifier:Ozone season
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:PM10
Reference:Richard L. Smith, Baowei Xu, and Paul Switzer (2009). Reassessing the relationship between ozone and short-term mortality in U.S. urban communities. Inhalation Toxicology, 2009; 21(S2): 37?65
Start age:
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Mortality Incidence (2020)
Beta:0.000257743
Beta distribution:Normal
P1Beta:0.000167
P2Beta:0
A:0.0027397
NameA:Scalar to convert annual mortality rate to daily rate
B:0
NameB:
C:0

NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:Mean
Author:Jerrett et al.
Qualifier:Metric adjusted using a ratio of 1.14 based on table 2 of Anderson & Bell
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Jerrett, Michael, Burnett, Richard T, Pope, Arden C, et al. 2009. Long-Term Ozone Exposure and Mortality. New England Journal of Medicine.
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2020)
Beta:0.004471161
Beta distribution:Normal
P1Beta:0.001510347
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Mortality>
Mortality
Bell:Pooling Method Type:None
Huang:Pooling Method Type:None
Smith:Pooling Method Type:None
Jerrett:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:School Loss Days
Endpoint:School Loss Days, All Cause
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Gilliland et al.
Qualifier:All year. 8-hour max from 8-hour mean.
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B
Year:2001
Geographic area:Everywhere

Other pollutants:
Reference:Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi
Start age:5
End age:17
Baseline functional form:Incidence*POP*A*B
Incidence dataset:Other Incidence (2000)
Beta:0.007824
Beta distribution:Normal
P1Beta:0.004444898
P2Beta:0
A:0.3929
NameA:Scalar for % of school days in ozone season
B:0.945
NameB:Population of school children at-risk for a new absence
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.School.Loss.Days>
School Loss Days
</Valuation.Pooling.Window.Name.School.Loss.Days>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Asthma Exacerbation
Endpoint:Asthma Exacerbation, One or More Symptoms
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:O'Connor et al.
Qualifier:
Function:(1-EXP(-Beta*DELTAQ))*A*POP*Prevalence
Year:2008
Geographic area:Everywhere
Other pollutants:PM2.5,NO2
Reference:O'Connor, G. T., L. Neas, et al. (2008). "Acute respiratory health effects of air pollution on children with asthma in US inner cities." J Allergy Clin Immunol 121(5): 1133-1139 e1131
Start age:6
End age:18
Baseline functional form:A*POP*Prevalence
Incidence dataset:
Beta:0.000966054
Beta distribution:Normal
P1Beta:0.002991454
P2Beta:0
A:0.207142857
NameA:Incidence rate
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Asthma.Exacerbation>
Asthma Exacerbation
</Valuation.Pooling.Window.Name.Asthma.Exacerbation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Katsouyanni et al.
Qualifier:Summer, 1985-1994, penalized splines, 8 df
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Katsouyanni, K., Samet, J. M., Anderson, H. R., Atkinson, R., Tertre, A. L., Medina, S., et al. (2009). Air Pollution and Health: A European and North American Approach (APHENA): Health Effects Institute.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.000636757
Beta distribution:Normal
P1Beta:0.000400294
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere

Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:0
End age:17
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Year:2009
Location:Seattle,WA
Other pollutants:
Geographic area:Everywhere
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Emergency.Room.Visits.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma

Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Child model, 8 hour maximum metric, 3 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:
End age:17
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.010436002
Beta distribution:Normal
P1Beta:0.004357595
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Mar and Koenig
Qualifier:Adult model, 8 hour maximum metric, 4 day lag, May-September
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., & Koenig, J. Q. (2009). Relationship between visits to emergency departments for asthma and ozone exposure in greater Seattle, Washington. Annals of Allergy, Asthma, & Immunology, 103, 474-479.
Start age:18
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.007696104
Beta distribution:Normal
P1Beta:0.002837389
P2Beta:0
A:0
NameA:
B:0
NameB:

C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
Mar:Pooling Method Type:None
Mar:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Respiratory Symptoms
Endpoint:Minor Restricted Activity Days
Pollutant:Ozone
Metric:D8HourMax
Metric statistic:None
Author:Ostro and Rothschild
Qualifier:8-hour max from 1-hour max.
Function:(1-(1/EXP(Beta*DELTAQ)))*A*POP
Year:1989
Geographic area:Everywhere
Other pollutants:PM2.5
Reference:Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.
Start age:18
End age:64
Baseline functional form:A*POP
Incidence dataset:
Beta:0.002596
Beta distribution:Normal
P1Beta:0.00077644
P2Beta:0
A:0.02137
NameA:mRAD18to64; Ostro and Rothschild, 1989, p 243.
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Acute Respiratory Symptoms
</Valuation.Pooling.Window.Name.Acute.Respiratory.Symptoms>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-5

BENMAP-CE AUDIT TRAIL REPORT
PM25.2020.PROJ.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 09:06:49
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2020
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 08:43:47
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2020.proj.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 08:43:19
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2020.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984

</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Start age:18
End age:24
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:45
End age:54
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225

Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:55
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:25
End age:44
Race:
Ethnicity:
Gender:
Pollutant:PM2.5

Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0

NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>
<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Start age:0
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
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<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
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Default Monte Carlo Iterations:5000
Random Seed:1
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Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
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Name:Friant
ID:33
Columns:87

Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
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<Valuation.Aggregation>
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ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
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<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Mortality
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction

Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0

Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days

B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Acute.Myocardial.InfarctionPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:Incidence*POP*A

Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Acute Myocardial Infarction
Zanobetti:Pooling Method Type:None
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Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)

Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Hospital Admissions, Cardiovascular
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None

Author:Sheppard
Year:2003
Location:Seattle, WA
Other pollutants:
Geographic area:Everywhere
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Hospital Admissions, Respiratory
Zanobetti:Pooling Method Type:None
Sheppard:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm

Start age:0
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Emergency Room Visits, Respiratory
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
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ATTACHMENT B-6

BENMAP-CE AUDIT TRAIL REPORT
PM25.2020.PMIT.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 10:12:52
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Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2020
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 09:57:07
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2020.pmit.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 08:43:19
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2020.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984

</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Start age:18
End age:24
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:45
End age:54
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225

Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:55
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5

Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:25
End age:44
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0

NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>
<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Start age:0
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>

<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.9>
</Selected.health.impact.functions>
<Log.And.Message>
Processing complete. HIF processing time: 0 hours 15 minutes 20 seconds.
</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
Name:Friant
ID:33
Columns:87

Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Valuation.Aggregation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Mortality>
Mortality
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Acute.Myocardial.InfarctionPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction

Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0

Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days

B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Acute.Myocardial.InfarctionPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:Incidence*POP*A

Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Myocardial.Infarction>
Acute Myocardial Infarction
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Acute.Myocardial.Infarction>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)

Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Cardiovascular>
Hospital Admissions, Cardiovascular
</Valuation.Pooling.Window.Name.Hospital.Admissions.Cardiovascular>
<Incidence.Pooling.And.Aggregation.>
<Hospital.Admissions.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None

Author:Sheppard
Year:2003
Location:Seattle, WA
Other pollutants:
Geographic area:Everywhere
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Hospital.Admissions.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
Zanobetti:Pooling Method Type:None
Sheppard:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm

Start age:0
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-7

BENMAP-CE AUDIT TRAIL REPORT
PM25.2031.PROJ.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 13:08:39
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2031
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 10:17:45
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2031.proj.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 10:17:21
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2031.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984

</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Start age:18
End age:24
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:45
End age:54
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225

Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:55
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5

Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:25
End age:44
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0

NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>
<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012

Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Start age:0
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>

<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
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</Selected.health.impact.functions>
<Log.And.Message>
Processing complete. HIF processing time: 0 hours 15 minutes 49 seconds.
</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
<Inflation.Adjustment>
Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
Name:Friant
ID:33
Columns:87

Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Incidence.Aggregation>
<Valuation.Aggregation>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Valuation.Aggregation>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
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Mortality
</Valuation.Pooling.Window.Name.Mortality>
<Incidence.Pooling.And.Aggregation.>
<Acute.Myocardial.InfarctionPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction

Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0

Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days

B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Acute.Myocardial.InfarctionPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:Incidence*POP*A

Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Acute.Myocardial.Infarction>
Acute Myocardial Infarction
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
Zanobetti:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Acute.Myocardial.Infarction>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)

Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Cardiovascular>
Hospital Admissions, Cardiovascular
</Valuation.Pooling.Window.Name.Hospital.Admissions.Cardiovascular>
<Incidence.Pooling.And.Aggregation.>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None

Author:Sheppard
Year:2003
Location:Seattle, WA
Other pollutants:
Geographic area:Everywhere
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Hospital.Admissions.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
Hospital Admissions, Respiratory
Zanobetti:Pooling Method Type:None
Sheppard:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Hospital.Admissions.Respiratory>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm

Start age:0
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Incidence.Pooling.And.Aggregation.>
<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

ATTACHMENT B-8

BENMAP-CE AUDIT TRAIL REPORT
PM25.2031.PMIT.TXT

BenMAP-CE 1.5.0
<Aggregate, Pool & Value>
Create Datetime:2021-04-19 12:22:02
IsRunInPointMode:False
Latin Hypercube Points:20
Population Dataset:PopFriantUpdated-Friant
Year:2031
Threshold:0
Incidence averaging:All
<Baseline.And.Control.Group0>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
<Baseline.Air.Quality.Surfaces>
Create Datetime:2021-04-19 12:05:19
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2031.pmit.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Baseline.Air.Quality.Surfaces>
<Control.Air.Quality.Surfaces>
Create Datetime:2021-04-19 10:17:21
Pollutant:PM2.5
Model Database File:C:\Users\Frank\Documents\My BenMAP-CE Files\Friant\Data\pm25.2031.base.benmap.csv
<Grid.Definition>
Name:Friant
ID:33
Columns:87
Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984

</Grid.Definition>
<Pollutant>
Name:PM2.5
Observation Type:Daily
Season0:January 1-March 31
Season1:April 1-June 30
Season2:July 1-September 30
Season3:October 1-December 31
Metric0:D24HourMean
Seasonal Metric0:QuarterlyMean
</Pollutant>
</Control.Air.Quality.Surfaces>
</Baseline.And.Control.Group0>
<Selected.health.impact.functions>
<Health.impact.function.0>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Start age:30
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Prevalence dataset:
Variable dataset:
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.0>
<Health.impact.function.1>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Start age:18
End age:24
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.1>
<Health.impact.function.2>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:45
End age:54
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225

Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.2>
<Health.impact.function.3>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:55
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.3>
<Health.impact.function.4>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:25
End age:44
Race:
Ethnicity:
Gender:
Pollutant:PM2.5

Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.4>
<Health.impact.function.5>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0

NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.5>
<Health.impact.function.6>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.6>
<Health.impact.function.7>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Start age:65
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012

Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.7>
<Health.impact.function.8>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Start age:0
End age:64
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.8>

<Health.impact.function.9>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Start age:0
End age:99
Race:
Ethnicity:
Gender:
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Prevalence dataset:
Variable dataset:
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
</Health.impact.function.9>
</Selected.health.impact.functions>
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Processing complete. HIF processing time: 0 hours 16 minutes 8 seconds.
</Log.And.Message>
Sort Incidence LHPs:False
Default Advanced Pooling Method:Roundweightstotwodigits
Default Monte Carlo Iterations:5000
Random Seed:1
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Dataset:
Year:-1
</Inflation.Adjustment>
<Income.Growth.Adjustment>
Dataset:
Year : -1
</Income.Growth.Adjustment>
<Incidence.Aggregation>
Name:Friant
ID:33
Columns:87

Rows:103
Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
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ID:33
Columns:87
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Grid Type:Shapefile
Shapefile Name:CEQA_FRanch_lc_87_103_4000_4000_-108_-256_WGS1984
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Mortality
Endpoint:Mortality, All Cause
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:Mean
Seasonal metric:QuarterlyMean
Author:Krewski et al.
Qualifier:Random effects cox; 44 individual and 7 ecologic co-variates; 1999--2000 follow-up (Commentary table 4)
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:TSP, O3, SO4, SO2
Reference:Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA
Start age:30
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Mortality Incidence (2000)
Beta:0.005826891
Beta distribution:Normal
P1Beta:0.000962763
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Mortality
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction

Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0

Weight:0
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<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days

B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:18
End age:24
Baseline functional form:Incidence*POP*A

Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:45
End age:54
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009

Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:55
End age:64
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.971812
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:25
End age:44
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.98148
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Acute Myocardial Infarction
Endpoint:Acute Myocardial Infarction, Nonfatal

Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP*A
Incidence dataset:Other Incidence (2014)
Beta:0.00225
Beta distribution:Normal
P1Beta:0.000591837
P2Beta:0
A:0.925661
NameA:% of hospMI surviving 28 days
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Acute Myocardial Infarction
Zanobetti:Pooling Method Type:None
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Zanobetti:Pooling Method Type:None
</Valuation.Pooling.Window.Name.Acute.Myocardial.Infarction>
<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Cardiovascular
Endpoint:HA, All Cardiovascular (less Myocardial Infarctions)
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Bell
Qualifier:National; Yearly
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2012
Geographic area:Everywhere
Other pollutants:
Reference:Bell, M.L. 2012. Assessment of the Health Impacts of Particulate Matter Characteristics. Research Report 161. Health Effects Institute. Research Report 161: 1-59.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)

Beta:0.0008
Beta distribution:Normal
P1Beta:0.000107143
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Hospital Admissions, Cardiovascular
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<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Year:2009
Location:26 U.S. Communities
Other pollutants:
Geographic area:Everywhere
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None

Author:Sheppard
Year:2003
Location:Seattle, WA
Other pollutants:
Geographic area:Everywhere
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
</Hospital.Admissions.RespiratoryPooling.Method.TypeNone>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, All Respiratory
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Zanobetti et al
Qualifier:All Seasons
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2009
Geographic area:Everywhere
Other pollutants:
Reference:Zanobetti, A., M. Franklin and J. Schwartz. 2009. Fine particulate air pollution and its components in association with cause-specific emergency admissions. Environmental Health Vol. 8: 58-60.
Start age:65
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.00207
Beta distribution:Normal
P1Beta:0.000446429
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0

</Health.impact.function>
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Health impact function dataset:EPA Standard Health Functions
Endpoint group:Hospital Admissions, Respiratory
Endpoint:HA, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Sheppard
Qualifier:
Function:(1-(1/EXP(Beta*DELTAQ)))*Incidence*POP
Year:2003
Geographic area:Everywhere
Other pollutants:
Reference:Sheppard, L. Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987-1994. In: Revised Analyses of Time-Series Studies of Air Pollution and Health. 2003, Health Effects Institute: Boston, MA. p. 227-230.
Start age:0
End age:64
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.003323789
Beta distribution:Normal
P1Beta:0.00104459
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
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Hospital Admissions, Respiratory
Zanobetti:Pooling Method Type:None
Sheppard:Pooling Method Type:None
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<Incidence.Pooling.And.Aggregation.>
<Health.impact.function>
Health impact function dataset:EPA Standard Health Functions
Endpoint group:Emergency Room Visits, Respiratory
Endpoint:Emergency Room Visits, Asthma
Pollutant:PM2.5
Metric:D24HourMean
Metric statistic:None
Author:Mar et al.
Qualifier:Entire study period (January 3, 1999 - May 30, 2002)
Function:(1-EXP(-Beta*DELTAQ))*Incidence*POP
Year:2010
Geographic area:Everywhere
Other pollutants:
Reference:Mar, T. F., J. Q. Koenig and J. Primomo. 2010. Associations between asthma emergency visits and particulate matter sources, including diesel emissions from stationary generators in Tacoma, Washington. Inhal Toxicol. Vol. 22 (6): 445-8. http://www.ncbi.nlm

Start age:0
End age:99
Baseline functional form:Incidence*POP
Incidence dataset:Other Incidence (2014)
Beta:0.005602959
Beta distribution:Normal
P1Beta:0.002103073
P2Beta:0
A:0
NameA:
B:0
NameB:
C:0
NameC:
Percentile:0
Weight:0
</Health.impact.function>
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<Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Emergency Room Visits, Respiratory
</Valuation.Pooling.Window.Name.Emergency.Room.Visits.Respiratory>
Processing complete. Valuation processing time: 0 hours 0 minutes 0 seconds.
</Aggregate, Pool & Value>

APPENDIX C
Resumes

James A. Westbrook

President
Principal Air Quality Scientist

Expertise

Air Quality Permitting & Compliance
Litigation Support
Strategic Business and Project Management
Mitigation Programs
Greenhouse Gas Management
Air Dispersion Modeling
CEQA Air Quality Impact Analysis
Chemical Spill Risk Management
Health Risk Assessment
Air Emissions Inventories
Emissions Credit Banking

Industry Focus

Power Generation
Refineries and Chemical Plants
Oil and Gas Production
LNG Facilities
Aggregate and Asphalt Production
Coating Operations
Pharmaceuticals

Building Materials Manufacturing
Aerospace Industry
Metal Plating Operations
General Manufacturing

Education

MS, Environmental Science, Indiana Univ.
BS, Atmospheric Sciences, UCLA

Certifications

Certified Consulting Meteorologist (CCM)
Certified Permitting Professional (CPP)

Associations / Memberships

American Meteorological Society
Air & Waste Management Association
California Alliance for Distributed Energy Resources (CADER)
LA Bar Association
CA Climate Action Registry

Company Background

BlueScape
Kleinfelder
ENVIRON Corporation
Engineering-Science, Inc.

Summary of Experience

In 1997, James A. Westbrook, founded BlueScape Environmental (BlueScape) to help businesses achieve practical, cost-effective air quality compliance solutions. Since then, he has independently grown BlueScape by way of exceptional skills in strategic business planning, marketing, and project management. BlueScape currently serves businesses with annual revenues in excess of one billion dollars, including power generation and manufacturing companies, developers and consulting firms.

Mr. Westbrook helps clients to obtain air permits and achieve strategic business goals by drawing upon his expert skills in regulatory analysis & negotiation, air emissions calculations, greenhouse gas emissions management, dispersion modeling, and human health risk and exposure assessment. Mr. Westbrook serves as an expert witness in litigation cases involving air emissions estimates, dispersion modeling, and health risk assessment. To provide superior customer service, he has assembled a team of engineers and scientists with a wide range of experience and knowledge with industrial equipment, emission control technologies, computer emissions and dispersion modeling tools, and agency contacts throughout the U.S.

Mr. Westbrook actively speaks to industry trade groups regarding air quality compliance issues. He is the co-instructor for the only publicly available training course on the Hotspots Analysis and Reporting Program (HARP) risk assessment software. His work background includes experience obtained at Kleinfelder in Pleasanton, CA, ENVIRON Corporation in Emeryville, CA, and Parsons Engineering-Science in Pasadena, California.

His formal education includes an M.S. in Environmental Science from Indiana University, Bloomington and a B.S. in Atmospheric Sciences from UCLA. He is a Certified Consulting Meteorologist (CCM) and is recognized as a Certified Permitting Professional (CPP) by the South Coast Air Quality Management District. Mr. Westbrook is listed as a CEQA Consultant for Air Quality by the County of San Diego, Planning Department.

Select Project Experience:

Human Health Risk and Exposure Assessment

- *Diesel Health Risk Assessment, Boeing Corporation, Long Beach*. Project Manager for completion of a health risk assessment for diesel PM emissions from 18 emergency and portable generators at Boeing's facilities in Long Beach. The work was completed using the HARP software. The purpose of the study was to evaluate the potential impacts from the engines, if included in a proposed South Coast Air Quality Management District air toxics rule. The results from the study were used to determine the location and time needed to operate the engines and be in compliance with the proposed rule.

- *Comprehensive Proposition 65 Audits, Confidential Power Producer, California*. For a confidential independent power producer, completed comprehensive Prop 65 audits for six facilities. The facilities combust petroleum coke, a byproduct of refining. Potential exposure areas covered included occupational and visitor, water discharges, air discharges, and exposure to a co-product from the electricity generation process. A report was prepared stating conclusions and whether there was a need to warn the community.

- *Duwamish Regional Health Risk Assessment, Seattle, Washington.* Teamed with Dillingham Software Engineering (DSE), the developer of California Air Resources Board Hotspots Analysis and Reporting Program (HARP), to complete a regional health risk assessment for the Duwamish River Valley just to the south of downtown Seattle. The modeling and health risk study included on-road diesel emissions sources, wood stoves, and criteria pollutant and air toxic emissions from more than 200 industrial facilities. BlueScape was responsible for developing the industrial facility air toxics emissions inventory, and completing a report utilizing modeling output provided by DSE. The study was sponsored by the Washington Department of Health.

- *AB2588 Health Risk Assessments, Multiple California Facilities*. Project Manager or Technical Lead for more than 20 AB2588 health risk assessment projects for industrial facilities located in Southern California. These included 10 Southern California Edison power plants, a fiberglass manufacturing facility, a spice processing plant, a plumbing supplies plant, the Kwikset manufacturing facility in Anaheim, two petroleum processing/refining facilities, two small parts coatings facilities (hexavalent chromium-based pigments), a resin manufacturer, a specialty resistor manufacturer and two aerospace part manufacturers. Used the SCREEN3 and ISCST3 dispersion models and the ACE2588 and HRA health risk assessment models to calculate and report health risks.

- *New Source Review Air Permitting Health Risk Assessments, Multiple California Facilities*. Project Manager or Technical Lead for completing health risk assessments to obtain air permits for a wide range of industrial emission sources located in California, for example, three separate air strippers, a can manufacturing facility, a landfill gas flare, two wood cabinet manufacturing facilities, a fiberglass manufacturing facility, a major refinery, and a power generation company. In the process of obtaining air permits, BLUESCAPE has used techniques ranging from consulting look-up tables and screening dispersion modeling, to full refined dispersion modeling and risk calculations.

- *Benzene Exposure Analysis, Confidential Refinery, Appalachian Region*. Lead dispersion modeler for an analysis of potential human exposure to benzene emitted from wastewater processing operations at a medium-sized petroleum refinery. Used the ISCST and COMPLEXI models to estimate ground-level impacts due to fugitive sources such as tanks, pipes, and ponds, as well as point sources such as cooling towers. Estimated potential excess cancer risk under various exposure scenarios, accounting for population mobility, indoor concentrations relative to outdoor concentrations, and movement of population between various microenvironments.

- *Evaluation of U.S. EPA's use of the HAPEM Exposure Model to Estimate Benzene Emissions from Mobile Sources, Confidential Client.* Lead modeler for evaluating U.S. EPA's application of the HAPEM exposure model to mobile source pollutants, especially benzene. Downloaded CO monitoring data from the Aerometric Information Retrieval System. Using statistical and graphical methods, analyzed the relationship between ambient measurements of CO and tailpipe benzene emissions to critically evaluate U.S. EPA's methodology.

Air Permitting: Minor New Source Review, PSD and Title V Air Permitting

- *Refinery Integration and PSD Review, Annual Emissions Reporting, Confidential Midwest Refineries.* Project Manager for securing air permits and avoiding major PSD permitting for integration of two refineries located in the Midwest, separated by one mile. Conducted PSD Review of such issues as stationary source definition and common control, project aggregation, projected

actual emissions, and capable of accommodating. In addition to integration of refinery operations, future projects included physical modifications and new units. Because the state determined that integration of both refineries was a change in method of operation, any future emissions increases above baseline would trigger major PSD permitting. BlueScape developed a method to use Projected Actual Emissions for integration plus aggregated projects to help the refineries avoid PSD. In addition to PSD review, the refineries hired BlueScape to develop a consistent Annual Emissions Reporting framework for both refineries and create a GHG emissions reporting plan under EPA's MRR program.

- *Hydrogen Plant Permits, Chevron Refinery, El Segundo, California.* Project Manager for securing installation permits for a new hydrogen plant, including a 780 MMBtu/hr heater, SCR system, process vents and components. The project was required to replace an old, existing plant under an Order for Abatement. Successfully negotiated installation of the project without requiring scarce and expensive emission credits (PM_{10}, 176 lb/day) that would have rendered the project impossible. Functionally identical replacement and concurrent modification offset exemptions were proposed and accepted by the South Coast AQMD. Negotiated permit conditions to provide operational flexibility during commissioning and startup conditions. Completed dispersion modeling using SCREEN3 and ISCST3 to show that short-term and long term operations will not cause or contribute to an exceedance of the health standards. Completed emission calculations and assembled all supporting documentation required as part of the rule review. Permits were issued in only six months, much less than the typical 1-2 years for similar projects, allowing the plant to be built and started as scheduled. BlueScape was a subcontractor to the Denali Group.

- *CEC Licensing and Air Quality Permits, Eastshore Energy Facility, Hayward, California.* Air Quality Project Manager for CEC licensing and air quality permitting for a 115.5 MW peaking power plant consisting of 14 natural gas-fired lean-burn engines. CEC application work supported the Air Quality and Public Health sections of the AFC, including construction emissions and modeling and the health risk assessment. Developed a CEQA PM10 mitigation plan provided to CEC. Participated in workshops and public meetings to resolve issues. Developed air permit conditions for the BAAQMD Final Determination of Compliance (PDOC).

- *PSD Permit, Confidential Fiberglass Manufacturer, Northern California.* Project Manager for completion of a PSD air permit application for a fiberglass manufacturing facility located in Northern California. Work included an air quality modeling analysis for PM_{10} and CO emissions. The facility's compliance with federal ambient air quality standards and with allowable PSD increment consumption was assessed. Mr. Westbrook assisted with preparation of a PM_{10} pre-construction monitoring and QA/QC plan, addressing monitor siting issues.

- *Expedited Distributed Generation Air Permits, RealEnergy Inc., California.* Managed Phase I & II installation of clean gas-fired internal combustion engines in 10 sites located in the South Coast Region and San Diego County of California. Worked with team members Resource Catalysts and Environmental Compliance Solutions under a very aggressive schedule to successfully obtain permits. Providing RealEnergy with ongoing permitting and compliance management support.

- *CEC Siting Application for a 62 MW Peaker Turbine Facility, RAMCO Inc. & PG&E, California.* Project leader with team member Resource Catalysts and other consultants; developed and submitted the licensing application for a peaking generation plant under the California Energy Commission 21-day expedited review process.
- *Backup Diesel Engine Air Permits, EDS Corporation and the U.S. Navy.* As subcontractor to Rancho Santa Fe Technologies, prepared air permit applications for five 1 MW diesel-fired engines as part of the U.S. Naval global military intranet system called "SPAWARS."

- *Title V Permits, Peaking Power Plant, Chowchilla, California.* BlueScape is prepared Title V permit applications for a peaking power plant consisting of 16 lean-burn gas engines, located in Chowchilla in the Valley Air District. The facility recently entered the program due to lowering of the Title V thresholds of NOx and VOC.

- *SIP Permit, Confidential Fiberglass Manufacturer, West Virginia.* Project Manager for completion of air dispersion modeling services for a fiberglass manufacturing facility located in West Virginia. The work was performed to assess the effect of changing the West Virginia State Implementation Plan on attainment of area PM_{10} NAAQS. On-site meteorological data was processed for multiple tower levels. The SCREEN3 model was used to reduce the number of nearby sources to be included in the NAAQS modeling analyses. The IGM model with ISCST and RTDM was used to model impacts from facility sources. ISCST and COMPLEX I were used to model impacts from nearby sources.

- *Synthetic Minor Air Permits, Three Prestolite Wire Corporation Facilities in the Midwest and Eastern US.* Project Manager for completion of synthetic minor air permit applications for telecommunication and automotive wire manufacturing facilities located

in Nebraska and Arkansas. Assisted facilities in preparing up-to-date emission inventories and avoiding Title V permitting requirements. For a third facility located in Georgia, negotiated with air pollution control agency staff to obtain an exemption from State air permitting requirements.

- *PSD Permit, Confidential Fiberglass Manufacturer, Georgia.* Managed and completed the modeling study to support a PSD application submittal for a fiberglass manufacturing facility located near Atlanta. The facility proposed to add sodium nitrate to raw batch materials to reduce odor-causing emissions of hydrogen sulfide from a melter. As a result, PSD for NO_2 was triggered. The project involved estimating process emissions of criteria pollutants, assessing compliance with NAAQS and increment thresholds for NO_2, and completing other required PSD analyses, including a visibility screening analysis.

- *Synthetic Minor Air Permit, Fisher-Hamilton Scientific, Two Rivers, Wisconsin*. Project Manager for completion of a Federally Enforceable State Operating Permit (FESOP) application for a wood furniture manufacturer. Our staff assisted the facility in implementing strategic measures to reduce VOC emissions and avoid Title V permit requirements. Calculations were performed for both actual and potential emissions based on future production scenarios, and drafted permit limits.

- *Title V Permits, Three California Facilities.* Assisted with completion of Title V permit applications for the Owens-Brockway glass facility in Tracy, California, the Lodi Metal Tech Facility in Lodi, California, and the Sony Electronics facility in San Diego, California. Lists of Title V-applicable regulations were developed for the facilities, and application forms were completed using client-supplied information.

- *Air Permits, Confidential Fiberglass Facility, Southern California*. Assisted a fiberglass facility in obtaining a modified air permit for an increase in production capacity on a highly restricted line. Although no net increase in emissions was expected following regulatory definitions, the permitting agency wanted air emission increases to be calculated using a restrictive methodology. This methodology triggered a Rule 1401 health risk assessment and led to delays in the permitting process. Assisted the facility throughout the process by analyzing the effect of agency requirements and presented ways to express production limits in a manner that would move the project forward. Ultimately, BlueScape succeeded in showing that the facility could expand production without causing significant health risk impacts or requiring emissions offsets. The facility received the modified air permit.

Air Dispersion Modeling Analyses

- *AERMOD Modeling, Bradwood Landing LNG Terminal, Oregon*. As a subcontractor to SRA, used the AERMOD model to assess impacts from a proposed Bradwood Landing LNG carrier vessel offloading terminal on the Columbia River. Developed an air dispersion modeling protocol in consultation with the Oregon Department of Environmental Quality. Analyzed impacts of emissions from submerged combustion vaporizers at rugged terrain along the banks of the river. Assisted the design team with exhaust design to optimize engineering design and satisfy applicable air quality thresholds.

- *OCD Modeling, Clearwater Port LNG Terminal, Ventura, California*. As a subcontractor to SRA, used the Offshore and Coastal Dispersion Model to assess overwater and onshore impacts from a proposed LNG offloading terminal and regasification platform 13 miles off Ventura County. Developed an air dispersion modeling protocol and completed modeling in consultation with the US EPA and the US Coast Guard.
- *LAX Construction Equipment Modeling Study, Los Angeles, California*. As a subcontractor to ECS, completed a dispersion modeling analysis for the proposed expansion of the Los Angeles International Airport. The majority of emissions resulted from diesel-fueled construction equipment. In order to show compliance with the Federal and State ambient air quality standards, completed ISCST3 air dispersion modeling using the ozone limiting technique for NOx emissions.

- *PSD Modeling Study, Columbia Ridge Landfill, Arlington, Oregon.* As a subcontractor to SCS Engineers, managed completion of a dispersion modeling study to assess impacts from increased fugitive PM10 emissions from a landfill. Impacts modeled using AERMOD were compared to the Oregon state ambient standards and increment levels. The project was particularly challenging given the amount of emissions from ground-level sources. Worked closely with the prime contractor to refine the modeling study emissions and source parameter inputs so that future operations will be in compliance with the standards.

- *Odor Modeling, San Diego Metropolitan Wastewater District (SDMWD), San Diego, California.* Completed dispersion modeling study using the ISCST3 model to assess potential odor impacts and health risks. The San Diego MWD planned construction of a Wet Weather Storage Facility (WWSF), consisting of two 7 million gallon underground storage tanks, to handle future peak wastewater flows during storm events. Required analysis of potential nuisance odors and health risk impacts as

compared to thresholds established by the San Diego APCD under Rule 1200 for surrounding businesses. Developed engineering design data, such as stack height, air flows, and scrubber control efficiency that would be required to meet City's odor design standards of 5 odor units (OU). Used conservative modeling and exposure assumptions, to show that odor impacts and health risks from the Wet Weather Storage Facility would meet design requirements.

- *Air Dispersion Modeling & Health Risk Assessment, THUMS, Inc., Long Beach, California*. Owner of natural gas and petroleum production fields, planned to site a 44 MW simple-cycle turbine facility in Long Beach harbor to provide onsite electricity for well pumping. Needed modeling and HRA to show that operation was in compliance with South Coast Air District Rules 1303 and 1401. Modeled impacts from criteria pollutants (NOx, PM10, etc.), ammonia slip, and air toxics found at three candidate site locations. Examined the effect of different stack heights, and the effect of building downwash on air quality impacts. For each candidate site, determined a stack configuration that would result in compliance with the district rules.

- *Ambient Air Quality Analysis, Motorola 52nd Street, Phoenix, Arizona.* Lead dispersion modeler for an ambient air quality analyses performed for a semiconductor manufacturing facility. Estimated off-site air quality impacts using the ISCST and SHORTZ dispersion models. From estimates of off-site concentrations and emissions data, compared modeling results to state ambient air quality guidelines. Completed feasibility studies to evaluate the impact of modifying facilities.

- *Stack Increase Study, Confidential Metal Container Manufacturer, Southern California.* Entrainment of sulfuric acid emissions released from three stacks into building ventilation intakes was apparently resulting in poor product finish quality for some can batches. As a subcontractor to Kleinfelder, made visual observations at the site and confirmed a potential problem during strong northeast winds. Using the ISCST3 model and ASHRAE guidance, stack height increases needed to avoid intake contamination were estimated. Reconstruction of the stacks was commenced based upon study recommendations.

- *Indoor Contamination Study, Confidential Hospital, Nevada*. A hospital in Nevada was evaluating reports of health effects possibly caused by indoor pollutant contamination. An investigation of rooftop stacks revealed that emissions from two boilers were potentially entrained into building ventilation intakes on the lee side (cavity area) of a downwind structure. The ASHRAE ventilation guidance was used to estimate boiler stack height increases recommended to avoid the building cavity zone.

- *Third-Party Modeling Review; Instantaneous and Short-Term Releases from Multiple Federal Munitions Disposal Facilities, Eastern United States.* Health risk assessments were performed by the facilities following the USEPA Human Health Risk Assessment Procedures (HHRAP) guidance document. Models proposed for use included OBODM, ISCST3, INPUFF, and TRPUF. Resulting documentation required third-party review by an independent source. The review focused primarily on the appropriateness of modeling input data assumptions, including emissions, source release parameters, and meteorological data. Comments were provided to Booz-Allen, and submitted along with other comments to USEPA and state air pollution agency staff.

- *Monitoring/Meteorological Data Validation Study, Confidential Municipal Waste Landfill, Southern California*. Compared vinyl chloride monitoring data to concurrently obtain meteorological measurements. Used on-site meteorological measurements as well as synoptic observations to validate monitoring data.

Mitigation Programs

- *Air Quality Mitigation and Monitoring Support, Confidential California Utility Transmission Project*. With ZMassociates, Project Director providing air quality mitigation support to a major utility. At the outset of the project the utility was required to mitigate more than 200 tons/year of NOx emissions. Refined project emissions estimates for updated route alignment and construction equipment forecasts. The outcome NOx mitigation requirements were removed. Calculated construction and operational GHG emissions and developed a plan for providing mitigation using carbon credits. Led team development of a Construction Emissions Monitoring Plan to track actual usage of construction equipment.

- *PM_{10} Mitigation Plan, Escondido, California*. Sempra Energy developed a 500 MW power generation facility in Escondido, California. Sempra was required to fund up to $1.9 million for local PM_{10} mitigation, with a preference for diesel exhaust mitigation. Under contract to City of Escondido, developed a PM_{10} mitigation plan identifying potential sources of local diesel mitigation. The mitigation plan considered the cost-effectiveness of diesel mitigation, as well as reducing emissions from other source types. Helped City of Escondido to apply for up to $500,000 in funding for particulate filters for several on-road and off-road diesel vehicles, and new school buses.

- *PM_{10} Mitigation Plan, Eastshore Energy Facility, Hayward, California*. Project Manager for developing a PM_{10} mitigation plan under California CEQA requirements. The Eastshore Energy facility is not required to mitigate PM_{10} under BAAQMD regulations. However, CEC requires that PM_{10} emissions be mitigated, especially during potential non-attainment periods. Developed a two-prong plan that proposes using BAAQMD-banked emission reduction credits, or a wood stove and fireplace replacement program. The mitigation is currently being negotiated with CEC.

- *LAX PM_{10} Mitigation Study, Los Angeles, California*. Completed research of PM_{10} mitigation options for the LAX expansion project. Focus of the research work was on air filtration in air conditioning systems in area schools.

- *Rule 1309.1 Priority Reserve Rule Review, Southern California*. For a confidential client, applying PM_{10} offsets, closely followed Rule 1309.1 Priority Reserve developments. Challenges to Rule 1309.1 placed many restrictions on facilities needing access to the Priority reserve. This will have a significant impact on the market for PM_{10} Emission Reduction Credits within the SCAQMD.

Greenhouse Gas Management

- *Johns Manville Corporation, Corporate Greenhouse Gas Inventory Management*. Johns Manville is a Berkshire Hathaway Company that manufactures residential and commercial insulation and roofing products (www.jm.com). The company has 50 manufacturing facilities worldwide. BlueScape conducted baseline emissions inventory work focusing on two California facilities that may be subject to AB32 reporting requirements. The 2006 emissions inventory data were be supplied to the California Climate Action Registry, and successfully verified by a third party. On a corporate level, BlueScape is working with Johns Manville to develop corporate strategies to address climate change issues, considering energy efficiency and credit development opportunities, national Climate Registry participation, and insulation product sales.

- *Greenhouse Gas Footprint Life Cycle Analysis, Confidential LNG Project, Western US*. BlueScape partnered with WorleyParsons Komex to prepare a GHG footprint life cycle analysis for a proposed liquefied natural gas project. The project will obtain natural gas from fields in Asia or Australia, clean and liquefy the gas and transport LNG across the Pacific Ocean to the US West Coast. Regasification and compression of natural gas will be accomplished utilizing four gas turbines. The project is being completed for submittal to the Coastal Commission, US Coast Guard and other agencies as part of a NEPA review. The life cycle GHG impact with and without the project (no action alternative) will be compared. The no action alternative considers forecasted Western US power industry fuel and generation technology mix, including coal, natural gas, renewable, nuclear and hydroelectric, from 2012 to 2050. To complete the work, BlueScape obtained and analyzed utility, CEC and PUC reports.

- *Confidential Independent Power Producer, Greenhouse Gas Emissions Inventory and Solutions, California.* BlueScape completed a baseline greenhouse gas emissions inventory for an independent power producer operating nine plants with 500 MW of total power production capacity. At six plants, the company combusts petroleum coke, a fuel with CO_2 emissions similar to coal. The company is facing contract renewal with PG&E, and is concerned that the facilities will not be competitive to natural gas-fired plants. BlueScape is working with the company to analyze possible solutions to reduce GHG emissions ahead of impending AB32 compliance requirements and PG&E contract renegotiation. Options identified to date include boiler oxy-firing, fuel switching, carbon sequestration, load shifting to re-permitted gas-fired power plants, and plant shutdown. The company is also considering investing in renewable energy projects to offset GHG emissions from fossil fuels. The project goal will be to help the company to remain competitive in the rapidly changing California power generation market.

- *Greenhouse Gas Emissions Inventory Verification, California Climate Action Registry.* BlueScape has completed verification work on three greenhouse gas emission inventories. The work was completed as a subcontractor to ICF Consulting, for 2006 inventories submitted to the California Climate Action Registry. The companies include Los Angeles County, Driftwood Dairy, and Termo Oil and Gas., all located in the Los Angeles area. The verification work included initial meetings, site visits, auditing of records and calculations, and filing a verification opinion.

- *Oil Production CO_2 Life Cycle Analysis, Client: Confidential Refinery, California.* Managed a project to complete a life cycle analysis to compare the CO_2 emissions from extraction and delivery of Los Angeles heavy crude oil to a Los Angeles refinery versus extraction, marine shipping, and delivery of Alaskan or Middle East light crude oil to a Los Angeles refinery. CO_2 emissions for extraction of Los Angeles heavy crude oil were based on an oil production lease's certified California Climate Action Registry emissions. CO_2 emissions for extraction of Canadian light crude oil were based on average natural gas combustion and production

data published by the Alaska Oil and Gas Conservation Commission. CO_2 emissions for extraction of Middle East light crude oil were estimated from Los Angeles/Canada data and a reduced water/oil ratio. CO_2 emissions from transportation considered heavy fuel oil combustion in main and auxiliary engines throughout the tanker travel distance, as well as marine diesel combustion by tugs and during maneuvering and hotelling. Results were compiled as a production carbon intensity to show that the higher CO_2 emissions from heavy crude oil production in Los Angeles were offset by the reduced transportation emissions.

Accidental Release Offsite Consequence Analyses

- *RMP Offsite Consequence Analysis, Multi-Chem, New Iberia, Louisiana and Denver City, Texas*. As a subcontractor to Denali, Inc., BlueScape completed an offsite consequence analysis for a chemical storage and distribution facility. The facility distributes acrolein, a highly toxic substances used in oil and gas fields in the petroleum industry. The worst-case and alternative release scenarios were assessed, including breach of a storage tank and a PRV release involving a fire. Modeling was completed using RMPComp and Aloha.

- *RMP Offsite Consequence Analysis, Hill Brothers Chemical Company and Modern Ice and Cold Storage, San Jose, California*. As a subcontractor to Denali, Inc., completed a CalARP (RMP) modeling study for a chemical company that stores and redistributes for sale anhydrous and aqueous ammonia, and a food cold storage facility. For each facility, assessed the worst-case and alternative release scenarios for each process utilizing ammonia, then calculated the source term (ammonia release rates) for each process. The worst-case and alternative case impacts were determined using the DEGADIS and/or other appropriate models or guidance.

- *Offsite Consequence Analysis, Microchip, Tempe, Arizona*. A semiconductor manufacturer needed to update its accidental release management plan for compressed gases, hydrochloric acid, and sulfuric acid. The ISCST3 model with one year of meteorological data was used to model compressed gas releases. DEGADIS was used to model acid spills. The radii of impact, based upon the distance to IDLH values, were found to be within the facility boundary. A report presenting the results of the analysis and showing the onsite radii of impact was completed.

- *Risk Management and Prevention Plan, Komag, Fremont, California.* For development of an RMPP, analyzed meteorological data to determine typical conditions that could occur during an accidental release. Developed a report section describing typical meteorological conditions in the RMPP.

- *Accidental Release Models Evaluation, Pure-Etch, Salinas, California*. As part of a CEQA study, an etching solution reclaim facility was required to conduct a "customized" accidental release analysis for a mitigated negative declaration. The chemicals at issue were sulfuric acid, hydrochloric acid, and ammonia. Assisted in the project by locating and evaluating candidate dispersion models for completing offsite consequence analyses.

Air Emissions Inventories

- *Air Emissions Fee Reports, Johns Manville Corporation, Corona, California.* Assisted a fiberglass company in Southern California in response to SCAQMD's request for revised Rule 301 emissions inventories for the period 1994-1997 and completed the 1997-1998 report. A full air compliance audit initiated the project to verify permit status and emissions source inclusion. Emission factors were updated to reflect recent source tests and a Title V emissions inventory.

- *Clean Air Act Emissions Inventory for Two ABEX/NWL Control Systems Facilities.* Managed the completion of facility-wide emissions inventories for two aerospace component manufacturing facilities located in Michigan and Georgia. The emission inventories were submitted to State agencies and became the basis for determining applicable Clean Air Act requirements, including Title V permitting.

- *Due Diligence Emissions Inventory, Confidential Golf Club Manufacturer, San Diego, California*. A golf club manufacturer was interested in estimating air toxic emissions from one of two facilities. Emissions had not been tracked closely in the past. The project proved to be challenging, since many different paint and solvent products were used, usage logs differed between different production areas, and materials were often transferred from another facility. Data gaps were filled to complete the inventory. Results of the due diligence inventory were compared to local air district regulations to assess compliance.

- *Dehydration Unit Emissions, Confidential Natural Gas Producer, Western U.S*. Using natural gas composition information supplied by the client, estimated VOC and hazardous air pollutant emissions from triethylene glycol dehydration units at three facilities. The purpose of the project was to determine if Title V permit applicability thresholds were exceeded. The GlyCalc 3.0 model was used to complete emissions estimates.

- *AB2588 Emissions Inventory, Johns Manville, Willows, California*. A fiberglass manufacturing facility was required to update its original AB2588 emissions report. Several new source test results had been completed. Using the source test data and other information sources, a comprehensive air toxics inventory was completed and submitted to the Glenn County Air Pollution Control District using FATES. From the results of the analysis, risk prioritization scores were estimated and the facility was counseled on potential updated risk assessment requirements.

- *AB2588 Emissions Inventory Plans, Calmat, Southern California*. Completed Air Toxics Inventory Plans for more than 10 sand and aggregate, batch concrete, and batch asphalt plants. Provided detailed information to agencies on processes and emission quantification methods. The plans were the basis for later completion of emissions inventory reports.

Clean Air Regulatory Analyses and Compliance Audits

- *Confidential Coatings Manufacturing Company, Air Permitting and Compliance – South Coast AQMD* – A coatings manufacturing facility in Los Angeles required help with emission calculations to avoid Title V major source permitting requirements. BlueScape avoided Title V, by completing alternative emission calculations for more than 20 vessels using EPA's TANKS equations and specific chemical mixture properties. Subsequently, when auditing facility permits, BlueScape found that the facility had not properly permitted several mixing vessels. BlueScape completed permits under SCAQMD's amnesty self-disclosure program, thus avoiding violations. BlueScape is currently working with the facility to triple the amount of throughput in a solvent recovery process. The project will require installation of a vapor condenser to reduce VOC and air toxic emissions increases.

- *Regulatory Analysis for the Petroleum Industry, Western States Petroleum Association*. Conducted a comparative analysis of over 150 environmental regulations affecting petroleum companies in five key areas: air toxics, new source review, endangered species, hazardous materials, and oil spills. Determined reporting requirements, and assessed inefficiencies and overlaps between regulations.

- *Clean Air Act Compliance Audits, Confidential National Client.* Task Manager for analyzing the impact of the 1990 Clean Air Act Amendments on over 30 facilities located in 11 states and engaged in a variety of manufacturing activities. Reviewed emissions and process information to determine the applicability of, and compliance with, Federal, State and local air quality regulations. Prioritized issues and gave recommendations for action.

- *General Motors Environmental Audit, Flint, Michigan*. As a team member with Golden Environmental, completed the air quality audit portion of the environmental for the maintenance services at "Buick City" located in Flint Michigan.

- *Environmental Compliance Audit, Triptych CD, Stockton, California.* Completed the environmental compliance audit for a company located in Stockton, California, which produces compact discs. Evaluated the facility's compliance with applicable air, solid waste, hazardous waste, and water discharge regulations.

- *Clean Air Act Compliance Audit, Confidential Aluminum Production Facility, South Carolina*. Completed a review of Clean Air Act regulations that might apply to the facility as part of an environmental audit. Assessed the applicability of NSPS, NESHAP, MACT, CAA Section 112(r) and other requirements.

Environmental Impact Air Quality Analysis

- *Air Quality Impact Analysis, Homestead Village, San Ramon, California*. Project Manager for completion of an air quality impact analysis for a hotel development, as part of a CEQA environmental impact report. The analysis was completed efficiently using BAAQMD guidance and a study previously completed for a shopping center. Using traffic information supplied by another consultant, insignificant project impacts were estimated.

- *Environmental and Air Quality Impact Review, City of Antioch and Pittsburg District Energy Facility.* Project Manager retained by The City of Antioch, and Intervener, to review the California Energy Commission's (CEC) Preliminary Staff Assessment

for the Pittsburg District Energy Facility. Worked with team members to developed written testimony regarding potential impacts to air quality, water quality, and infrastructure. Attended workshops and hearings to obtain information and present City of Anitoch's concerns to CEC staff.

- *Air Quality Modeling Analysis, Alta Ski Resort Draft EIR, Utah.* Revised the air quality impact section of a draft EIR for the Alta Ski Resort. The section was expanded to address lead agency comments regarding potential impacts on ambient air quality, visibility, and PSD increments. The SCREEN3 model and CALINE4 model were used to estimate impacts from direct and indirect sources. A formal response satisfying the comments was submitted.

- *Traffic and Air Emissions Study, Reno, Nevada*. As part of the environmental impact report for the Southern Pacific-Union Pacific railroad merger, estimated automobile air emissions due to increased traffic delays caused by train trips in downtown Reno. Estimated emissions using MOBILE5. Train emissions were estimated using emission factors supplied by the Washoe County Air Agency.

- *Air Quality Impact Analysis, Vintage Faire Mall, Modesto, California.* The Vintage Faire Mall was planning to expand to include additional services with added parking spaces. An analysis was completed to determine air quality impacts from increased automobile trips. The EMFAC7F model was run to obtain vehicle emission factors. Impacts from CO and other emissions were estimated using the CALINE4 model and CEQA guidance.

Litigation Support

- *Litigation Support, SLOAPCD Rule 1001, Oceano Dunes, California*. On behalf of Friends of Oceano Dunes, reviewed the South County Phase 2 Particulate Study for Oceano Dunes and the proposed San Luis Obispo County APCD Rule 1001 to permit and control dust emissions within the State Vehicular Recreation Area (SVRA). BlueScape's report, among other things, challenged a direct connection between monitored PM concentrations and dust generated from within the SVRA, and also the practical enforceability of Rule 1001. The report was presented to the San Luis Obispo County Board of Directors, and used in subsequent litigation.

- *Confidential Litigation, CO Poisoning Case, New Mexico*. Project Manager and Expert Witness for a litigation case involving a CO exposure and poisoning case at a hotel in New Mexico. Performed site investigation and analysis of meteorological data as a preliminary step to indoor CO exposure modeling. Developed procedures to conduct modeling, considering placement of CO monitors and air flow into and out of emission source and exposure areas. The case was settled.

- *Confidential Odor Litigation Case, Southern California*. Project Manager and Expert Witness for a litigation case involving a pet food manufacturing plant and reports of odors in the community. Reviewed the previous emission calculations and modeling approach completed by a consultant using ISCST3, and updated air quality modeling using AERMOD, the current EPA-required dispersion model for offsite impacts. Meteorological data were updated to nearby wind monitors and using MM5 prognostic upper air data. Peaking factors were developed to extrapolate one-hour average model impacts to 3-minute average impacts. The case is pending trial.

- *Litigation Case for a Residential Housing Developer, San Diego.* Project Manager and Expert Witness to support a residential housing developer as Defendant. A resident that lived on the road to a new housing developing sued the developer for dust and diesel emissions entering the property, claiming severe asthma and other health impacts. Developed an analysis of ambient ozone and particulate matter concentrations, and pollen data. Reviewed local wind data and proximity of roadways to the plaintiff's house. The case is pending trial.

- *Confidential Air Toxics Litigation Case, Southern California.* Project Manager and Expert Witness for a toxic tort litigation case in Southern California. The case involved transport of emissions from open burning and open detonation of waste munitions into a residential community. Developed meteorological data for air dispersion modeling using the CALMET system. Dispersion modeling was completed using ISCST3, OBODM, and CALPUFF to assess various historical operational scenarios. Deposed regarding modeling results. Case was settled out of court.

- *Litigation Support for an Accidental Chemical Release, Confidential Pesticide Manufacturing Company*. Served as an Expert Witness on behalf of the Defendant, a pesticide manufacturing company, that had released chlorosulfonic acid from a tank.

The Plaintiff claimed injury from exposure to hydrochloric acid (HCL) generated from the release. Work involved meteorological data analysis to show that the Plaintiff could not have been in contact with an acid cloud, and SLAB dispersion modeling to predict downwind concentrations of HCL. Deposed regarding modeling results. The case ended in a settlement favorable to the Defendant.

- *Proposition 65 Litigation, Confidential California Facility.* Prepared a Proposition 65 health risk assessment for a metal polishing and plating facility that uses perchloroethylene in a vapor degreasing operation. A citizen's group contended that the facility failed to warn off-site receptors of perchloroethylene levels above the no significant risk level (NSRL). BlueScape used refined analysis methods to show that, given very conservative exposure assumptions that overstate actual risk, exposure values above the NSRL were confined to locations very near the emissions source.

- *Proposition 65 Litigation and Evaluation Services, Nine Confidential California Companies*. Project Manager or Technical Lead in Proposition 65 services ranging from due diligence audits to litigation support. Industries served include battery manufacturers, a glass container manufacturer, a golf club manufacturer, two metal plating facilities, an electronics manufacturing firm, and an airplane parts manufacturing company. Completed community exposure assessments using the SCREEN3 and ISCST models. Evaluated representativeness of assumptions used in litigant's and plaintiff's modeling analyses, including meteorological data inputs, monitoring and emissions data referenced, equipment operating schedules, estimates of indoor concentrations of lead relative to outdoor concentrations, and mobility of worker populations.
- *Litigation Assistance for a Consortium of Confidential Petroleum Refineries, Texas.* Assisted several petroleum refineries located in Texas in class action litigation involving fugitive benzene emissions from piping and tanks, and chromium emissions from cooling towers. Performed dispersion modeling for benzene impacts using plaintiff's input files and ISCST, but revised benzene emissions estimates reflecting more realistic assumptions. Also, used plaintiffs ISCST and FDM input files to evaluate chromium impacts for various particle sizes and surface roughness lengths.

- *Air Toxics Litigation, Confidential Chemical Manufacturer, Texas*. A chemical company in Texas was being sued by nearby residents alleging exposure to benzene and other chemicals was causing various health ailments. Depositions from over 30 litigants were reviewed to develop an exposure parameters database. Used a visual basic-driven system to estimate benzene exposure under various scenarios. The scenarios accounted for population mobility, indoor concentrations relative to outdoor concentrations, and movement of population between various micro-environments.

Papers and Presentations:

- Westbrook, J.A. 2007. How to Calculate and Reduce Fleet Carbon Emissions. Presented at the National Alternative Fuels & Vehicles Conference, Anaheim, California, April.

- Westbrook, J.A. and Sullivan, P.S. 2006. Fugitive Dust Modeling for PM10 Emissions from a Municipal Waste Landfill. Presented at the "Guideline on Air Quality Models: Applications and FLAG Developments — An A&WMA Specialty Conference", Denver, Colorado, April.

- Westbrook, J.A. and Dillingham, J. 2005. *Rule 1401 Health Risk Assessment Course*. One-day course presented in Anaheim, California.

- Westbrook, J.A. and Dillingham J. 2005. *Air Toxics Health Risk Assessment Featuring HARP Software*. Two-day course presented in Anaheim and San Francisco, California.

- Westbrook J.A. 2004. *Environmental Justice & DER*. Presented at the 2004 California Alliance for Distributed Energy Resources Conference, San Diego, California.

- Tarde J.A. and Westbrook J.A. 2003. *Air Quality Modeling in a Highly Industrialized Valley Regime: A Comparison of AERMOD–PRIME to ISCST–PRIME and ISCST3 Results for PM10 Emissions*. Presented at the "Guideline on Air Quality Models; the Path Forward" Conference, Mystic, Connecticut, October.

- Westbrook, J.A. 1998. *Regional Risk Analysis and CALPUFF: A Review of the Tri-State Initiative.* Presented at the 10th Joint Conference on the Applications of Air Pollution Meteorology with the AW&MA, Phoenix, Arizona.

- Westbrook, J.A. 1998. *Facilitating the Air Permitting Process: Strategic Planning Makes a Difference*. Presented at the 1998 Johns Manville Environmental Coordinator's Conference, Denver, Colorado.

- Westbrook, J.A. 1998. *Air Dispersion Models: Tools to Assess Impacts from Air Pollution Sources.* Natural Resources & Environment New Science and Technology Issue. ABA Section of Natural Resources, Energy, and Environmental Law, Chicago, Illinois, Spring.

- Westbrook J.A., and Tarde J.A., 1995. Dispersion Modeling Techniques for Horizontal, Titled or Capped Emission Sources. Presented at the 88th Meeting of the Air & Waste Management Association, San Antonio, Texas.

- Hayes S.R., and Westbrook J.A. 1992. Analysis of Regulatory Requirements for Petroleum Companies in California. Presented at the DOE California Petroleum Industry Environmental Workshop, Bakersfield, California.

Francisco J. Matamala

Photochemical Modeler, Software Engineer

Expertise

Air Quality & Photochemical Models
- CALPUFF
- CALGRID
- CMAQ
- CAMx
- SCIPUFF
- SCICHEM
- AERMOD

Business Solutions

Databases
- MySQL 5
- SQL Server 2005-2014
- PostGREQL 9.0

Environmental Engineering

Meteorological Models
- WRF
- CALMET
- RAMS

Software Development
- Visual Studio .NET (C# .NET 4.6)
- Delphi 7 – BDS 2007
- Java (J2SE, J2EE)
- Fortran 77/90
- C/C+
- PHP 5.0
- JavaScript, HTML & CSS
- JQuery / Bootstrap

Tracer Studies

Industry Focus

Landfill
Lumber Industry
Mining Industry
VisualCheck

Education

Civil Eng, Computer Science
Universidad de Chile

Certifications

MBS, Great Plains Report Writer

Company Background

EnviroModeling Ltda
Lakes Environmental, Inc. Canada
NetCAS Ltda
AeroVironment, Inc. USA

Summary of Experience

Twenty-four (24) years of experience in air quality modeling and in the development of software solutions for environmental engineering companies and the mining industry. Has participated in dozens of environmental engineering projects worldwide, leading modeling teams in every stage of the consulting process. Has designed and developed software for the visualization and analysis of air quality modeling data, emissions inventories and other environmental data sets.

Has extensive experience with air dispersion models, including mastery of the CALPUFF modeling system, SCIPUFF and AERMOD. Has ample experience with complex photochemical models, including CMAQ, CAMx and SCICHEM. Has designed and developed software for the visualization and analysis of air dispersion and photochemical models (CALPUFF, SCIPUFF, CAMx), commercialized and sold all over the world.

Has implemented the Weather Research and Forecast meteorological model WRF (versions 3.5 and newer) and setup dynamic execution clusters in both Lakes Environmental and EnviroModeling. Extensive knowledge of the execution, processing and visualization of WRF, implementing the model in projects worldwide.

Has led development teams in the implementation of intelligent real-time systems for air pollution management (FETS-RT Web), with deployments in Canada, Mexico, and Australia.

Innate problem solver, able to visualize and solve complex tasks. Can perform proper design abstraction and the practical implementation of a solution. Understands and utilizes agile development methodologies, in particular cyclical development with prototypes. Practices domain driven design.

Excellent grasp of most high level development languages, including C/C++/C#, Delphi, Java (J2EE), Fortran, amongst others. Extensive experience with the .NET platform, up to and including .NET 4.6. Comprehensive knowledge of database management and design, having ample experience with SQL Server 2005-2014 and MySQL.

Select Project Experience:

Select Dispersion Modeling and Tracer Studies

- ***ARAMCO Saudi Arabia*.** SF6 tracer studies 2001 – 2002. Validation of the CALPUFF System.

- ***Enami, Chile*.** SF6 tracer studies at Ventana and Paipote cooper smelters. 2006 – 2007. Validation of CALPUFF system.

- ***EnviroModeling Ltda., IT Manager and Senior Partner, Chile***. Main IT support for all air quality consulting projects, such as lead engineer and project manager for WRF execution cluster. Lead developer of CAMx modeling engineer and CalDESK and other software products. Provided main IT support for all air quality consulting projects.

- ***Lakes Environmental, Inc., Senior Developer, Canada***. Implemented a distributed graphical rendering engine. Lead team member built to support air quality software packages, such as FETS-RT that was a three (3) year project. Lead developer and project manager for WRF distributed execution cluster. Team member for Kuwait AQMIS project for UNDP. Provided developer support for CALPUFF View.

- ***WoodTech S.A., Independent Consultant, Las Condes, Las Condes***. Developed main infrastructure and core components of the Logmeter 4000 system.

- ***PROTAB S.A., Independent Consultant, Spain***. Developed multiple business solutions modules.

- ***NetCAS Ltda, IT Manager,*** Designed and implemented business solutions projects for ERPs for Great Plains, Solomon, J.D. Edwards and PeopleSoft). Course Instructor (Crystal Reports and Report Writer of Microsoft Dynamics)

Software Products

- ***CALPUFF Online Modeling System*.** Development of a CALPUFF Online Modeling System (COS) to evaluate in real time the air quality due to odor emission from land fields and similar process. The COS software runs using local meteorology as well as meteorology generated from WRF runs.

- ***CalDESK***. Software for the visualization and analysis of the CALPUFF Modeling System (CALMET/CALPUFF/CALGRID). Sold internationally since 1997, with hundreds of licenses in over 20 countries. Currently at version 2.98. CalDESK has multiple features, including:
  - CALMET, CALPUFF, and CALGRID data visualization with multiple views. Surface views, vertical XZ and YZ slices, vertical profile at a specific point, time series, and a dual slice view provide complete visualization capabilities. Multiple variables can be displayed within a single view, and views can be linked for paired viewing.
  - Visualization of CALMET meteorological data and CALPUFF concentrations at the same time. Wind fields, contours, box fills, streamlines and line graphs are available.
  - Puff visualization in surface and vertical views, using detailed display options that include specific colors per emission source, transparency based on puff concentrations, and color fills based on puff age.
  - Advanced trajectory analysis module, which allows the users to perform complex trajectory analysis, calculating the trajectories for an entire period and allowing the user to visualize specific trajectories with varied display options. Trajectories can be saved for future analysis, independent of the CALMET data file.

- ***FETS-RT Web (Participated as Lead Developer).*** Real-time web-based program which can demonstrate the correlation between pollutant emissions from industrial processes and their impact concentrations. FETS-RT Web performs continuous air dispersion modeling runs to project the most

probable outcomes for a collection of user-defined operating scenarios. This involves using forecast meteorology data and real-time data from monitoring stations as input to an air dispersion model which calculates the expected concentrations of a pollutant based on source parameters and emission properties. FETS-RT Web has been implemented in several industrial sites within Canada, Mexico, and Australia.

- **Kuwait AQMIS *(Participated as Developer)*:** Developed for KEPA under a UNDP contract, the Kuwait AQMIS is web-based platform that uses a Geographic Information System (GIS) style user interface to show where sources as they are physically located in relationship to other features. It also includes meteorology data to run five (5) years of AERMOD air modeling in order to identify all possible dispersion options. The AQMIS provides KEPA with a nation-wide tool to manage all elements of air quality. The major functions of the AQMIS are to:
    - Serve as a National Emissions Inventory Repository and prepare periodical reports on hazardous air pollutants and greenhouse gas emissions.
    - Provide air dispersion modeling for all sources and receptors in the country and conduct human health risk assessments based on population exposure.
    - Establish an emission source permitting and tracking program to issue Permits to Construct and Permits to Operate.
    - Collect atmospheric data from mobile and fixed site air monitoring stations, as well as point source data from emissions monitoring systems at major sources.
    - Track site visits to emission sources and manage outstanding violations.

- **SisDCA**: Air Quality Diagnostics System - Management system for the analysis of the results of air quality simulations. Used to generate meteorological input data for the CALPUFF modeling system and to provide analysis tools for the visualization of air quality data.

- **CAMxDESK**: Visualization and analysis platform for the photochemical model CAMx, versions 3.0 to 5.0. Based on CalDESK development platform.

- **GradsDESK**: Visualization and analysis platform for GrADS synoptic data files. Based on CalDESK development platform.

- **ECOSOFT**: Environmental legislation visual database, in a web based platform.

- **SIMPCA**: Air dispersion prediction system, implemented for the copper smelter Fundicion Hernan Videla Lira (ENAMI) in Copiapo, Chile.

- Radomiro Tomic mine of CODELCO Chile.

- ***RIPIO-Gaby***. Similar to RIPIO-RT, developed for the Gaby mine.

- ***MODEEM*.** Estimation model for metallurgical extraction, developed for the South Mine Geo-Metallurgical Plan, CODELCO Chile.

- ***MCA-Teniente***. Graphical implementation of the water quality model developed for the El Teniente division of CODELCO Chile. Developed working under engineers of CIMM.

- ***MCA-Andina***. Similar to MCA-Teniente, developed for the Andina division of CODELCO Chile.

Education

PhD, Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania, 2004

BS (with honors), Petroleum Engineering, Montana College of Mineral Science and Technology, Butte, Montana, 1985

AA, Computer Science, Montana College of Mineral Science and Technology, Butte, Montana, 1983

Quotes

"You may not remember, but during my freshman year and your junior year (as I was struggling with Physics 1 {mechanics} from Jack Youngblood) you were gracious enough to give me a 30 minute lesson on dimensional analysis which helped me better understand alternative methods for checking my work and applicable to almost all of my engineering classes. I have never forgotten what you did for me...thank you. I've done the same thing for many other engineering students over the years."

Ron Layton
11-Jan-2016

"Jim is an excellent balance of engineer and scientist with a seemingly unlimited capacity for solving complicated problems. He is fearless and dependable, and a real pleasure to work with."

Stephen Andersen
26-Jan-2016

IT Manager,

Senior Consulting Engineer,

Senior Software Developer,

Dr. Wilkinson possesses knowledge and experience in applied research and directly related technical experience in disciplines spanning the physical sciences, geophysical sciences, mathematics, and computational sciences. His experience includes but is not limited to managing large scale, multidisciplinary applied research projects with multiple stakeholders and sponsors, such as urban- to continental-scale air quality (CAMx, CMAQ) and meteorological (WRF, MM5) modeling studies. Jim also has experience in emissions modeling system design, development, and application (e.g., SMOKE, CONCEPT, and EMS-95); micro- to global-scale environmental data base management system design and deployment; design, development, and application of computational mathematical models of the environment (e.g., URM and BIOME).

Dr. Wilkinson has experience in the application of Failure Mode and Effects Analysis (FMEA), Threat and Hazard Identification and Risk Analysis (THIRA), and Hazard Consequence Modeling and Risk Assessment. He has applied the Process Hazard Analysis Software Tool (PHAST) to assess hazards and risks associated with gaseous and liquid hydrocarbon pipelines, carbon dioxide pipelines, and hazardous chemicals storage tanks. He has used these techniques to prepare siting plans for Liquefied Natural Gas (LNG) facilities and acrylonitrile production facilities.

Dr. Wilkinson is an experienced software developer having designed, developed, tested, deployed, and maintained systems across Windows and Linux platforms. He has expertise across the LAMP and WAMP environments working in frameworks such as LINQ, .NET, and Entity Framework with the C#, PHP, and ReactJS languages.

Jim has formulated public policy perspectives associated with the technical and scientific findings of basic and applied research, and taught at the university level.

Employment History

Organic Materials Review Institute (OMRI) – Eugene, Oregon
IT Manager (Mar-2020 to Present)
Senior Software Developer (Jul-2016 to Mar-2020)

Staff mentoring and project supervision. Business development, cost modelling, personal resource deployment and load balancing, project management, technical leader for air quality modeling and meteorological modeling.

Terra-Technologies. – Eugene, Oregon
Senior Consultant (Nov-2015 to Present)

Staff mentoring and project supervision. Business development, cost modelling, personal resource deployment and load balancing, project management, technical leader for air quality modeling and meteorological modeling.

Golder Associates Inc. – Portland, Oregon
Senior Consultant (Aug-2013 to Nov-2015)

Staff mentoring and project supervision. Business development, cost modelling, personal resource deployment and load balancing, project management, technical leader for air quality modeling, process safety management, risk assessment, and hazard consequence studies.

Alpine Geophysics, LLC – Eugene, Oregon
Senior Engineer and Managing Partner (1993 to 2013)

Business development, project management, and technical leader providing guidance on air quality modeling studies. Cost modelling and personal resource deployment.

Radian Corporation – Sacramento, California
Senior Engineer (1992 to 1993)

Project and technical leader who provided guidance on air quality modeling studies.

Radian Corporation – Sacramento, California
Staff Engineer and Computer Scientist/Engineer (1988 to 1992)

Project technical leader who provided environmental engineering and air quality modeling services. Provided database and systems development services for environmental engineers.

ARCO Alaska, Inc. – Anchorage, Alaska
Petroleum Engineer (1985 to 1986)

Drilling engineer and operations engineer supporting production drilling and facilities operations in Prudhoe Bay, Kuparuk River, and Cook Inlet fields.

Montana Tech Computer Services – Butte, Montana
Programmer II (1984 to 1985)

Provided support for campus-wide computer services.

ARCO Alaska, Inc. – Anchorage, Alaska
Petroleum Engineer (1984)

Provided reservoir modeling support on Cray supercomputer.

Montana Tech, Environmental Engineering Department – Butte, Montana
Teaching Assistant (1982 to 1984)

Provided necessary support to a professor to teach environmental engineering to undergraduates. Ran computer laboratory for various classes.

PROJECT EXPERIENCE – METEOROLOGICAL & AIR QUALITY MODELLING

WRF, SMOKE, CMAQ Modelling for the City of Hamilton
Hamilton, Ontario

Dr. Wilkinson developed model inputs for WRF, SMOKE, and CMAQ to support comprehensive air quality modelling over Hamilton for 2012. He prepared data sets for nested 36-12-4-1.33 km domains centered over Hamilton with 30 vertical levels extending to 100 mb. Dr. Wilkinson conducted model performance evaluations for WRF and CMAQ to determine their skill at reproducing historical conditions. Pollutants considered in this assessment included B(a)P, formaldehyde, cadmium, ammonia, mercury, and chromium among others.

Steamboat Springs
Colorado

Estimated the impacts that planned improvements to the Steamboat Resort will have on air quality. Using MOVES2014a and NONROAD2008 to estimate the emissions (volatile organic compounds [VOCs], nitrogen oxides [NOx], sulfur dioxide [SO2], particulate matter [PM], and greenhouse gases [GHG]) from diesel and gasoline-fueled vehicles used during construction and operation. Impacts were estimated based on activities occurring during the summer of 2017.

MOVES2014 Modelling for Chicago, Minneapolis, and Kansas City; Urban Air Initiative

Dr. Wilkinson prepared inputs to and ran the Motor Vehicle Emissions Simulator (MOVES2014) for the subject cities for 2017 based on default data. Based on new fuel parameter data supplied by the sponsor, he adjusted the MOVES2014 inputs to reflect the alternate fuel parameters that were indicative of real-world fuels. A comparison of the on-road emissions estimates based on the default data and those based on the real-world fuel parameters showed that MOVES2014 may incorrectly account for changes in fuel parameters specifically associated with ethanol-blended fuels above E10.

Acid Mist Modelling with AERMOD Glencore --Mopani Copper Mines;
Zambia, Africa

Dr. Wilkinson prepared analyzed observational data for sulfuric acid concentrations and meteorology in order to prepare inputs to the MAKEMET and AERMOD models. MAKMET was used to estimate meteorological parameters necessary to drive AERMOD in its screening mode. AERMOD was used in screening mode to predict acid concentrations from an acid mist system used at the copper heap leach pad. The purpose of the modelling was to determine if acid concentrations are predicted to exceed established WHO levels at any time during the year. The team discovered that the proposed location of the heap leach pad was such that acid concentrations were likely to exceed regulatory levels near established neighborhoods. Based on our efforts, we offered alternative nearby locations for the proposed heap leach pad such that during its operation, there were predicted to be no exceedances of the WHO levels.

WRF Modelling for the City of Toronto
Toronto, Ontario

Dr. Wilkinson developed WRF model inputs for the initialization, 3D analysis nudging, and observational nudging fields based on data from the NCEP North American Regional Reanalysis data sets maintained at UCAR and routine monitoring data maintained at NOAA National Climatic Data Centre. He prepared WRF data sets for nested 36-12-4 km domains centered over Toronto with 30 vertical levels extending to 50 mb. WRF was run for each hour of 2012 to predict two- and three-dimensional prognostic meteorological fields including wind speed, wind direction, temperature, solar radiation, and mixing ratio. Dr. Wilkinson conducted a model performance evaluation to determine WRF's skill at reproducing historical meteorological conditions. Finally, he converted WRF outputs for use in CALPUFF simulations.

WRF Modelling over the Chukchi Sea; ConocoPhillips
Chukchi Sea

Using the Weather Research and Forecasting (WRF) system, prognostic meteorological simulations for period July through November, 2007, 2008, and 2009 were constructed and run for a 36-12-04 km nested domain structure, with a 37 layer vertical structure extending to 50 mb, for the Chukchi Sea off the coast of northwest Alaska. NCEP GFS 0.5 degree model data was used for WRF initialization and analysis nudging. NCEP GFS data were also used for sea ice and sea surface temperatures updated every six hours. Model performance evaluation (MPE) was conducted with MAPS and METSTAT at both the surface and aloft using available observations from routine monitoring. Model performance for mixing ratio, temperature, wind speed, and wind direction met or exceeded performance metrics. Finally, WRF outputs were converted for use in CALPUFF.

Eldora Mountain Resort Expansion
Colorado

Examined the impacts that a planned expansion to the Eldora Mountain Ski Resort will have on air quality. Using MOVES2010b and NONROAD2008 to estimate the emissions (VOCs, NOx, SO2, PM, and GHG) from diesel and gasoline-fueled vehicles used in the construction and operation phases of the project. The planned expansion is for the period 2015 through 2019, with peak operation impacts occurring in 2023.

Houston 8-Hour Dual Ozone Phenomena
Texas

Currently involved in research efforts focused on determining the conditions that led to the 8-hour dual-ozone formation phenomena in the Houston-Galveston-Brazoria (HGB) region of Texas. Developing and applying ensemble air quality modeling techniques that can further bound the range of modeled 8-hour ozone. Developing and applying 8-hour modeled ozone bias correction techniques. These methods and techniques, which are based on applied research that are taken from such forecasting efforts as hurricane and tsunami tracking, are directed at developing control scenarios that better address the unique dual ozone formation conditions that arise in the HGB 8-hour ozone non-attainment region.

Ethanol Fuels Study; CRC
Illinois, Michigan, and Georgia

Constructing a turn-key system that integrates the SMOKE emissions modeling platform with the CAMx air quality modeling for the Coordinating Research Council (CRC) to support its study of the impacts of alternative ethanol-blended fuels on air quality in multiple urban regions in the United States. Leading the effort to ingest multiple link-based on-road mobile source networks into SMOKE and apply on-road mobile source emissions factors from the MOVES2010b motor vehicle emissions simulator that have been adjusted to account for effects on emissions factors due to alternative ethanol-blended fuels. An additional component to this effort is likely to be an assessment of the effects of meteorology that is “flexi-nested” from 12 kilometers to 4 kilometers in CAMx, contrasted to a meteorology derived from first principles at 4-kilometer resolution using MM5.

San Joaquin Valley WOE
California

Developed methods that can be used in weight of evidence (WOE) analyses to support State Implementation Plans (SIPs). One method developed concerns determining the plausible range of future year design values for 8-hour ozone in the Central California Ozone Study (CCOS). Analyzed air quality model outputs to determine the range of ozone outcomes in both the base year and future year. Also examined the outputs to determine if grid cells selected for use in the relative response factor (RRF) are inappropriate for more than one monitor. Another method examined concerns the longitudinal trends that are being observed between ambient measurements of ozone and its precursors. Further, this trends analysis was extended to determine how the trends in the planning inventories are tracking with precursor trends.

Agricultural Emissions Tool (AgTool)
California

Developed a geographic information systems (GIS)-based platform in PostgreSQL-PostGIS to store and manipulate agricultural emissions. Developed methods to ingest agricultural surrogate data that can be used to spatially allocate emissions to grid cells. Further, provided a means to better temporalize agricultural emissions. This system was developed in tandem with an agricultural emissions forecasting system.

United States On-road Mobile Source Emissions Estimates
United States

Used MOVES2010a to develop hourly on-road mobile source emissions estimates for the years 2008, 2009, 2010, and 2020 for each county in the United States for each month of the years and for representative weekends and weekdays. Used the MOVES/SMOKE Interface Tool to facilitate the process of using MOVES to create on-road mobile source emissions estimates for use in air quality modeling. The MOVES/SMOKE Interface Tool is comprised of scripts that automate the proper use of the Emission Rate calculations. The SMOKE-MOVES tool provides three major functions: (1) Meteorological data preprocessor; (2) MOVES2010 model processor; and (3) SMOKE model processor. Modified the meteorological data preprocessor (MET4MOVES) to prepare month-specific, hourly profiles of temperature and humidity that are suitable for direct input to MOVES. Built custom SQL scripts to better facilitate the loading of data directly into the MOVES databases.

Areas of Influence; Various Clients
Various

Conducts research in the areas of emissions uncertainty and economic-based incentives (e.g., market trading programs) to control regional emissions. Current primary research project is concerned with determining the geographic extent of areas whose sources may contribute to air quality exceedances. These areas are known as Areas of Influence (AOI). Also interested in elucidating the impacts that uncertainty in biogenic emissions estimates have on urban- and regional-scale emissions control strategies.

Modeling On-Road Mobile Source Emissions Estimates for SESARM
Georgia

Used MOVES2010a to develop on-road mobile source emissions factors that can be used to estimate emissions for 10 states that cover the southeast United States. Modeled the year 2007 for winter and summer fuels for 40 representative counties in the 10 southeast states. Used the MOVES/SMOKE Interface Tool to facilitate the process of using MOVES to create on-road mobile source emissions estimates for use in air quality modeling. The MOVES/SMOKE Interface Tool is comprised of scripts that automate the proper use of the Emission Rate calculations. The SMOKE-MOVES tool provides three major functions: (1) Meteorological data preprocessor; (2) MOVES2010 model processor; and (3) SMOKE model processor. The Meteorological data preprocessor (MET4MOVES) prepares spatially and temporally averaged temperatures and relative humidity data to set up the meteorological input conditions for MOVES2010 and SMOKE using the Meteorology-Chemistry Interface Processor (MCIP) output files. The MOVES2010 model processor creates data input files (i.e., runspec) for use in MOVES2010 that specifies the characteristics of the particular scenario to be modeled, and it reformats the resulting MOVES2010 emission rates lookup tables that are suitable for input to SMOKE. The SMOKE postprocessor (MOVESMRG) estimates emissions from on-road mobile sources based on MOVES2010-based emission rate lookup tables and meteorology data from MET4MOVES.

Review of the Houston 8-hour Ozone SIP; TCEQ
Texas

Provided in-depth analyses of emissions, meteorological, and air quality modeling results developed by the Texas Commission on Environmental Quality (TCEQ) for use in preparing the 8-hour ozone State Implementation Plan (SIP). Six multi-day episodes in 2005, 2006, and 2018 were modeled. Conducted CAMx model performance evaluation of the Houston region to further understand the meteorological phenomena that led to elevated ozone levels. Conducted independent CAMx modeling and sensitivity analyses through the use of OSAT to elucidate the emissions source sectors and source regions that contribute to high ozone in the Houston region. Developed independent sets of stationary, area, non-road, on-road, and biogenic source emissions files suitable for use in SMOKE to provide parallel, corroborative, and alternative base case and future year episodic emissions development capabilities for use by the 8-hour Coalition and the US Environmental Protection Agency (EPA). Produced alternative analyses for the ozone modeled attainment demonstration based on the flexibility that is afforded in EPA's guidance. Performed extensive analysis of the ambient air quality record to examine trends in the regulatory design values (DV) at all monitors in the Houston region. Studied and evaluated the performance of the monitor-specific baseline design values (DVb), relative response factors (RRFs), and future year design values (DVf) with multiple tools including MATS. Models that are being used in this effort include CAMx, CMAQ, MM5, SMOKE, EPS3, MEGAN, BEIS3, GloBEIS, NONROAD, MOBILE6, and MOVES2010a.

Sacramento Air Quality Modeling Study
California

Provided emissions, air quality, and meteorological modeling capabilities to determine impacts to the Sacramento urban heat island, biogenic emissions, and air quality as a result of alternative tree planting scenarios in the Sacramento urban area. The goal of this effort was to quantify the State Implementation Plan (SIP) credit that can be taken for planting new urban forests in Sacramento or exchanging lower-emitting tree species for existing high-emitting tree species. Used urbanized-MM5 (uMM5) to quantify localized meteorological changes that may occur due to landuse/landcover changes as the results of tree planting scenarios. Propagated the meteorological predictions through BEIS3 and MEGAN to estimate changes in biogenic emissions. Finally, used CAMx to determine the outcome on air quality, in particular ozone, due to changes as a result of various tree planting scenarios.

CAMx Google Earth
Illinois

Developed a software tool to display Comprehensive Air Quality Model with extensions (CAMx) predictions in Google Earth. The software tool allows a user to select the time period and chemicals to display from a CAMx output file, and prepares a KMZ file containing PNG graphics and a KML file. The tool is based on Open Source and freeware tools PostgreSQL, PostGIS, and perl. Recently extended the tool to display stationary source daily emissions as estimated by SMOKE. Currently extending the tool to display air quality observations.

Enhancements to the California ITN
California

Developed version three of the Integrated Transportation Network (ITN) for the California Air Resource Board. The ITN was constructed using Open Source and freeware tools PostgerSQL, PostGIS, and perl. The ITN was based on the travel demand modeling results from more than 20 metropolitan planning organizations (MPOs). The ITN was constructed to function within the CONCEPT framework, but can also operate as a stand-alone system. The ITN utilized on-road mobile source emissions factors that were extracted from EMFAC2007. The extraction of emissions factors from EMFAC2007 was automated with the Windows-based tool AutoIt. The goal of this effort was to construct a unified travel demand modeling link-based network with associated travel analysis zone (TAZ) data for the state of California that can be used for such purposes as environmental justice litigation, conformity planning, development of on-road mobile source emissions estimates, and State Implementation Plan (SIP)-level air quality modeling.

Columbia River Gorge Air Quality Modeling Study
Oregon

Worked on a study of historical regional haze in the Columbia River Gorge. The study focused on assigning source culpability to haze and visibility degradation in the Columbia River Gorge. Developed CAMx-ready emissions estimates using SMOKE for winter and summer episodes in 2005 and 2018. Used SMOKE to develop CAMx-ready emissions estimates for such sources as confined animal feeding operations, commercial marine vessels, railroad operations, dairy operations, pulping operations, lumber mills, and electric generating units (EGUs)]. Prepared hourly estimates of sulphur dioxide (SO2) emissions from Mt. St. Helens. Estimated hourly emissions of carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter (PM) 2.5, PM-coarse, and ammonia (NH3) from controlled burns and wildfires. Prepared hourly estimates of emissions from EGUs and pulping facilities based on data extracted from the US Environmental Protection Agency (EPA) continuous emissions monitoring (CEM) archive. The emissions estimates were aggregated into multiple categories for use in the Particulate Matter Source Apportionment Technology (PSAT) tool of the CAMx air quality model. Developed an Excel workbook with associated Visual Basic macros that allows a user to investigate emissions by source category and source region (further extending the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) capabilities of CAMx. The Excel workbook with Visual Basic macros takes output from the SMOKE/SMKREPORT tool as input to the spreadsheet. Further, the Excel workbook has macros that allow the user to prepare summary graphics of the emissions estimates. Finally, modeled air quality using CAMx for 2018 to determine if air quality objectives for regional haze and visibility can be met.

Control Strategy Tool (CoST); EPA
North Carolina

Worked with the US Environmental Protection Agency (EPA) to develop the Control Strategy Tool (CoST). CoST is EPA's vision to replace AirControlNET. CoST is used to develop overall program costs associated with the selection of control measures and control programs that may be implemented to control emissions to achieve future year air quality objectives. Collected control measure and control program data and costs for criteria pollutants, air toxics, and greenhouse gases (GHGs). Provided analyses to determine the applicability of these data to sources in the US, as some of these data are being derived from programs outside the US.

Integration of the Model of Emissions and Gases from Nature (MEGAN) into ConCEPT
Illinois

Worked with the Lake Michigan Air Directors Consortium (LADCo) to update the Consolidated Community Emissions Processing Tool (ConCEPT) to include the biogenic emissions estimates model MEGAN. MEGAN (the Model for the Emissions of Gases and Aerosols from Nature) is the state-of-the-science model to estimate biogenic emissions. MEGAN is currently designed in MS-Access VBA and MS-Excel VBA. Lead analyst and programmer converting MEGAN to run under the PostgreSQL database. Performed the tasks to improve throughput of MEGAN under the SQL framework, as well as the throughput of the CONCEPT meteorological data processor. Also guided the effort to verify the MEGAN emissions estimates against the BEIS3 emissions estimates.

Retrospective Analysis of Trending Air Quality and Emissions Inventories in California
California

Prepared spatially and temporally resolved emissions estimates from stationary, area, and on-road mobile sources for a period spanning 1990 through 2004. These emissions estimates were compared to air quality measurements made over the same period to determine if trends in the air quality matched trends in the emissions inventory. One goal of this effort was to determine where deficiencies existed in the emissions inventory. Currently working with the California Air Resources Board (ARB) to determine trends of nitrogen oxides (NOx) and volatile organic compound (VOC) emissions versus ozone in Central California from 1990 through 2004. Comparisons of emission trends with ambient air quality trends at an air-basin level of aggregation may obscure important local changes, but the large-scale comparisons serve to illustrate why the rates of progress in improving ozone levels may be of concern in some areas. For example, in both the San Joaquin Valley (SJV) and South Coast Air Basin (SoCAB) areas, emissions of carbon monoxide (CO) declined by approximately 60 percent between 1990 and the present, and maximum ambient concentrations of CO declined by about the same amount (60 percent) in the two areas. In both areas, substantial (albeit somewhat different) decreases occurred in the emissions of both nitrogen oxides (NOx) and reactive organic gases (ROG). In both areas, ambient nitrogen dioxide (NO2) levels declined by approximately the same magnitude as did NOx emissions (35 to 40 percent). Yet, maximum 1-hour and 8-hour ozone levels declined appreciably in the SoCAB while remaining virtually unchanged in the SJV. Providing emissions support for this study, preparing emissions data for use in regression and trends analyses.

Central Regional Air Planning Area of Influence; CENRAP
Oklahoma

Prepared Area of Influence (AOI) diagrams and estimated emissions reductions needed to attain visibility objectives by 2018 for 10 Central Regional Air Planning Association (CENRAP) Class I areas and 12 near-CENRAP Class I areas. Developed AOIs for the 22 Class I areas by synthesizing the following data: Residence Time Difference plots; Probability of Regional Source Contribution to Haze (PORSCH) plots; and Tagged Species Source Apportionment (TSSA) results. The results of this effort were converted to geocoded coverages and maps using ARC/Info. Estimated sensitivity coefficients (for example, a sulphur dioxide [SO2] reduced value of -0.001 µg/m3 of sulfate per ton per day means that for each ton of SO2 reduced within an AOI, the Class I area will exhibit a decrease of 0.001 µg/m3 in sulfate concentration) by synthesizing the results of numerous brute force and DDM-3D air quality model runs. These data were in turn used to estimate the annualized costs to achieve emissions reductions necessary to meet future year air quality objectives in each of the Class I areas.

Consolidated Community Emissions Processing Tool (ConCEPT)
Illinois

Helped design and implement the open source emissions modeling system Consolidated Community Emissions Processing Tool (CONCEPT). CONCEPT is a PostgreSQL-based system whose goal is to house all data related to the emissions modeling process under a single database. Geographic information systems (GIS)-related functions are managed within the same PostgreSQL database using the PostGIS plugin.

California ITN; California ARB
California

Commissioned by the California Air Resources Board (ARB) to develop version two of the California Integrated Transportation Network (ITN). Recently completed the first version of the ITN using data from transportation demand models (TDMs) from 15 California metropolitan planning organizations (MPOs). In version two of the ITN, TDM data from approximately 20 MPOs were used. The ITN is a seamless representation of the on-road mobile source transportation network for all of California. On behalf of the ARB, used the ITN, in conjunction with the on-road emissions factors model EMFAC2002 and the Direct Travel Impact Model (DTIM), to estimate on-road mobile source emissions for a variety of multi-day air quality modeling episodes spanning the years 2000 through 2010. An interesting component of this effort was the development of a transportation gravity model in Excel VBA that can be used to estimate commercial truck trips and their distribution on the ITN.

1997 Southern California Ozone Study
California

In collaborative research with Dr. Robert Bornstein at San Jose State University, used MM5 to develop meteorological fields for the 1997 Southern California Ozone Study (SCOS-97). Developed the initialization fields and the four-dimensional data assimilation (FDDA) fields for use in MM5 for the 4-7 August 1997 modeling period. Developed alternative inputs to MM5 for this period (e.g., updated landuse) in an effort to garner better performance. Responsible for all aspects of model performance evaluation. Ultimately, used the MM5 outputs to prepare meteorological inputs to the CAMx air quality model.

Texas Biogenic Emissions Estimates
Texas

Completed work to estimate emissions for four ozone episodes in the Houston, Texas area using GloBEIS. Estimated emissions for 36-kilometer, 12-kilometer, and 4-kilometer grid structures. Prepared all meteorological inputs (base temperatures, antecedent temperatures, Palmer Drought Index, phased array radar [PAR], wind speed, and mixing ratio) based on predictions from MM5. The episodes ran from 8 to 15 days in duration. GloBEIS outputs were speciated using CB4 and reformatted for use in the CAMx and CMAQ chemical transport models.

Biogenic Emissions in Missouri and Kansas; Missouri DNR
Missouri

Prepared estimates of biogenic emissions for the Missouri Department of Natural Resources (DNR) for 36-kilometer, 12-kilometer, and 4-kilometer grid structures that center on St Louis, Missouri. Used SMOKE/BEIS to model the emissions for three multi-day episodes. Prepared all input files to SMOKE/BEIS. The landuse data were derived from version three of the Biogenic Emissions Landuse Database (BELD3). Temperature and phased array radar [PAR] data were based on MM5 predictions.

San Francisco Bay Area Air Quality Modeling Study; BAAQMD
California

Completed an emissions modeling study for the Bay Area Air Quality Management District (BAAQMD). Estimated emissions for multi-day ozone episodes for base case years in July 1999 and July 2000. Estimated emissions for future years 2002, 2005, 2007, and 2010. Estimated emissions for area sources, stationary sources, non-road mobile sources, on-road mobile source, commercial marine shipping, and biogenics for an airshed that encompassed most of California. The emissions estimates developed by him were used to model base year air quality levels over California with particular emphasis on model performance over the San Francisco Bay Area. Further, the future year emissions estimates will be used in on-going air quality modeling efforts to develop emissions control strategies for mitigation of the 1-hour and 8-hour ozone National Ambient Air Quality Standards. In an effort to understand where potential deficiencies in the emissions inventory exists, also completed an in-depth, comparative analysis of emissions estimates among common source categories between the Central California Ozone Study (CCOS) emissions database and the VISTAS emissions database.

Southern Appalachian Mountains Initiative
Georgia

Lead emissions and air quality modeler for the Southern Appalachian Mountains Initiative (SAMI) project. The SAMI was a multi-episodic, integrated (i.e., acid deposition, ozone, and visibility/particulate matter), regional-scale air quality modeling study over the eastern United States with particular focus on the southern Appalachian Mountains. The selected episodes were 7 to 15 days in length and span 1990 through 1995, with future years of 2010 and 2040. In the SAMI project, responsible for the preparation of all aspects of the air quality model ready inputs including, but not limited to, emissions estimates (e.g., area source spatial surrogates, mobile source emissions estimates, biogenic emissions estimates, emissions estimates speciation, and data management of the emissions data); conversion of prognostic meteorological modeling results from RAMS and MM5 to URM-ready meteorological fields (including interpolation of the fields from the meteorological grid structure to the air quality modeling grid structure); and diagnosis of boundary and initial air quality conditions. In the SAMI study, designed, implemented, and maintained the geographic information system (GIS)-based components of the emissions and air quality modeling system. As part of the GIS for the SAMI project, maintained coverages of population, housing, urban areas, water, political boundaries (i.e., states, counties, national boundaries, and airsheds), forests, biogenic land cover, railroads, major roadways, water ports, airports, major stationary sources of air pollution, and air quality monitoring stations. The GIS-based data were used to disaggregate county-wide estimates of emissions from minor emissions sources into sub-county areas for the purposes of air quality modeling. Used the GIS-based data to link and display emissions estimates to sources, air quality observations, and air quality model predictions. Further, responsible for developing inputs to URM so air quality model performance goals for ozone, particulates, and wet/dry acid deposition were met.

Peninsula Florida Ozone Study
Florida

Prepared point source, area source, on-road mobile source, and biogenic emissions estimates for multiple ozone episodes over peninsular Florida. Developed a wildfire emissions estimates model that could estimate temporally and spatially varying wildfire emissions based on fuel types and fuel loads. Collected day-specific emissions for all electric generating utilities in the air quality modeling domain. Prepared alternative emissions estimates for commercial marine shipping. Point and area source emissions were based on the 1996 NEI, supplemented with emissions data and estimates from the Florida Department of Environmental Protection (DEP). Biogenic emissions were estimated using BEIS, BEIS2, and GloBEIS. Future year inventories were grown using E-GAS derived growth and control factors, supplemented with growth and control factors developed for specific source categories as determined by the Florida Department of Environmental Protection (DEP).

Biogenic Emissions from Mexico
Mexico

Performed a study to develop the first biogenic emissions inventory for northern Mexico. The new biogenic emissions inventory was integrated with existing anthropogenic emissions in an effort to better understand transboundary air pollution along the Mexico-United States border. The biogenic emissions inventory was developed from Mexican-supplied ground-truthed agricultural and forest coverage data, as well as satellite-based land use data. The data were compiled for use in BEIS2.

Breton Island Air Monitoring Program
Louisiana

Helped to complete a design of an air quality and meteorological monitoring network for the Breton Island National Wildlife Refuge Class I Area, located in the Gulf of Mexico just east of New Orleans, Louisiana. Designed the geographic information system (GIS) emissions, air quality, and meteorological database management system that will be used to house these data when the Breton Island Air Monitoring Program (BAMP) field program is implemented.

NH3 from Concentrated Animal Feeding Operations (CAFOs) in San Joaquin Valley
California

Completed a study to evaluate and improve existing ammonia emissions estimate techniques for use in the San Joaquin Valley of California. This study included a comprehensive literature review that focused on the following: methods that were used to estimate ammonia emissions; the development of a new ammonia emissions inventory for the study domain; the implementation of a pilot field study to improve upon methods to estimate ammonia emissions from dairy livestock, soils, and wastewater treatment plants; and the development of methods to estimate quantitative values of uncertainty about the ammonia emissions estimates. Developed a statistical model to estimate ammonia emissions from dairies.

Pittsburgh-Beaver Valley 1-hour Ozone SIP
Pennsylvania

Helped to complete the technical analysis for the State Implementation Plan (SIP) for the Pittsburgh-Beaver Valley 1-hour ozone non-attainment area. The technical analysis included the emissions modeling, air quality modeling, and attainment demonstration work needed for the SIP.

Study of Particulates and Health in Atlanta
Georgia

Completed work to determine the association of airborne pollutants to increased visits of children with respiratory problems to Atlanta-area emergency rooms. Using the geospatial statistical method known as kreiging, prepared maps of temporally and spatially disaggregated air quality measurements over greater Atlanta, Georgia. Coupled these data with information derived from emergency room visits to Atlanta-area hospitals to determine that there was a statistically significant increase in respiratory-associated visits to the emergency room in the presence of elevated ozone levels.

Horizontal Advection Solver
Pennsylvania

Involved in examining the impacts of the horizontal advection solver in three-dimensional air quality models on emissions control strategies. In that study, responsible for running the UAM-IV and CIT models for established air quality modeling studies, and statistical analysis of the air quality modeling outputs. The statistical analyses were conducted to isolate and quantify the numerical interference due to various horizontal advection solvers that were introduced into the UAM and CIT air quality models.

OTAG
NE United States

Involved in the Ozone Transport and Assessment Group's (OTAG) efforts to examine regional-scale air quality in the eastern United States. Primary engineer tasked with preparing emissions modeling inputs (e.g., area source spatial surrogates, on-road mobile source transportation network, and geographic information systems [GIS]-based EMS-95 foundation data) for the Emissions Modeling System version 1995 (EMS-95). Provided technical support to the OTAG participants in the application of EMS-95 to the eastern United States and southern Canada.

GEMAP
California

Instrumental in the design and development of the Geocoded Emissions Modeling and Projections System (GEMAP) which was the predecessor of EMS-95. Prepared design documents for the overall architecture of the system, as well as for the point and area source models. Developed both SAS and ARC/Info code for the point source, area source, and on-road mobile source models. Applied GEMAP to develop emissions estimates for the SARMAP and LMOS air quality modeling studies.

Houston 8-hour Ozone Coalition
Texas

Currently involved in research efforts focused on determining the conditions that led to the 8-hour dual-ozone formation phenomena in the Houston-Galveston-Brazoria (HGB) region of Texas. Developing and applying ensemble air quality modeling techniques that can further bound the range of modeled 8-hour ozone. Developing and applying 8-hour modeled ozone bias correction techniques. These methods and techniques, which are based on applied research that are taken from such forecasting efforts as hurricane and tsunami tracking, are directed at developing control scenarios that better address the unique dual ozone formation conditions that arise in the HGB 8-hour ozone non-attainment region.

PROJECT EXPERIENCE – HAZARD CONSEQUENCE ASSESSMENT

UEO DTI; Momentum, LLC
Leesville, Ohio

15 MMscfd of natural gas is conveyed along a 4 mile long, 15 inch diameter underground pipeline operating at 525 psi and 38°F. The purpose of the study was to determine if high consequence areas (HCAs) (i.e., sensitive ecosystems, drinking water supply, or populated areas) were impacted due various leak and rupture scenarios that result in natural gas being released. Using PHAST, models of hazardous events were constructed. Consequences that were modelled include pooling-evaporation and 10% lower explosive level assessment that might result in an explosion or fire. Model results were overlaid on a geo-referenced aerial photograph to graphical show the areal extent of impacts to HCAs.

Facility Hazard Assessment Review; National Renewable Energy Laboratory
Golden, Colorado

Conducted hazard consequence modelling for scenarios involving accidental releases of arsine, silane, ammonia, dodecane, and hydrogen. Using PHAST, estimated hazard distances to IDLH-AEGL-ERPG toxic thresholds, overpressure threshold (1 psi) from explosions, and thermal threshold (4 $kW \cdot m^{-2}$) from fires. Estimated thermal intensity for grassland wildfire to determine if ethanol storage facility was at risk. Determined likely impacts to worker and general public health and safety. Conducted asphyxiation assessment due to liquid nitrogen spill. Conducted asphyxiation assessment due to carbon monoxide release. Conducted dropped load risk assessment due to excessive crane load.

Aqueous NH3 Storage Tank Consequence & Risk Assessment; TransAlta Canada
Edmonton, Alberta

Aqueous ammonia is transported, stored, and utilized at a gas-fired power plant. Accidental release scenarios were developed including the rupture of the delivery line, the rupture of the transfer pipe, and a ten minute release. Five years of meteorological data were analyzed to determine the joint probability of the occurrences of wind speed, wind direction, and atmospheric stability. The Process Hazard Analysis Software Tool (PHAST) was used to estimate the hazard distance for each hazard scenario. Maximum concentration plume footprints were estimated based on IDLH, ERPG-1, ERPG-2, ERPG-3, AEGL-1, AEGL-2, and AEGL-3 values. The likelihood of these events was estimated based on historical accidental release data. The 1-in-1,000,000 individual risk of fatality was estimated should an event occur. The number of residences was estimated to be impacted by a hazardous event. The information was used to develop a Risk Management Plan, including shelter-in-place and emergency evacuation procedures, for mitigation and communication.

Anhydrous NH3 Storage Tank Consequence & Risk Assessment; TransAlta Canada
Edmonton, Alberta

Liquid anhydrous ammonia is transported, stored, and utilized at a gas-fired power plant. Accidental release scenarios were developed including the rupture of the delivery line, the rupture of the transfer pipe, activation of the relief valve, and a ten minute release. Five years of meteorological data were analyzed to determine the joint probability of the occurrences of wind speed, wind direction, and atmospheric stability, which impact the transport and dispersion of ammonia released to the atmosphere. The consequences of these hazard events were modelled using PHAST, and the hazard distance estimated for each hazard scenario. The likelihood of these events was estimated based on historical hazard events. Overall risk was estimated as number of chances in one million that event would occur. Maximum concentration plume footprints were estimated based on IDLH and ERPG-2 values, and the number of residences was estimated to be impacted by the hazardous event. The information was used to develop a Risk Management Plan for mitigation and communication purposes.

Diesel & Bitumen Pipelines Emergency Release and Odour Analyses; TransCanada Pipelines Limited (TransCanada)
Ft. McKay, Alberta

Conducted an air quality modelling assessment using PHAST of odour effects resulting from a potential accidental leak from the proposed pipelines near the Hamlet of Fort MacKay, Alberta. The project included two buried pipelines (a Diluent Pipeline and a Bitumen Pipeline) that are located together on the same right-of-way. The goal of the air quality modelling assessment was to address concerns over possible odour effects and exceedances of Alberta Ambient Air Quality Objectives for H2S, BTX, and mercaptans from an accidental release of product. Accidental release events considered were three sizes of corrosion leaks, and a full rupture of a pipeline by an impact such as a backhoe strike. Leak sizes assumed were 20 mm, 50 mm, and 80 mm in diameter. A full rupture was assumed to last for 10 minutes before the line fully emptied and was shut down. These events are considered worst case, and possible leaks or ruptures may not be as large or continue for as long as the hypothetical scenarios.

UEO M3 HCA; M3 Midstream, LLC
Scio, Ohio

LNG, ethane, and propane are being transported via three separate pipelines (both above and below ground). The purpose of the study is to determine the consequences of a pipeline rupture due to a strike from a backhoe during uncovering and to determine if there adverse impacts to populated areas. Using PHAST, a model of the hazardous event has been constructed. Consequences that have been modelled include the following: pooling and evaporation; toxic endpoint (IDLH) assessment; jet-fire assessment; and explosion assessment. Model results have been overlaid on a geo-referenced aerial photograph to graphical show the areal extent of impacts to populated areas.

Propane-Air Plant & Storage Facility FMEA; Puget Sound Energy
Renton, WA

Conducted a failure mode effects analysis (FMEA) of a Propane-Air Plant and Storage facility. The purpose of the FMEA was to determine if any of the identified potential failure modes could result in significant adverse safety consequences (e.g., bodily injury, death). Each potential failure mode was evaluated based on a qualitative assessment of the probability of failure, the severity of effects, and the likelihood of detection. The scales assigned to the probability of failure, the severity of effects, and the likelihood of detection ranged from one to five with the higher value indicating a more detrimental effect. The product of these three values provided a qualitative means to rate the potential failure modes. Based on the FMEA results, it was determined that no additional quantitative risk analysis would be required for the facility.

CO_2 Pipeline Rupture Consequence Analysis; Anadarko Petroleum Company
Casper, WY

CO2 is transported via pipeline to wellheads for use in enhanced oil recovery (i.e., injection). Two PHAST modelling scenarios were considered: breach of a 20" pipe operating at approximately 1400 psi; and breach of a 30" pipe at approximately 300 psi (both operating at 40 F). Ambient meteorological conditions modelled included wind speed of 5 mph, D atmospheric stability class, temperature of 14 F, and atmospheric pressure of 11.5 psia. The total weighted average permissible limit (TWA) for CO2 is 5,000 ppm, and the short term exposure limit (STEL) is 30,000 ppm based on NIOSH and OSHA standards. Steady state was achieved almost instantly for both cases when concerning the 30,000 ppm STEL boundary. The higher pressure 20" pipe spread to a distance of approximately 90' and the lower pressure release achieved a distance of 14'. Both scenarios showed high elevations (>60') at this concentration. The 5,000 ppm cloud from the high pressure 20" pipe rupture did not descend to the ground until approximately 135' from the source. Final diffusion to concentrations lower than 5,000 ppm occurred at 522' from the source (at steady-state). The lower pressure 30" pipe rupture reached steady state almost instantly and did not reach ground level before diffusion reduced concentrations below 5,000 ppm. The cloud did reach a distance of approximately 112' (at an elevation of 102') from the source before diffusion.

PROJECT EXPERIENCE – EXPERT TESTIMONY

Garfield County, Colorado Oil and Gas Commission
Denver, Colorado

Dr. Wilkinson provided testimony to the Colorado Oil and Gas Commission on behalf of Garfield County who represented the Energy Producing Attainment Counties of Colorado in their efforts to challenge expansion of new emissions controls on oil and gas exploration/production operations outside the Denver 8-hr ozone non-attainment area. Dr. Wilkinson prepared and delivered evidence refuting claims by Environmental Defense Fund (EDF) that expansion of emissions controls state-wide would be beneficial to society. He demonstrated that air quality modelling results were incorrectly interpreted by the EDF, and that an alternative explanation of the modelling results showed virtually no predicted improvement in air quality would occur with the state-wide expansion of changes to Regulation 7; however, the cost to implement such state-wide changes would be large..

Columbia Pacific Bio-Refinery (CPBR), Oregon Department of Environmental Quality (DEQ)
Portland, Oregon

Dr. Wilkinson conducted research into claims made by plaintiffs that accused CPBR of using incorrect data to determine its facility-wide emissions, which kept the facility under PSD permitting requirements. CPBR is a facility that transloads Bakken crude oil from trains to barges on the Columbia River. He specifically focused on chemical analyses of the crude oil and its vapor, which the plaintiffs claimed were grossly underestimated by CPBR. Based on his research, Dr. Wilkinson determined that the data used by CPBR to estimate its facility-wide emissions were appropriate.

MOVES2014 Modelling for Chicago, Minneapolis, and Kansas City; Urban Air Initiative

Dr. Wilkinson prepared inputs to and ran the Motor Vehicle Emissions Simulator (MOVES2014) for the subject cities for 2017 based on default data. Based on new fuel parameter data supplied by the sponsor, he adjusted the MOVES2014 inputs to reflect the alternate fuel parameters that were indicative of real-world fuels. A comparison of the on-road emissions estimates based on the default data and those based on the real-world fuel parameters showed that MOVES2014 may incorrectly account for changes in fuel parameters specifically associated with ethanol-blended fuels above E10.

TransAlta Sundance 7, Alberta Utilities Commission
Edmonton, Alberta

Dr. Wilkinson provided testimony on behalf of TransAlta and its application to install an 856 MW natural gas-fired electricity generating facility in the Lake Wabamun area west of Edmonton, Alberta. He delivered testimony to the Alberta Utilities Commission, which is the provincial licensing agency in Alberta. As approximately 15 to 40 metric tons of ammonia need be stored on site for use in the selective catalytic reduction system, Dr. Wilkinson spoke specifically to the consequences of an accidental release of anhydrous and aqueous ammonia. He spoke specifically to the modelling methods and tools used to estimate the consequences of an accidental release and the probability of such events occurring. He explained the differences in the toxic endpoints (i.e., AEGL, ERPG, and IDLH) that were used to determine hazard distances.

Western Energy Operators, Colorado Oil and Gas Commission
Denver, Colorado

Dr. Wilkinson provided testimony on behalf of Davis, Graham and Stubbs, LLP, who represented the Western Energy Operators, in its efforts to challenge new emissions controls on oil and gas exploration/production operations proposed under Regulation 7. He delivered testimony to the Colorado Oil and Gas Commission. Dr. Wilkinson prepared and delivered evidence refuting claims by the Colorado Department of Public Health and the Environment (CDPHE) that air quality modelling showed that the proposed emissions controls would be beneficial to society. He demonstrated that air quality modelling results were incorrectly interpreted by the CDPHE, and that an alternative explanation of the modelling results showed virtually no predicted improvement in air quality would occur with the implementation of changes to Regulation 7.

Houston 8-hour Ozone SIP Coalition, Texas Commission on Environmental Quality
Austin, Texas

Dr. Wilkinson provided testimony on behalf of the Houston 8-hour Ozone SIP Coalition in its efforts to modify emissions control rules for industrial facilities in the Houston-region. He delivered testimony indicating that some elevated ozone days in Houston were due to fires occurring in the Pacific Northwest, Alberta, and British Columbia. He also demonstrated the contribution of flaring emissions to overall predicted air quality.

Bay Area Air Quality Management District (BAAQMD)
San Francisco, California

Dr. Wilkinson provided testimony to support BAAQMD in its efforts to defend the adequacy of its comprehensive air quality modelling studies. Plaintiffs claimed that BAAQMD made inappropriate assumptions in its modelling analyses, which led to the construction of emissions control strategies that were far less stringent than needed to be in order to attain the ozone NAAQS for the greater San Francisco Bay Area. Dr. Wilkinson's analyses showed that for each assumption made by the BAAQMD, the modelling assumption was appropriate and in some cases more conservative than needed to be.

PROFESSIONAL AFFILIATIONS

Air and Waste Management Association (AWMA)

Institute of Electrical and Electronics Engineers (IEEE)

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"MOVES2014a Emissions Estimates Due to Snowmass Multi-Season Recreation Project." Prepared for Ms. Gabby Voeller, Associate Planner, SE Group, PO Box 2729, Frisco, CO 80443. Prepared by James G. Wilkinson, PhD, Senior Engineer, 2076 Westwood Lane, Eugene, OR 97401. 01-October-2016.

"Hazard Consequence Modeling of a Natural Gas Pipeline from the Leesville Cryogenic Processing Plant to the DTI Interconnect." Prepared for Utica East Ohio Midstream, LLC, 10 East Main Street, Salineville, OH 43945. Prepared by Golder Associates Inc., 9 Monroe Parkway, Suite 270, Lake Oswego, OR 97035. Report Number 140766_CO1a_RevB. July 31, 2015

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System Documentation.” Prepared by James G. Wilkinson, PhD, Alpine Geophysics, LLC, 2076 Westwood Lane
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Appendix F

Health Risk Assessment

HEALTH RISK ASSESSMENT

for the

Friant Ranch Community Development Project

***Prepared for*:**

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March 4, 2021

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GLOSSARY OF TERMS AND ACRONYMS

Acronym	Description
AADT	Annual average daily traffic
AERMOD	AMS/EPA Regulatory Model
AM	Morning (ante meridiem)
aREL	Acute Reference Exposure Level
ASF	Age sensitivity factor
AT	Averaging time
BAAQMD	Bay Area Air Quality Management District
C	Annual Average or Maximum Hourly Air Concentration
CalEEMod	California Emissions Estimator Model
Cal/EPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CAS #	Chemical Abstracts Service Registry Number
CEQA	California Environmental Quality Act
CF	Conversion factor
CPF	Cancer potency factor
cREL	Chronic Reference Exposure Level
DBR	Daily breathing rate
DPM	Diesel particulate matter
ED	Exposure duration
EF	Exposure frequency
EIR	Environmental Impact Report
EMFAC2017	California Air Resources Board's Mobile Source Emissions Factor Inventory
ET	Exposure Time
FAH	Fraction time at home
g/sec	Grams per second
HI	Hazard index
HIA	Health Impact Analysis
HQ	Hazard quotient
HRA	Health risk assessment
IF_{inh}	Intake Factor for Inhalation
K	Kelvin
kg	Kilograms
kW	Kilowatt
L	Liters
LP	Limited Partnership
m	Meters
m^2	Square meters
m^3	Cubic meters
MEI	Maximally Exposed Individual
mg	Milligrams
m/s	Meters per second
NED	National Elevation Dataset
OEHHA	Office of Environmental Health Hazard Assessment
PM	Afternoon (Post Meridiem)
PM_{10}	Particulate Matter 10 Micrometers or less in aerodynamic

GLOSSARY OF TERMS AND ACRONYMS

Acronym	Description
	diameter
SAFE	Safer Affordable Fuel-Efficient factor
SJVAPCD	San Joaquin Valley Air Pollution Control District
TAC	Toxic air contaminant
TOGD	Total Organic Gases in Diesel Exhaust
TOGG	Total Organic Gases in Gasoline Exhaust
TRU	Transport refrigeration unit
USEPA	US Environmental Protection Agency
USGS	United States Geological Survey
$\mu g/m^3$	Microgram per Cubic Meter
UTM	Universal Transverse Mercator
WWTP	Wastewater treatment plant
yd^3	Cubic yards

1.0 INTRODUCTION

At the request of the County of Fresno (County) and the San Joaquin Valley Air Pollution Control District (SJVAPCD), BlueScape Environmental (BlueScape) prepared this Health Risk Assessment (HRA), which describes local health impacts due to emissions of toxic air contaminants (TACs) associated with the proposed Friant Ranch Community Development Project (Project) in Friant, California. The HRA was prepared to support the Project's California Environmental Quality Act (CEQA) documentation.[1] The Project consists of the Friant Ranch Specific Plan, the update to the Friant Ranch Community Plan, a new wastewater treatment facility, and improvements at such locations as the Depot Parcel.

The California Air Resources Board (CARB) maintains a list of TACs, defined as an "air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health" (CARB 2007). A TAC HRA, utilizing dispersion modeling to determine atmospheric concentrations, is the type of study typically requested by SJVAPCD for CEQA analyses to determine localized health impacts of a Project.

The Project site is located nearly twenty (20) miles to the north of Downtown Fresno, California in a largely rural setting within the jurisdiction of the SJVAPCD. A few scattered residential neighborhoods are located to the east, northeast, and west of the Project site.

Construction of the Project is assumed to begin in 2022 and is scheduled to occur in five phases over an approximate ten-year period, starting with Phase 1 in the northern-most area of the Project site. Impacts from construction emissions over the ten-year period are considered in this analysis. However, as discussed in this report, a screening analysis using SJVAPCD's risk prioritization score calculator demonstrates that health risk impacts on on-site and off-site residents from construction activities will not exceed thresholds that, if exceeded, would indicate a need for further evaluation of health risk impacts. Therefore, Project construction emissions-related impacts are considered to be insignificant and only Project operational impacts are analyzed for this HRA.

Full Project operation is projected to begin in 2031. The HRA considered potential impacts from traffic due to the Project, as well as from cumulative traffic that is not related to the Project in 2031, using traffic volume data from the year 2030, which is the closest year to 2031 for which projected traffic data was available. These two scenarios (called Project-only and Cumulative, respectively) analyze potential impacts from diesel and gasoline exhaust from traffic on roads adjacent to the Project site, as well as from diesel-powered generators proposed to be installed nearby at a new wastewater treatment

[1] A Project HRA was discussed with the SJVAPCD in a 9/13/2014 meeting.

plant (WWTP). Diesel exhaust includes diesel particulate matter (DPM) and speciated components including benzene, formaldehyde, and other TAC compounds. Gasoline exhaust includes speciated components such as acrolein, naphthalene, and other TAC compounds. Air emissions were calculated using emission factors obtained from the CARB's Mobile Source Emissions Factor Inventory, EMFAC2017 (CARB 2017) and from the California Department of Transportation (or Caltrans) peak hour volume data for No-Project conditions in 2030 and for With-Project conditions in 2030 provided in the Friant Ranch Draft Environmental Impact Report (County of Fresno 2009).

The HRA was completed by referencing the SJVAPCD *Update to District's Risk Management Policy to Address OEHHA's Revised Risk Assessment Guidance Document* (SJVAPCD 2015b), the SJVAPCD *Framework for Performing Health Risk Assessments* (SJVAPCD 2018), the SJVAPCD *Draft Guidance for Air Dispersion Modeling* (SJVAPCD 2007), and the Office of Environmental Health Hazard Assessment *Risk Assessment Guidelines* (OEHHA 2015). This report provides a brief description of diesel and gasoline exhaust emission sources from Project operations, traffic that is not related to the Project, and the WWTP diesel generators. The TAC emission calculations, calculation of TAC concentrations from air dispersion modeling, and estimation of health risk impacts are provided in the report attachments.

As stated in the HRA report conclusions, the Project-only localized health risk impacts on off-site and on-site residential receptors from Project operational emissions are not expected to exceed a 20 in one million excess cancer risk CEQA significance threshold. The Project-only non-cancer chronic and acute localized health risk impacts will not exceed a 1.0 hazard index (HI) CEQA significance threshold. The Cumulative localized health risk impacts on off-site and on-site residential receptors are not expected to exceed a 100 in one million excess cancer risk CEQA significance threshold. The Cumulative non-cancer chronic and acute health risk impacts will not exceed a 10 HI CEQA significance threshold. Therefore, the Project is not expected to expose off-site or on-site residences to substantial amounts of TAC emissions that would cause a significant health impact and require further mitigation.

1.1 Site Setting and Project Description

The proposed Project is a mixed-use development proposed by Friant Ranch LP (Project sponsor). The Project would develop retail, residential, and open space uses on a 942-acre site in Friant, California as shown in Figure 1. The Project will be primarily residential, with up to 2,270 dwelling units age restricted to over 55, and up to 230 dwelling units without age restriction.

The site is in a mostly rural area, with scattered neighborhoods and houses to the northwest, northeast, and southwest of the Project site. Off-site roads near the Project site include North Friant Road, which runs in a northwest/southwest direction directly along the eastern property line of the Project. North Friant Road becomes Millerton Road at the northern tip of the Project site where the

direction changes to mostly an east/west direction. North Fork Road / Road 206 branches off at the N. Friant Rd. / Millerton Rd. transition, and runs in an east/west direction. These off-site roads are included in the HRA.

A wastewater treatment facility will be developed to support the Project and other expected growth in the Friant Community at a different site (the Beck Property) on the west side of Friant Road. The wastewater treatment facility will require two diesel emergency generators at full build-out, and for the analysis presented in this report, are considered to be a part of the Project.

1.2 Objective

The purpose of the air quality analysis was to assess potential health impacts that would result from emission of TACs from the operation of the Project consistent with guidelines and methodologies from SJVAPCD, CARB, the Office of Environmental Health Hazard Assessment (OEHHA), and the US Environmental Protection Agency (USEPA). Consistent with the methods recommended in those guidelines, the HRA evaluated the estimated excess lifetime cancer risk associated with TACs that would be emitted by the Project's operational stationary source emissions (e.g., diesel generators) as well as from Project-related diesel and gasoline vehicles. The Cumulative analysis estimates excess lifetime cumulative cancer risks from TACs that are attributable to existing and projected future mobile sources within the Project vicinity, and a gasoline dispensing facility, in addition to impacts from the Project. Chronic and acute non-cancer impacts are also estimated for the Project during operation, and for the Cumulative analysis.

As requested in discussion with SJVAPCD, the HRA evaluated excess lifetime cancer risks and chronic and acute hazard indices from Project operational emissions to existing sensitive receptor populations.

Following CARB recommendations and using guidance from the Bay Area Quality Management District (BAAQMD) for an approximate 1,000-foot zone of influence surrounding the site, cumulative excess lifetime cancer risks and non-cancer chronic and acute hazard indices resulting from major roadway mobile source TAC emissions, as well as stationary source TAC emissions, were evaluated.

1.2.1 Construction Emissions Health Risk Screening

The construction emissions associated with the ten years and five phases of Project construction were considered for the HRA. Because TAC emissions from other sources such as gasoline exhaust will be negligible during construction, and only diesel exhaust will drive the health impacts, only diesel exhaust from construction equipment was included in risk screening. SJVAPCD guidance (SJVAPCD 2015a) states that construction emissions shall be analyzed separately from operational emissions. To determine whether or not emissions from Project construction need to be included in the HRA, the SJVAPCD Prioritization Risk Screening Tool was used to screen cancer, chronic, and acute

risk impacts due to the maximum diesel particulate matter (DPM) emissions from construction activities over the approximate 10-year construction period (CAPCOA 2016). If a cancer prioritization score exceeds a value of 10 at the nearest residential receptor, then the health risk impact from the construction operations must be included in the HRA. Additionally, if a chronic and/or acute non-cancer prioritization score exceeds a value of 10, then SJVAPCD recommends that further review of construction health risk impacts be conducted (SJVAPCD 2018).

The California Emissions Estimator Model (CalEEMod), v.2016.3.2, was used to model emissions for each year of construction, starting in 2022 and ending in 2031. The average unmitigated DPM construction emissions for that ten-year period were estimated by CalEEMod to be 0.204 tons/year or 1.57 lb/day, and a maximum of 4.94 lbs/day. A receptor proximity of 250 meters was chosen for screening purposes, which is the minimum distance from the middle of construction Phase 1 and from the middle of construction Phase 2 to the nearest resident, either off-site or on-site.

To screen for cancer risk impacts, the average annual DPM emissions of 0.204 tons/year were annualized over a 70-year lifetime cancer risk time period, by multiplying by 10 years/70 years. This annualized DPM emissions number was then entered into the prioritization screening tool with the DPM Chemical Abstracts Service Registry Number (CAS #) 9901. The resulting cancer score for a receptor that is between 250 meters and 500 meters from a source is 5.39, which does not exceed the cancer prioritization score of 10.

To screen for chronic risk impacts, the average annual DPM emissions of 0.204 tons/year were entered into the prioritization screening tool with the DPM CAS #9901. The resulting chronic score for a receptor that is between 250 meters and 500 meters from a source is 0.056, which does not exceed the chronic prioritization score of 10.

To screen for acute risk impacts, the maximum daily DPM emissions of 4.94 lbs/day were divided by the assumed 8 hrs/day workday to give 0.62 lbs/hr. Then, the resulting 0.62 lbs/hr were apportioned to each of the speciated components in diesel exhaust using the weight fractions of compounds in diesel exhaust shown in Table 10. Each of the seven Total Organic Gases in Diesel Exhaust (TOGD) components that have acute risk Reference Exposure Levels (aRELs) were entered into the prioritization screening tool with their corresponding CAS numbers. The resulting acute score for a receptor that is between 250 meters and 500 meters from a source is 0.12, which does not exceed the acute prioritization score of 10.

Since none of the screening prioritization scores exceed their limits, impacts on residents from Project construction were not included in this HRA.

1.2.2 Off-Site and On-Site Traffic Emissions

In addition to traffic emissions from off-site roads, emissions from on-site roads were considered. Cal/EPA's 2005 Land Use Handbook (Cal/EPA 2005) recommends that health protective distances (500 feet at minimum) be implemented to separate sensitive uses from freeways, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day. Traffic on the main off-site access roads into the Friant Ranch Community such as Friant Road is not expected to exceed 3,000 vehicles/day, but has been included at SJVAPCD's request. As recommended by BAAQMD Guidance, the off-site traffic emissions within 1,000 feet from the Project site were considered for the HRA.

The on-site roads in the Friant Ranch retirement community will have much lower daily vehicle traffic volumes spread over a large area as compared to the main access roads located within 1,000 feet of the Project site. Impacts from the on-site roads would be inconsequential compared to impacts from the off-site roads that were included in the HRA. Therefore, impacts from Project on-site roads were not analyzed in this HRA.

1.2.3 Unmitigated vs. Mitigated Traffic Emissions

A detailed study of unmitigated and mitigated emissions due to traffic exhaust was conducted using CalEEMod in the Health Impact Analysis (HIA) report that addresses regional air quality and health impacts (BlueScape 2021). For this localized HRA, vehicle exhaust emissions were calculated using a calculation method similar to the one used in the HIA, except that, to obtain necessary TAC emissions details, CalEEMod was not used to quantify these emissions. Both CalEEMod and the HRA calculations shown in the report tables use EMFAC2017 and the "Safer Affordable Fuel-Efficient" (SAFE) factors (CARB 2019), and the emissions calculated using these two methods resulted in very similar emissions numbers between the two studies. Because there are no additional feasible mitigation methods for vehicle exhaust due to traffic on these off-site roads, the DPM, Total Organic Gases from Gasoline Exhaust (TOGG), and TOGD emissions calculated are considered mitigated emissions in this HRA.

1.3 Methodology

Due to the Project, there will be traffic-related operational TAC emissions as well as TAC emissions from two stationary standby emergency generators located at the proposed wastewater treatment facility. Cancer risks and non-cancer chronic and acute hazard indices from total organic gases from gasoline and diesel exhaust (TOGG and TOGD) and diesel particulate matter (DPM) from traffic at the site and the standby emergency generators were evaluated.

To meet these objectives, the HRA was conducted consistent with the following guidance:

- *Air Toxics Hot Spots Program Risk Assessment Guidelines*, Office of

Environmental Health Hazard Assessment (OEHHA) and California Environmental Protection Agency (OEHHA 2015);

- *Update to District's Risk Management Policy to Address OEHHA's Revised Risk Assessment Guidance Document*, San Joaquin Valley APCD (SJVAPCD 2015b);
- *Framework for Performing Health Risk Assessments*, San Joaquin Valley APCD (SJVAPCD 2018); and
- *Draft Guidance for Air Dispersion Modeling*, San Joaquin Valley APCD (SJVAPCD 2007).

Excess lifetime cancer risks and non-cancer chronic and acute hazard indices were evaluated based on the emissions estimation methods described in the following sections.

1.3.1 Project Sources – Operation at Project Build-Out (2031)

According to the Project sponsor, the Project will be developed in phases over multiple years. Project emissions at full build-out in 2031, the first year when the Project site can be fully occupied, were analyzed. However, the HRA was performed using traffic volumes assuming full Project operation in the year 2030, which was the year analyzed in the EIR's traffic study (County of Fresno 2009). This is a conservative approach, given that improvements in vehicle technology and turnover within the vehicle fleets are expected as time goes by. Emissions in 2030 are expected to be slightly higher than emissions in 2031.

1.3.2 Cumulative Sources at Project Build-Out (2031)

Emissions were based on Project Build-out conditions and 2030 cumulative traffic volumes[2], but the HRA was performed for year 2031 which is consistent with the Project-only analysis.

2.0 OPERATIONAL EMISSIONS ESTIMATES

For each source of operational emissions, the most conservative (i.e., with the greatest potential impact) options were evaluated. While both the Friant Ranch Community and the wastewater treatment facility will be developed in stages, this analysis assumes that the Project is at full build-out in 2031, and it is understood that this year also corresponds with the first year that the Project site could be fully occupied. The operational emissions discussed here include gasoline and diesel exhaust from mobile and stationary sources due to the Project and due to non-Project traffic and operations. Mobile and stationary source diesel exhaust was analyzed in this HRA as both DPM and the TACs in

[2] 2030 traffic estimates were the closest year available to the build-out date from the EIR (County of Fresno 2009).

that exhaust, known as total organic gases (TOGD). Mobile source gasoline exhaust was analyzed in this HRA as the TACs in that exhaust, known as total organic gases (TOGG).

2.1 Calculation Methodologies for Stationary Sources

The Project includes two new diesel emergency generators to support a small, 0.8 million gallon per day wastewater treatment facility. The wastewater treatment facility, which will run on electricity, will only require one 500-kilowatt (kW) backup generator for many years, until demand necessitates the use of another 300-kW backup generator. However, it is conservatively assumed that the entire complement of emergency generators (800 kW) would be in use in 2031. This conservative approach also ensures that the analysis includes the highest possible exposure scenario for the nearby receptors. The backup generators will be used infrequently up to 50 hours/year for testing and during any emergencies. Emissions from both generators were calculated for an engine with the Tier 3 emissions standards using the methodology presented in Table 1.

Stationary sources that are not a part of the Project include a gas station that dispenses around 1.6 million gallons per year within 600 feet of the Project site. This source, which is located adjacent to the northern portion of the Project site at the intersection of N. Fork Road and Millerton Road/N. Friant Road, is included in the Cumulative analysis.

2.2 Calculation Methodologies for Mobile Sources

The analysis included emissions from vehicle trips, based on estimated 2030 PM peak hourly traffic volumes provided by the traffic engineer in the Draft EIR (the highest estimated traffic year from the Draft EIR) (County of Fresno 2009). Project traffic emissions were estimated assuming full Project build-out in 2031 with the understanding that 2031 would also be the first year that residents could fully occupy Friant Ranch. Note that the traffic volumes provided in the Draft EIR were for a land use plan with more proposed homes than the version of Project approved by the County of Fresno in 2011 (Alternative 3 from the Draft EIR) and being considered again by the County. This assumption of a larger number of homes than are currently being considered adds an additional layer of conservatism. Traffic volumes for the Project-only analysis were obtained by subtracting the 2030 No-Project Conditions from the 2030 With-Project Conditions estimated PM peak hourly traffic volumes. The Cumulative analysis relied on the traffic volumes provided as the 2030 With-Project Conditions as a conservative measure. Afternoon (PM) peak hourly traffic volumes were converted to annual average daily traffic (AADT) volumes by applying the 75th percentile "K" factor (7.88%) from CalTrans 2017 data for Fresno County[3], as many traffic studies only estimate

[3] A "K" factor represents the percentage of the AADT in both directions during the peak hour. Data for this analysis gathered from the following source: CalTrans 2017. Peak Hour Volume Data.

AM and PM peak hourly traffic. The PM peak hourly and AADT volumes for the Project at the relevant traffic segments are shown in Table 2.

Mobile emission factors were calculated for each individual year over a 70-year period (beginning in calendar year 2031 as described above) for DPM, diesel TOG, and gasoline TOG. Mobile emissions over a time period of 70 years are required for the HRA, as exposure to pollutants over a 70-year period is consistent with SJVAPCD guidance for calculating lifetime cancer risk impacts (SJVAPCD 2018) and includes children in utero in their mothers' third trimester of pregnancy, rounded from 70.25 to 70 years. While the same traffic volumes are assumed for each year, vehicle emission factors are reduced every year due to automobile turnover and increasingly stringent emissions regulations. Table 3a shows the emission factors used for the analysis. The emission factors were developed on a gram per mile basis using EMFAC2017, assuming that DPM and diesel TOG are emitted via running exhaust vehicle emission pathways, and that gasoline TOG is emitted via running exhaust and evaporative running loss pathways. These gram per mile emission factors were used to develop emissions estimates for each roadway analyzed in the HRA and were also used to develop residential receptor exposure weighted emission factors (presented in Table 3b) for use in the HRA dispersion modeling for cancer risk analysis. Exposure assumptions and dispersion modeling methods are discussed in further detail in the following report sections. To develop these exposure weighted emissions, the gram per mile emission factors from Table 3a were weighted on a year-by-year basis by the product of a residential receptor's Daily Breathing Rate (DBR), Fraction of time at Home (FAH), and Age Sensitivity Factor (ASF) exposure parameters consistent with 2015 OEHHA guidance. The 70-year average exposure-weighted emission factor is used in the HRA dispersion modeling.

Table 4 shows the percentage split of diesel and gasoline vehicles in 2031 in Fresno County (CARB 2017). This county-wide breakdown is used for both the Project-only and Cumulative analysis. The breakdown of gasoline and diesel vehicles is required to estimate emissions from the traffic.

In addition to the roadway vehicle trips discussed above, Friant Ranch will have six to twelve businesses that may require deliveries, resulting in truck idling and transport refrigeration unit (TRU) operation at local business loading docks. Most of the businesses would only require deliveries on a sporadic basis, likely one truck per day or less. The loading docks at the Friant Ranch businesses will be equipped with 110/208-volt power outlets in order that any TRU can be plugged in for deliveries. Localized risks from diesel traffic and TRU idling at retail or dining establishments are not typically estimated for projects due to the minimal risk expected due to the small level of diesel traffic. CARB's Air Quality and Land Use Handbook (Cal/EPA 2005) describes potential risks from distribution centers, which have significantly higher diesel traffic, and thus risks, and sets the threshold for special consideration of distribution centers at 100 trucks per day, more than 40 trucks with operating TRUs per day, or where TRU unit operations exceed 300 hours per week. Since the

operations at Friant Ranch are much lower than this threshold in the aggregate, the risk due to diesel and TRU idling from off-site sources is expected to be minimal and well below significance thresholds. Accordingly, they do not warrant quantitative emission estimation or modeling.

3.0 AIR CONCENTRATION ESTIMATES

For the Project analysis, TAC concentrations due to Project traffic and the two emergency generators at the proposed wastewater treatment facility are quantified. For the Cumulative analysis, TACs from the estimated total traffic and Project emergency generators are quantified; other potential contributors to risk are discussed qualitatively.

3.1 Chemical Selection

The excess lifetime cancer and chronic risk analyses in the HRA were based on DPM emissions and TOGs from on-road gasoline vehicles. Diesel exhaust, a complex mixture that includes hundreds of individual constituents, is identified by the State of California as a known carcinogen (CARB 1998). Under California regulatory guidelines, DPM is used as a surrogate measure of carcinogen exposure for the mixture of chemicals that make up diesel exhaust as a whole (OEHHA 2015). OEHHA and other proponents of using the surrogate approach to quantifying excess lifetime cancer risks associated with the diesel mixture indicate that this method is preferable to use of a component-based approach because it provides a protective approach to estimating health risks. A component-based approach involves estimating risks for each of the individual components of a mixture. Critics of the component-based approach believe it will underestimate the risks associated with diesel as a whole mixture because the identity of all chemicals in the mixture may not be known and/or exposure and health effects information for all chemicals identified within the mixture may not be available. Furthermore, OEHHA has concluded that "potential cancer risk from inhalation exposure to whole diesel exhaust will exceed the multi-pathway cancer risk from the speciated components." (OEHHA 2015). These analyses were based on the surrogate approach, as recommended by OEHHA. DPM also has a chronic non-cancer toxicity value associated with it, so the chronic risk analysis was based on this surrogate approach, as well. Speciated components of gasoline (TOGG) are also included as carcinogens and/or contributors to chronic risk.

There is currently no acute non-cancer toxicity value available for DPM. Thus, speciated components of diesel total organic gases (TOGD) with acute toxicity values were included in the acute non-cancer hazard analysis. Speciated components of gasoline TOGG are similarly included in the acute non-cancer hazard analysis. Toxicity values for DPM as well as for the individual components speciated from diesel and gasoline TOGs are included in Table 9.

3.2 Model Selection and Parameters

Consistent with SJVAPCD guidance, near-field air dispersion modeling of DPM, TOGD, and TOGG was conducted using the USEPA's AERMOD model version 19191 (USEPA 2019). For each receptor location, the model generated average air concentrations that result from emissions from multiple sources.

Air dispersion models such as AERMOD require a variety of inputs such as source parameters, meteorological parameters, topography information, and receptor parameters. When site-specific information was unknown, default parameter sets that are designed to produce conservative (i.e., overestimates of) air concentrations were used.

The AERMOD output files are included in Appendix A.

Meteorological data: Air dispersion modeling applications require the use of meteorological data that ideally are spatially and temporally representative of conditions in the immediate vicinity of the site under consideration. For this HRA, SJVAPCD's Fresno meteorological data for years 2013 through 2017 (v. 18081) was used. According to SJVAPCD, the v. 19191 version of this data is not available, and the v. 18081 version is suitable for use.[4]

Terrain considerations: Elevation and land use data was imported from the National Elevation Dataset (NED) maintained by the United States Geological Survey (USGS). An important consideration in an air dispersion modeling analysis is the selection of rural or urban dispersion coefficients. Based on the rural area in which the Project site is located, rural dispersion coefficients were used.

Source parameters: Source location and parameters are necessary to model the dispersion of air emissions. Elevated line-volume sources are used to represent the roadway traffic sources, and the line-volume sources extend over 1,000 feet beyond the Project boundary to capture the sources relevant to the Project receptors. The roadways modeled are presented in Figure 1. A release height of 3.05 meters (10 feet) with an initial vertical dimension (sigma z) of 1.42 m (4.65 feet) was used for the roadway sources, which is a conservative estimate of initial exhaust plume lift from multiple types of vehicles on the roadways. The source parameters used in the AERMOD input files for each roadway line-volume source are presented in Table 5.

The location of the diesel emergency generators was determined by the Project sponsor. Figure 1 shows the modeled location of the proposed generators. Refined modeling of the operational emissions was performed for the two emergency generators. The two generators were modeled as a single point source, with a stack exit temperature of 739.8 Kelvin (K), a stack exit velocity of 45.3 meters per second (m/s), and a stack diameter of 0.183 meters (m). Building downwash caused by the Project buildings, as well as neighboring

[4] Email communication from Kyle Melching of SJVAPCD, dated Jan. 11, 2021.

buildings, was not accounted for.

Emission rates: The emission rates associated with each roadway source are shown in Tables 6a and 6b for both the Project and Cumulative HRAs. These emission rates were entered into AERMOD for each roadway line-volume source. For traffic, exhaust-emitting activities were modeled to reflect the distribution of traffic throughout the day. As discussed in Section 2.1.2, daily emissions can be estimated from the data provided by the traffic engineer, but hourly emission rates are needed as input to the dispersion model used to calculate concentrations. Hourly emission rate scalars are necessary to correlate emissions with the appropriate meteorological conditions if long-term concentrations are required. Table 7 shows the hourly scalar values used in the AERMOD input files to distribute emissions throughout the day. These hourly scalar values were entered into AERMOD as variable emission factors so that the annualized roadway emissions are distributed throughout the day, matching estimated traffic patterns (e.g. less traffic in the middle of the night, more traffic in the daytime hours). The variable emission factors were used only for annual, long-term model runs. The acute, short-term model runs assumed even traffic throughout the 24-hr day so that maximum hourly emissions were not adjusted within the model. The hourly variable emission factors were calculated from data obtained through the EMFAC2017 model, a model designed to provide emission factors for automobile traffic in California, run in the "burden mode" for Fresno County in 2031 (CARB 2017).

The maximum time allowed by maintenance and testing of emergency generators, 50 hours per year, were considered for this analysis.[5] Annual total DPM emissions from the maintenance and testing of the emergency generators were assumed to be spread over each year, since long-term cancer and chronic risks are based on long-term daily average dose. Emission factors were based on Tier 3 standards from the CARB and USEPA Off-Road Compression-Ignition (Diesel) Engine Standards (CARB 2013). Emission factors for DPM are conservatively based on the PM emission standard. Emission factors for TOGD are calculated using proportions of TOG to non-methane hydrocarbons as provided by USEPA's "Conversion Factors for Hydrocarbon Emission Components" (USEPA 2005).

Receptors: In order to evaluate health impacts, receptors were placed on the Project site with 20-meter spacing and a 185-foot setback from Friant Road (as per Project design). Receptors were also placed on off-site residential communities. Receptors were modeled at a height of 1.8 meters above terrain height, a default breathing height for ground-level receptors (CAPCOA 2005). Modeled receptors are shown in Figure 1.

[5] Maximum hours determined as per CARB Stationary Diesel Engine ATCM. Available at: https://ww3.arb.ca.gov/diesel/documents/finalreg2011.pdf

4.0 RISK CHARACTERIZATION METHODS

The following sections discuss in detail the various components required to conduct the HRA.

4.1 Sources Evaluated

As discussed in Section 1.2, excess lifetime cancer risks, and chronic and acute non-cancer hazards were evaluated for the following scenarios:

- Project traffic and stationary source emissions reflective of traffic at Project build-out of 2031 (2030 in traffic study) and full emergency generator use at the wastewater treatment facility. 70-year average traffic emission factors weighted by exposure parameters were used.

- Cumulative emissions, including traffic emissions reflective of Project build-out year of 2031 (2030 in traffic study). Cumulative traffic emissions consist of the Project traffic and other future anticipated growth, also with conservative 70-year average traffic emission factors weighted by exposure parameters. Cumulative emissions also include the emergency generators and a nearby gasoline dispensing facility as described in Section 2.1.1.

4.2 Cancer Risk Exposure Assessment

Potentially Exposed Populations: The following receptor populations were evaluated:

- On-site and off-site 70-year lifetime residents for the Project scenario.

- On-site and off-site 70-year lifetime residents for the Cumulative scenario.

Residential exposure assumptions are more conservative than those for other sensitive receptor types as residential uses have the longest exposure time and exposure duration and highest exposure frequency. No other sensitive receptors (such as schools or daycare centers) were identified in the area that would have higher risk impacts than for residential receptors.

Exposure Assumptions: The exposure parameters used to estimate excess lifetime cancer risks for potentially exposed populations for the Project and Cumulative scenarios were obtained using risk assessment guidelines from OEHHA (OEHHA 2015) and SJVAPCD (SJVAPCD 2018), unless otherwise noted, and are presented in Table 8.

Calculation of Intake: The dose estimated for each exposure pathway is a function of the concentration of a chemical and the intake of that chemical. The intake factor for inhalation, IF_{inh}, can be calculated as follows:

$$IF_{inh} = \frac{DBR \times ET \times EF \times ED \times ASF \times FAH \times CF}{AT}$$

Where:

IF_{inh} = Intake Factor for Inhalation (m^3/kg-day)
DBR = Daily Breathing Rate (L/kg-day)
ET = Exposure Time (hours/24 hours)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
ASF = Age Sensitivity Factor (unitless)
FAH = Fraction at Home (unitless)
CF = Conversion Factor, 0.001 (m^3/L)
AT = Averaging Time (days)

The estimated excess lifetime cancer risks for residents were adjusted using the age sensitivity factors (ASFs) recommended in the OEHHA Hot Spots Guidance (OEHHA 2015). This approach accounts for an "anticipated special sensitivity to carcinogens" of infants and children. Cancer risk estimates are weighted by a factor of 10 for exposure of the age group that includes the third trimester fetus up to two years of age and by a factor of three for exposures that occur from two years through 15 years of age. No weighting factor (i.e., an ASF of one, which is equivalent to no adjustment) is applied to ages 16 and above.

Typically, the chemical intake or dose is estimated by multiplying the inhalation intake factor, IF_{inh}, by the chemical concentration in air, C_i. When coupled with the chemical concentration, this calculation is mathematically equivalent to the dose algorithm given in OEHHA Hot Spots guidance (OEHHA 2015). For this Project, since traffic emission factors decrease by year, these emission factors were weighted by a product of DBR, ASF, and FAH and averaged for the 70-year exposure duration for the AERMOD modelling. The AERMOD outputs were then processed by incorporating other terms in the above equation (see Section 4.4).

4.3 Cancer Risk Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure and the nature and magnitude of adverse health effects that may result from such exposure. For purposes of calculating exposure criteria to be used in risk assessments, adverse health effects are classified into two broad categories – cancer and non-cancer endpoints. Toxicity values used to estimate the likelihood of adverse effects occurring in humans at different exposure levels are identified as part of the toxicity assessment component of a risk assessment.

The carcinogenic toxicity for DPM and additional organic gases from on-road

gasoline-powered vehicles are included. Toxicity values are summarized in Table 9.

4.4 Estimation of Cancer Risks

The equation used to calculate the potential excess lifetime cancer risk for the inhalation pathway is as follows:

$$Risk_{inh} = C_i \times CF \times IF_{inh} \times CPF_i$$

Where:

$Risk_{inh}$ = Cancer Risk; the incremental probability of an individual developing cancer as a result of inhalation exposure to a particular potential carcinogen (unitless)
C_i = Annual Average Air Concentration for chemical i (µg/m^3)
CF = Conversion Factor, 0.001 mg/µg
IF_{inh} = Intake Factor for Inhalation (m^3/kg-day)
CPF_i = Cancer Potency Factor for chemical i (mg chemical/kg body weight-day)$^{-1}$

Cancer risk estimations were determined using average concentrations from the period average concentration over all five years of meteorology modeled.

4.5 Estimation of Chronic Non-cancer Hazard Quotients / Indices

The potential for exposure to result in adverse chronic effects is evaluated by comparing the estimated annual average air concentration of chemical to the chronic reference exposure level (cREL) for each chemical evaluated in this analysis. When calculated for a single chemical, the comparison yields a hazard quotient (HQ) for that chemical. To evaluate the potential for adverse chronic health effects from simultaneous exposure to multiple chemicals, the HQs for all chemicals are summed, yielding a hazard index (HI).

$$HQ_i = {Ci}/{cREL_i}$$

$$HI = \sum HQ_i$$

Where:

HQ_i = Chronic hazard quotient for chemical i
HI = Hazard index
C_i = Annual average concentration of chemical i (µg/m^3)
$cREL_i$ = Chronic reference exposure level for chemical i (µg/m^3)

4.6 Estimation of Acute Non-cancer Hazard Quotients / Indices

The potential for exposure to result in adverse acute effects is evaluated by comparing the estimated one-hour maximum air concentration of chemical to the acute reference exposure level (aREL) for each chemical evaluated in this analysis. When calculated for a single chemical, the comparison yields a HQ. To evaluate the potential for adverse acute health effects from simultaneous exposure to multiple chemicals, the HQs for all chemicals are summed, yielding a HI.

$$HQ_i = {}^{Ci}/_{aREL_i}$$

$$HI = \sum HQ_i$$

Where:

HQ_i = Acute hazard quotient for chemical i
HI = Hazard index
C_i = One-hour maximum concentration of chemical i (µg/m^3)
$aREL_i$ = Acute reference exposure level for chemical i (µg/m^3)

5.0 RESULTS FROM PROJECT ANALYIS

This section presents the Project impact results for on-site and off-site residents.

The SJVAPCD CEQA air quality significance thresholds (SJVAPCD 2018) for health risks and hazards from a Project are:

- An excess lifetime cancer risk level of more than 20 in one million; and
- A non-cancer (chronic or acute) HI greater than 1.0.

Table 11 shows the excess lifetime cancer risk and chronic/acute non-cancer HIs for the maximally exposed individual (MEI) receptor for potential on-site receptors and on off-site residential communities.

The lifetime cancer risk for the on-site MEI was estimated to be 10.5 in a million, which does not exceed a SJVAPCD CEQA significance threshold of 20 in a million. This conservatively assumes that the two generators at the wastewater treatment facility will both start to operate in 2031, and a 70-year resident scenario that will result in the highest exposure, including risks from childhood exposures. To the extent that this Project reflects age-restricted housing, consisting mostly of a population of older people who are less sensitive than children to health risk impacts, these risks are overestimated.

The actual lifetime cancer risk for on-site receptors will likely be much lower than 10.5 in a million.

The lifetime cancer risk for the off-site MEI was estimated to be 17.5 in a million, which also does not exceed a corresponding SJVAPCD threshold of 20 in a million. However, this receptor is located right next to N. Friant Rd., on a large, rural residential-zoned lot, and not where an actual residence is located (the nearest residence to this receptor location is 450 feet to the east). The actual lifetime cancer risk for the resident nearest to this MEI receptor would be much lower than 17.5 in one million.

The chronic and acute non-cancer HIs due to Project operation for on-site receptors are 0.002 and 0.006, respectively; and the chronic and acute non-cancer HIs for off-site receptors are 0.004 and 0.010, respectively, which are well below the SJVAPCD significance threshold of 1.0.

6.0 RESULTS FROM CUMULATIVE ANALYSIS

6.1 Methodology

While SJVAPCD does not have specific guidance for a Cumulative health risk analysis, an analysis to determine the health risk from existing traffic on the proposed Project receptors and off-site resident receptors was requested by the SJVAPCD staff.[6] The CEQA air quality significance thresholds used to evaluate cumulative impacts on on-site and off-site residents are based on the Bay Area Air Quality Management District *CEQA Guidelines* (BAAQMD 2017). The BAAQMD CEQA significance thresholds for cumulative cancer and non-cancer risk are based on EPA guidance for conducting air toxics analyses and making risk management decisions at the community-scale level (USEPA 1989). BAAQMD CEQA significance thresholds for cumulative impacts are:

- An excess lifetime cancer risk level of more than 100 in one million; and
- A non-cancer (chronic or acute) HI greater than 10.

Traffic information provided by the Project traffic engineer was used to estimate excess lifetime cancer risk and chronic and acute hazard indices due to traffic emissions within 1,000 feet surrounding the Project. Both the Project and non-Project traffic were considered, and the 2030 estimated traffic volumes were used.

6.2 Cumulative Risk Results

Besides the cumulative traffic, the emissions from the two generators at the WWTP, and that from a nearby gasoline dispensing facility were also considered. Table 12 shows a summary of the estimated excess lifetime cumulative cancer risks and non-cancer chronic and acute hazard indices from the total traffic and other sources at the MEI locations. Conservatively

[6] Discussed with Leland Villavazo during a 9/4/2014 phone call.

calculated cumulative cancer risks were determined to be less than 44 in one million for on-site MEI and less than 55 in one million for off-site MEI, primarily due to the total traffic emitting DPM from the nearby highway. These cancer risk results do not exceed the BAAQMD CEQA significance threshold of 100 in a million.

The chronic and acute non-cancer HIs due to cumulative traffic for on-site receptors are 0.008 and 0.011, respectively; and the chronic and acute non-cancer HIs for off-site receptors are 0.010 and 0.015, respectively, which are well below the BAAQMD CEQA significance threshold of 10.

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TABLES

Table 1
Emergency Generator Emissions for AERMOD modeling
Friant Ranch Community
Friant, California

Location	Size		Fuel Type	Operation[1] (hrs/yr)	Emission Factors[2]		Max. Emissions for Short-Term (1-hr) Modeling	Avg. Annual Emissions for Long-Term Modeling	Exposure Weighted AERMOD Emissions[3]
					TOGD	DPM	TOGD	DPM	DPM
	[kW]	[hp]			[g/bhp-hr]		[g/s]	[g/s]	[(g/s)*(L/kg-day)]
WWTP at Beck Property	300	402	diesel	50	0.16	0.15	1.82E-02	9.6E-05	0.098
WWTP at Beck Property	500	671	diesel	50	0.16	0.15	3.04E-02	1.6E-04	0.164
						Total Emissions:	4.86E-02	2.55E-04	0.2619

Notes:

1. Operation is assumed to be 50 hours per year, consistent with the maximum hours of operation allowed under ARB's Stationary Diesel Engine ATCM (ARB 2011).

2. Emission factors based on Tier 3 standards from the ARB and USEPA Off-Road Compression-Ignition (Diesel) Engine Standards (ARB 2013). Emission factors for DPM are conservatively based on the PM emission standard. Emission factors for TOGD are calculated using proportions of TOG to Non-methane hydrocarbons as provided by EPA's "Conversion Factors for Hydrocarbon Emission Components" (EPA420-R-05-015, December 2005).

3. Exposure weighted emission factors for AERMOD modeling calculated by averaging the annual DPM emissions over a full year, then weighting that g/s emission rate by the product of a residential receptor's Daily Breathing Rate (DBR), Fraction of Time at Home (FAH), and Age Sensitivity Factor (ASF) for each age group in a given year over 70 years (starting from third trimester in 2031) consistent with recommended values from 2015 OEHHA guidelines (presented in Table 8).

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Abbreviations:

DPM: diesel particulate matter
TOGD: total organic gases in diesel exhaust
TOGG: total organic gases in gasoline exhaust

Table 2
Traffic Volumes for AERMOD modeling
Friant Ranch Community
Friant, California

Segment Name	Segment Description (Listed North to South)	2030 No-Project Conditions		2030 With-Project Conditions		2030 Project Trips	
		PM Peak Hourly Traffic	AADT estimate[1]	PM Peak Hourly Traffic	AADT estimate[1]	PM Peak Hourly Traffic	AADT estimate[1]
Friant Road (South to North)							
A	Lost Lake to N Willow Ave	2,104	26,701	3,058	38,807	954	12,107
B	Root Ave to Lost Lake	2,118	26,878	2,758	35,000	640	8,122
C	Granite Ave to Root Ave	2,138	27,132	2,553	32,398	415	5,266
D	Parker Ave to Granite Ave	2,145	27,221	2,566	32,563	421	5,343
E	206 to Parker	2,125	26,967	2,599	32,982	474	6,015
Road 206							
F	Friant Road to Road 145	2,164	27,462	2,611	33,135	447	5,673
Millerton Road							
G	206 to Winchell Cove	1,733	21,992	1,839	23,338	106	1,345

Notes:

1. AADT estimated by applying the 75th percentile "K" factor (the percentage of AADT during peak hour) from CalTrans 2017 data for Fresno County.

Abbreviations:

AADT: annual average daily traffic

References:

Draft Friant Community Plan Update & Friant Ranch Specific Plan, Fresno County, CA.

Environmental Impact Report. Appendix D: Traffic Impact Study. Tables 8.2 & 14.2

CalTrans 2017. Peak Hour Volume Data, Available online at: https://dot.ca.gov/programs/traffic-operations/census

Table 3a

Traffic Emission Factors for AERMOD modeling[1]
Friant Ranch Community
Friant, California

Year[5]	DPM[2]	TOG: Diesel[3]	TOG: Gasoline[4]
	grams/mile		
2031	0.0199	0.0350	0.0654
2032	0.0197	0.0343	0.0630
2033	0.0195	0.0337	0.0606
2034	0.0193	0.0331	0.0581
2035	0.0191	0.0326	0.0558
2036	0.0189	0.0322	0.0542
2037	0.0188	0.0318	0.0528
2038	0.0187	0.0315	0.0515
2039	0.0186	0.0312	0.0503
2040	0.0185	0.0309	0.0491
2041	0.0185	0.0307	0.0482
2042	0.0184	0.0305	0.0474
2043	0.0184	0.0303	0.0470
2044	0.0184	0.0302	0.0465
2045	0.0184	0.0301	0.0461
2046	0.0184	0.0300	0.0458
2047	0.0184	0.0299	0.0455
2048	0.0183	0.0298	0.0452
2049	0.0183	0.0298	0.0450
2050	0.0183	0.0297	0.0448
2051	0.0183	0.0297	0.0448
2052	0.0183	0.0297	0.0448
2053	0.0183	0.0297	0.0448
2054	0.0183	0.0297	0.0448
2055	0.0183	0.0297	0.0448
2056	0.0183	0.0297	0.0448
2057	0.0183	0.0297	0.0448
2058	0.0183	0.0297	0.0448
2059	0.0183	0.0297	0.0448
2060	0.0183	0.0297	0.0448
2061	0.0183	0.0297	0.0448
2062	0.0183	0.0297	0.0448
2063	0.0183	0.0297	0.0448
2064	0.0183	0.0297	0.0448
2065	0.0183	0.0297	0.0448
2066	0.0183	0.0297	0.0448
2067	0.0183	0.0297	0.0448
2068	0.0183	0.0297	0.0448
2069	0.0183	0.0297	0.0448
2070	0.0183	0.0297	0.0448

Table 3a (cont')

Traffic Emission Factors for AERMOD modeling[1]
Friant Ranch Community
Friant, California

Year[5]	DPM[2]	TOG: Diesel[3]	TOG: Gasoline[4]
	grams/mile		
2071	0.0183	0.0297	0.0448
2072	0.0183	0.0297	0.0448
2073	0.0183	0.0297	0.0448
2074	0.0183	0.0297	0.0448
2075	0.0183	0.0297	0.0448
2076	0.0183	0.0297	0.0448
2077	0.0183	0.0297	0.0448
2078	0.0183	0.0297	0.0448
2079	0.0183	0.0297	0.0448
2080	0.0183	0.0297	0.0448
2081	0.0183	0.0297	0.0448
2082	0.0183	0.0297	0.0448
2083	0.0183	0.0297	0.0448
2084	0.0183	0.0297	0.0448
2085	0.0183	0.0297	0.0448
2086	0.0183	0.0297	0.0448
2087	0.0183	0.0297	0.0448
2088	0.0183	0.0297	0.0448
2089	0.0183	0.0297	0.0448
2090	0.0183	0.0297	0.0448
2091	0.0183	0.0297	0.0448
2092	0.0183	0.0297	0.0448
2093	0.0183	0.0297	0.0448
2094	0.0183	0.0297	0.0448
2095	0.0183	0.0297	0.0448
2096	0.0183	0.0297	0.0448
2097	0.0183	0.0297	0.0448
2098	0.0183	0.0297	0.0448
2099	0.0183	0.0297	0.0448
2100	0.0183	0.0297	0.0448
Max EFs	**0.0199**	**0.0350**	**0.0654**

Notes:

1. Emission factors developed on a gram per mile basis by dividing EMFAC2017 Fresno County emissions by the VMT for the relevant pollutants, emission factors, and vehicle fuel types as described in the following notes. SAFE factors (Off-Model Adjustment Factors for Gasoline Light Duty Vehicle Emissions in EMFAC2017) have been applied to the EMFAC values.

2. DPM emission factors calculated based on PM_{10} running exhaust emissions from diesel fueled vehicles.

3.Diesel TOG emission factors calculated based on TOG running exhaust emissions from diesel fueled vehicles

4. Gasoline TOG emission factors calculated based on TOG running exhaust and running loss emissions from gasoline fueled vehicles.

5. Emission Factors in EMFAC are only projected to 2050. To be conservative, it is assumed that vehicle emissions after this year will be the same as year 2050.

Abbreviations:
DPM: diesel particulate matter
TOG: total organic gas
VMT: vehicle miles travelled
EMFAC: CA ARB's mobile source emission factors

Table 3b
Exposure Weighted Traffic Emission Factors for Annual AERMOD Modeling[1]
Friant Ranch Community
Friant, California

Year[2,3]	DPM	TOG: Diesel	TOG: Gasoline
	[(grams/mile)*(L/kg-day)]		
2031	234.67	413.01	772.18
2032	214.31	373.82	686.62
2033	212.21	367.17	660.50
2034	43.08	74.08	129.95
2035	42.65	72.96	124.63
2036	42.31	72.00	121.15
2037	42.01	71.11	118.05
2038	41.76	70.34	115.12
2039	41.56	69.64	112.34
2040	41.41	69.07	109.76
2041	41.31	68.58	107.77
2042	41.22	68.15	106.04
2043	41.20	67.78	104.99
2044	41.11	67.54	104.01
2045	41.07	67.28	103.14
2046	41.04	67.03	102.34
2047	3.12	5.09	7.73
2048	3.12	5.07	7.68
2049	3.12	5.06	7.65
2050	3.12	5.05	7.62
2051	3.12	5.05	7.62
2052	3.12	5.05	7.62
2053	3.12	5.05	7.62
2054	3.12	5.05	7.62
2055	3.12	5.05	7.62
2056	3.12	5.05	7.62
2057	3.12	5.05	7.62
2058	3.12	5.05	7.62
2059	3.12	5.05	7.62
2060	3.12	5.05	7.62
2061	3.12	5.05	7.62
2062	3.12	5.05	7.62
2063	3.12	5.05	7.62
2064	3.12	5.05	7.62
2065	3.12	5.05	7.62
2066	3.12	5.05	7.62
2067	3.12	5.05	7.62
2068	3.12	5.05	7.62
2069	3.12	5.05	7.62
2070	3.12	5.05	7.62
2071	3.12	5.05	7.62

Table 3b (cont')
Exposure Weighted Traffic Emission Factors for Annual AERMOD Modeling[1]
Friant Ranch Community
Friant, California

Year[2,3]	DPM	TOG: Diesel	TOG: Gasoline
	[(grams/mile)*(L/kg-day)]		
2072	3.12	5.05	7.62
2073	3.12	5.05	7.62
2074	3.12	5.05	7.62
2075	3.12	5.05	7.62
2076	3.12	5.05	7.62
2077	3.12	5.05	7.62
2078	3.12	5.05	7.62
2079	3.12	5.05	7.62
2080	3.12	5.05	7.62
2081	3.12	5.05	7.62
2082	3.12	5.05	7.62
2083	3.12	5.05	7.62
2084	3.12	5.05	7.62
2085	3.12	5.05	7.62
2086	3.12	5.05	7.62
2087	3.12	5.05	7.62
2088	3.12	5.05	7.62
2089	3.12	5.05	7.62
2090	3.12	5.05	7.62
2091	3.12	5.05	7.62
2092	3.12	5.05	7.62
2093	3.12	5.05	7.62
2094	3.12	5.05	7.62
2095	3.12	5.05	7.62
2096	3.12	5.05	7.62
2097	3.12	5.05	7.62
2098	3.12	5.05	7.62
2099	3.12	5.05	7.62
2100	3.12	5.05	7.62
70-year Weighted Average	**19.59**	**33.32**	**57.00**

Notes:

1. Exposure weighted emission factors calculated by weighting the per mile emission factors from Table 3a by the product of a residential receptor's Daily Breathing Rate (DBR), Fraction of Time at Home (FAH), and Age Sensitivity Factor (ASF) for each age group in the given year (starting from third trimester in 2031) consistent with recommended values from 2015 OEHHA guidelines (presented in Table 8).

2. Values have a large decrease in 2047 due to the assumed maximum exposed receptor reaching a daily breathing rate of age 16 (see Table 8).

3. Values flatten in 2050, as EMFAC data is only available through 2050; values after this date are therefore conservative.

Abbreviations:
DPM: diesel particulate matter
TOG: total organic gas
EMFAC: CA ARB's mobile source emission factors

70 Averaging Time (years)

Table 4

Diesel and Gasoline Split[1] for Traffic Emissions Calculations

Friant Ranch Community
Friant, California

	VMT	Percentage
Diesel	4,254,968	13.3%
Gasoline	26,662,657	83.3%
Electric	1,084,129	3.4%
Natural Gas	16,457	0.1%
Total	32,018,211	100%

Notes:

1. Split based on EMFAC-2011 categories for year 2031 VMT in Fresno County.

Abbreviations:

VMT: vehicle miles travelled

Table 5
Roadway Source Parameters for Traffic Emissions Calculations
Friant Ranch Community
Friant, California

Source ID	Road	Roadway Line-Volume Source Parameters				
		Elevation (m)	Plume Width (m)	Initial Sigma y (m)	Length (m)	Length (mi)
ROAD_A	N. Friant Rd. from Lost Lake to N. Willow Ave.	Imported from AERMAP	30	13.95	1402.1	0.871
ROAD_B	N. Friant Rd. from Root Ave. to Lost Lake	Imported from AERMAP	30	13.95	1138.3	0.707
ROAD_C	N. Friant Rd. from Granite Ave. to Root Ave	Imported from AERMAP	30	13.95	185.9	0.116
ROAD_D	N. Friant Rd. from Parker Ave. to Granite Ave.	Imported from AERMAP	30	13.95	340.8	0.212
ROAD_E	N. Friant Rd. from Road 206 to Parker Ave.	Imported from AERMAP	30	13.95	361.5	0.225
ROAD_F	Road 206 from Friant Rd. to Road 145	Imported from AERMAP	15	6.98	338.7	0.210
ROAD_G	Millerton Rd. from Road 206 to Winchell Cove	Imported from AERMAP	15	6.98	1055.5	0.656

Road Elevated LINE-VOLUME Sources
For all Road Sources:
Release Ht. = 3.05 m
Plume Height = 6.096 m
Initial Sigma z = 1.42 m

Abbreviations:
AERMAP: AERMOD's terrain processor
m: meters
mi: miles

Table 6a
Traffic Emission Rates for Acute Impact AERMOD Modeling
Friant Ranch Community
Friant, California

Contaminant	DPM[2]	TOGD	TOGG	DPM[2]	TOGD	TOGG
EF[1] (g/mile)	0.02	0.03	0.07	0.02	0.03	0.07
Percent Fleet	13%	13%	83%	13%	13%	83%
Roadway Link	Project Emissions (grams/sec)			Cumulative (2030 With-Project) Emissions (grams/sec)		
ROAD_A	N/A	1.07E-03	1.26E-02	N/A	3.44E-03	4.03E-02
ROAD_B	N/A	5.85E-04	6.85E-03	N/A	2.52E-03	2.95E-02
ROAD_C	N/A	6.19E-05	7.25E-04	N/A	3.81E-04	4.46E-03
ROAD_D	N/A	1.15E-04	1.35E-03	N/A	7.02E-04	8.22E-03
ROAD_E	N/A	1.38E-04	1.61E-03	N/A	7.54E-04	8.84E-03
ROAD_F	N/A	1.22E-04	1.42E-03	N/A	7.10E-04	8.32E-03
ROAD_G	N/A	8.98E-05	1.05E-03	N/A	1.56E-03	1.83E-02

Note:

1. Emission factors are the maximum year emission factors for TOGD and TOGG from Table 3a.

2. DPM is not modeled for Acute risk. Instead, TOGs from diesel exhaust (TOGD) are evaluated.

Abbreviations:

DPM: diesel particulate matter

TOGD: total organic gas from diesel

TOGG: total organic gas from gasoline

Table 6b
Exposure Weighted Traffic Emission Rates for Annual AERMOD Modeling
Friant Ranch Community
Friant, California

Contaminant	DPM	TOGD[2]	TOGG	DPM	TOGD[2]	TOGG
EF [(grams/mile)*(L/kg-day)][1]	19.6	33.3	57.0	19.6	33.3	57.0
Percent Fleet	13%	13%	83%	13%	13%	83%
Chronic Risk Correction Factor[3]	0.0010	0.0011	0.0011	0.0010	0.0011	0.001
Roadway Link	**Project Emissions (grams/sec*(L/kg-day))**			**Cumulative (2030 With-Project) Emissions (grams/sec*(L/kg-day))**		
ROAD_A	3.18E-01	N/A	5.79E+00	1.02E+00	N/A	1.86E+01
ROAD_B	1.73E-01	N/A	3.16E+00	7.46E-01	N/A	1.36E+01
ROAD_C	1.83E-02	N/A	3.34E-01	1.13E-01	N/A	2.06E+00
ROAD_D	3.41E-02	N/A	6.22E-01	2.08E-01	N/A	3.79E+00
ROAD_E	4.07E-02	N/A	7.42E-01	2.23E-01	N/A	4.07E+00
ROAD_F	3.60E-02	N/A	6.56E-01	2.10E-01	N/A	3.83E+00
ROAD_G	2.66E-02	N/A	4.85E-01	4.61E-01	N/A	8.41E+00

Note:

1.The emission factor is the weighted average as calculated in Table 3b.

2. TOGD (TOGs from diesel exhaust) are not analyzed for annual (long-term) impacts. Instead, DPM is analyzed for annual impacts.

3. The Chronic Risk Correction Factor is the maximum year emission factors for DPM, TOGD and TOGG from Table 3a, divided by the Exposure weighted chronic traffic emissions, in order to calculate chronic risk without including the Exposure Parameters.

Abbreviations:

DPM: diesel particulate matter

TOGD: total organic gas from diesel

TOGG: total organice gas from gasoline

Table 7
Hourly Scalars for Annual (Long-Term) AERMOD modeling[1]
Friant Ranch Community
Friant, California

Hour	DPM[2]	TOG: Diesel[3]	TOG: Gasoline[4]
1	0.939	N/A	0.138
2	0.488	N/A	0.069
3	0.817	N/A	0.070
4	1.549	N/A	0.045
5	0.886	N/A	0.072
6	1.215	N/A	0.248
7	1.792	N/A	0.821
8	1.224	N/A	1.533
9	1.218	N/A	1.554
10	1.514	N/A	1.291
11	1.577	N/A	1.400
12	1.559	N/A	1.538
13	1.401	N/A	1.574
14	1.433	N/A	1.578
15	1.085	N/A	1.722
16	0.743	N/A	1.796
17	1.025	N/A	1.933
18	0.588	N/A	2.097
19	0.630	N/A	1.428
20	0.271	N/A	1.031
21	0.501	N/A	0.771
22	0.822	N/A	0.637
23	0.413	N/A	0.395
24	0.312	N/A	0.258

Notes:

1. Calculated as a percentage of predicted total emissions per hour for Fresno County in 2031 from EMFAC-2017 (run in burden mode). Hourly scalers used only in Annual (Long-Term) AERMOD modeling runs.

2. DPM hourly scalars estimated based on PM_{10} running exhaust emissions from diesel fueled vehicles.

3. Diesel TOG hourly scalers not required because TOGD is not analyzed in long-term modeling.

4. Gasoline TOG hourly scalars calculated based on TOG running exhaust and running loss emissions from gasoline fueled vehicles.

Abbreviations:
DPM: diesel particulate matter
TOG: total organic gas

Table 8
Residential Receptor Exposure Parameters
Friant Ranch Community
Friant, California

Receptor Age Group	Exposure Parameter					
	Daily Breathing Rate (DBR)[1] (L/kg-day)	Exposure Duration (ED)[2] (years)	Fraction of Time at Home (FAH)[3] (unitless)	Exposure Frequency (EF)[4] (days/year)	Averaging Time (AT) (days)	Age Sensitivity Factor[5] (ASF)
3rd Trimester Duration	361	0.25	1	350	25,550	10
Infant Exposure (0<2 Years)	1090	2	1	350	25,550	10
Child Exposure (2<16 Years)	745	14	1	350	25,550	3
Adult Exposure (16-70 Years)	233	54	0.73	350	25,550	1

Equation used:

IF_{inh} = DBR * ET * EF * ED * ASF * FAH * CF / AT

CF: 0.001 (m^3/L)

Notes:

1. Daily breathing rates reflect default breathing rates from OEHHA 2015 as follows: 95th percentile for children <16 years, and 80th percentile for adults 16-70 years. For this cancer risk analysis, daily breathing rates were incorporated into the exposure weighted AERMOD modeled emissions rates as presented in Table 3b.

2. The total exposure duration for operation reflects the default residential exposure duration from OEHHA 2015.

3. Fraction of time at home was conservatively assumed to be 1 for age groups younger than 16 years old (100%). The FAH of 0.73 for age group 16 and above reflects the default value from OEHHA 2015. For this cancer risk analysis, FAH values were incorporated into the exposure weighted AERMOD modeled emissions rates as presented in Table 3b.

4. Exposure frequency (EF) reflects default exposure frequency for residents from OEHHA 2015.

5. Age sensitivity factors for each age group are consistent with OEHHA 2015 guidance. ASFs were incorporated into the exposure weighted AERMOD modeled emissions rates as presented in Table 3b.

Abbreviations:

DBR: daily breathing rates
ET: exposure time (hours/24 hours)
EF: exposure frequency
ED: exposure duration
ASF: age sensitivity factor
FAH: fraction at home
CF: conversion factor
AT: averaging time
OEHHA: Office of Environmental Health Hazard Assessment
kg: kilogram
L: liter
m^3: cubic meters

Reference:

OEHHA 2015. Air Toxics Hot Spots Program, Risk Assessment Guidelines, Guidance Manual for Preparation of Health Risk Assessments, Office of Environmental Health Hazard Assessment (OEHHA), February 2015. Available online at: http://oehha.ca.gov/air/hot_spots/hotspots2015.html.

Table 9
Toxicity Values
Friant Ranch Community
Friant, California

Chemical		Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Chronic Reference Exposure Level $(\mu g/m^3)$	Acute Reference Exposure Level $(\mu g/m^3)$
Diesel Particulate Matter (DPM)[1]		1.10	5.0	--
TACS from TOGG[2]	1,3-Butadiene	0.60	2	-
	Acetaldehyde	0.01	140	470
	Acrolein	-	0	3
	Benzene	0.10	3	27
	Ethylbenzene	0.01	2000	-
	Formaldehyde	0.02	9	55
	Hexane	-	7000	-
	Methanol	-	4000	28000
	Methyl ethyl ketone	-	-	13000
	Naphthalene	0.12	9	-
	Propylene	-	3000	-
	Styrene	-	900	21000
	Toluene	-	420	5000
	Xylenes	-	700	22000
TACS from TOGD	1,3-butadiene	-	-	660
	Benzene	-	-	27
	M-xylene	-	-	22000
	O-xylene	-	-	22000
	Toluene	-	-	5000
	Acetaldehyde	-	-	470
	Formaldehyde	-	-	55

Notes:

All toxicity values from Cal/EPA (2020).

-- not available

1. Diesel Particulate Matter (DPM) is used as a surrogate measure of carcinogen and chronic non-cancer exposure for the mixture of chemicals that make up diesel exhaust as a whole. There is currently no acute non-cancer toxicity value available for DPM. Accordingly, acute impacts from diesel combustion engines are typically not evaluated. As a conservative measure for traffic related emissions, speciated components of diesel total organic gas exhaust emissions (TOG) with acute toxicity values were included in the acute non-cancer hazard analysis.

2. Cancer potenty factors from TOG represent only the chemicals from the gasoline components (any diesel related emissions chemical potencies are incorporated as part of the DPM CPF).

Abbreviations:

(mg/kg-day): milligram per kilogram-day
$\mu g/m^3$: micrograms per cubic meter
ARB: California Air Resources Board
Cal/EPA: California Environmental Protection Agency
DPM: diesel particulate matter
HI: hazard index
OEHHA: Office of Environmental Health Hazard Assessment
TAC: toxic air contaminant
TOG: total organic gas

Reference:

California Environmental Protection Agency (Cal/EPA). 2020. OEHHA/ARB Consolidated Table of Approved Risk Assessment Health Values. Updated Oct. 2, 2020. http://www.arb.ca.gov/toxics/healthval/contable.pdf

Table 10
Vehicle Exhaust TOG Weight Fractions
Friant Ranch Community
Friant, California

Chemical	CAS Number	Weight Fraction
TOGs from Gasoline (TOGG)[1]		
1,3-Butadiene	106-99-0	0.0055
Acetaldehyde	75-07-0	0.0028
Acrolein	107-02-8	0.0013
Benzene	71-43-2	0.0247
Ethylbenzene	100-41-4	0.0105
Formaldehyde	50-00-0	0.0158
Hexane	110-54-3	0.0160
Methanol	67-56-1	0.0012
Methyl ethyl ketone	78-93-3	0.0002
Naphthalene	91-20-3	0.0005
Propylene	115-07-1	0.0306
Styrene	100-42-5	0.0012
Toluene	108-88-3	0.0576
Xylenes	1330-20-7	0.0480
TOGs from Diesel (TOGD) - Heavy Duty Vehicles[2]		
1,3-butadiene	106-99-0	0.029
Benzene	71-43-2	0.044
M-xylene	108-38-3	0.029
O-xylene	95-47-6	0.018
Toluene	108-88-3	0.051
TOGs from Diesel (TOGD) - Light Duty Vehicles[2]		
Acetaldehyde	75-07-0	0.0291
Formaldehyde	50-00-0	0.0861

1. Gasoline TOG Speciation from BAAQMD "Recommended Methods for Screening and Modeling Local Risks and Hazards," Table 14.

2. Diesel TOG Speciation from EPA Speciation Profile 1201 (LDV) and 95227 (HDV). Only the chemicals with acute risk RELs are listed. Summing LDV and HDV weighted RELs to be conservative.

Table 11
Modeled Excess Lifetime Cancer Risk, and Chronic and Acute Hazard Indices - Project
Friant Ranch Community
Friant, California

Source	Receptor Type	Cancer Risk[1] (in one million)	Chronic HI[2]	Acute HI[2]
Project Operations (Traffic and Emergency Generators)	Onsite MEI	10.5	0.002	0.0058
	Offsite MEI	17.5	0.004	0.0098
SJVAPCD Project Significance Threshold		**20**	**1**	**1**
Exceed Threshold?		**No**	**No**	**No**

Notes:

1. Excess lifetime cancer risks are estimated as the upper-bound incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to potential carcinogens. The estimated risk is expressed as a unitless probability. The cancer risks attributed to the emissions associated with operation of the Project were conservatively calculated based on the maximum modeled annual average air concentrations over the five modeled years, the intake factors presented in Table 8, and the CPFs presented in Table 9.

2. The potential for exposure to result in adverse chronic and acute non-cancer effects is evaluated by comparing the estimated annual average and one-hour maximum air concentration to the non-cancer chronic and acute REL for each chemical, respectively. When calculated for a single chemical, the comparison yields a ratio termed a hazard quotient. To evaluate the potential for adverse chronic and acute noncancer health effects from simultaneous exposure to multiple chemicals, the hazard quotients for all chemicals are summed, yielding a hazard index. The chronic and acute hazard indices attributed to the emissions associated with operation of the Project and non-project traffic were calculated based on the modeled annual average and one-hour maximum air concentrations, respectively, and the chronic and acute reference exposure levels presented in Table 9.

Abbreviations:

m: meter

$\mu g/m^3$: micrograms per cubic meter

HI: hazard index

MEI: maximally exposed individual

Table 12
Excess Lifetime Cancer Risk, and Chronic and Acute Hazard Indices - Cumulative
Friant Ranch Community
Friant, California

Source	Receptor Type	Cumulative Cancer Risk[1] (in one million)	Chronic HI[2]	Acute HI[2]
Project Operations + Non-Project Traffic	Onsite MEI	34	0.008	0.011
	Offsite MEI	45	0.010	0.015
Offsite Stationary Sources[3]	N/A	<10	--	--
Cumulative Total	Onsite MEI	<44	0.008	0.011
Cumulative Total	Offsite MEI	<55	0.010	0.015
CEQA Cumulative Significance Threshold		**100**	**10**	**10**
Exceed Threshold?		**No**	**No**	**No**

Notes:

1. Excess lifetime cancer risks are estimated as the upper-bound incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to potential carcinogens. The estimated risk is expressed as a unitless probability. The cancer risks attributed to the cumulative emissions associated with operation of the Project and non-project traffic were calculated based on the modeled annual average air concentrations over the five modeled years, the intake factors presented in Table 8, and the cancer potency factors presented in Table 9.

2. The potential for exposure to result in adverse chronic and acute non-cancer effects is evaluated by comparing the estimated annual average and one-hour maximum air concentration to the non-cancer chronic and acute REL for each chemical, respectively. When calculated for a single chemical, the comparison yields a ratio termed a hazard quotient. To evaluate the potential for adverse chronic and acute noncancer health effects from simultaneous exposure to multiple chemicals, the hazard quotients for all chemicals are summed, yielding a hazard index. The chronic and acute hazard indices attributed to the emissions associated with operation of the Project and non-project traffic were calculated based on the modeled annual average and one-hour maximum air concentrations, respectively, and the chronic and acute reference exposure levels presented in Table 9.

3. Offsite stationary sources included one gas station (that dispenses around one million gallons per day as per SJVAPCD staff) within 600 feet of the project. According to the California Environmental Protection Agency (Cal/EPA 2005), a cancer risk of less than 10 in a million is expected at the fenceline of a gas station dispensing less than 3.6 million gallons per day. Conservatively, in the cumulative health risk assessment it was assumed that a cancer risk impact of <10 in a million applied to both onsite and offsite receptors, regardless of their distance to the gas station.

-- not available

Abbreviations:

MEI: maximally exposed individual

HI: hazard index

Reference:

Cal/EPA. 2005. Air Quality and Land Use Handbook: A Community Health Perspective. April. Available online at: http://www.arb.ca.gov/ch/handbook.pdf.

FIGURES

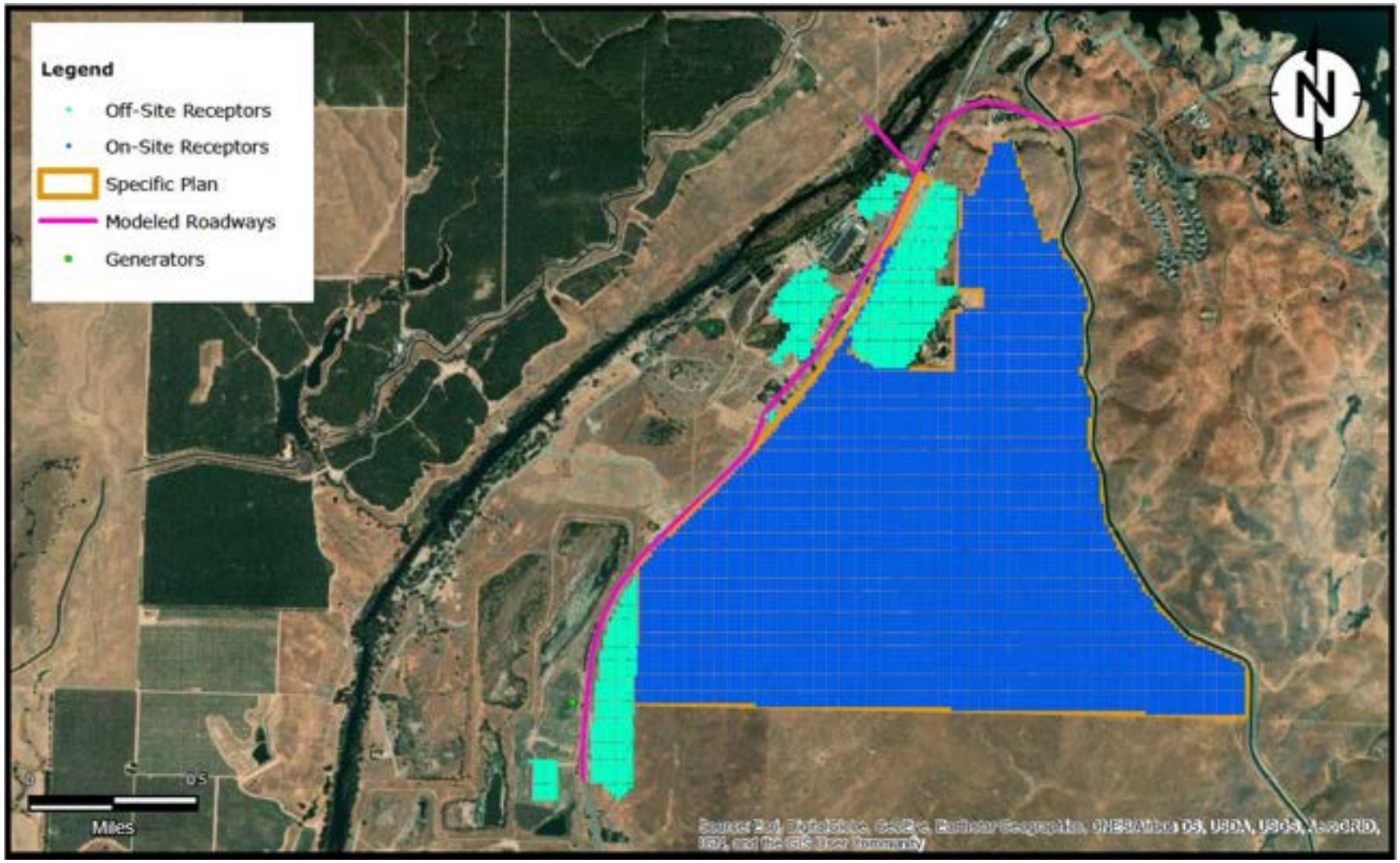


Figure 1: Friant Ranch Community AERMOD Model Set-Up

B.4 Ramboll – Air Quality Impacts Analysis 2019

Prepared by
Ramboll US Corporation
San Francisco

Project Number
1690013624

Date
July 2019

CALIFORNIA STATE UNIVERSITY–DOMINGUEZ HILLS
AIR QUALITY IMPACTS ANALYSIS
CARSON, CALIFORNIA

RAMBOLL

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1. INTRODUCTION

This report presents an estimate of the potential health impact of the emissions of criteria pollutants that may result from the adoption and implementation of California State University Dominguez Hills (CSUDH)'s 2018 Campus Master Plan (the proposed Project). The proposed Project retains the existing campus enrollment cap of 20,000 full-time-equivalent students (FTES), while providing a framework for development of the University's campus in a forward-looking manner that accommodates growth from the current enrollment of approximately 11,000 FTES to the maximum enrollment of 20,000 FTES over a planning horizon extending to 2035.

As background, Environmental Impact Reports (EIRs) prepared pursuant to the California Environmental Quality Act (CEQA) have long evaluated project-related health impacts of toxic air contaminants, such as diesel particulate matter, through quantitative and/or qualitative means relative to air district-issued thresholds of significance. However, EIRs historically have not evaluated the specific health impacts 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 at the time, CEQA analysis historically and traditionally 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.

In response to comment on the proposed Project's Draft EIR, and in light of a cited decision issued by the California Supreme Court issued in December 2018, this analysis estimates the health impacts of criteria pollutants and their precursors, specifically those that are evaluated by the U.S. Environmental Protection Agency (USEPA) in rulemaking setting the national ambient air quality standards: oxides of nitrogen (NOx), volatile organic compounds (VOC), carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), and particulate matter smaller than 2.5 microns in diameter[2] ($PM_{2.5}$). NOx and VOCs are not criteria air pollutants but, in the presence of sunlight, they form O_3 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 impacts from O_3 and $PM_{2.5}$ are examined for this Project because the USEPA has determined that these criteria pollutants would have the greatest impact to human health. The emissions of other criteria pollutants, including VOC, NOx and SO_2, are analyzed in their contribution in the formation of O_3 and secondary $PM_{2.5}$.

Notably, CEQA practitioners and other expert agencies (like air districts) are still developing tools and methodologies to provide the type of CEQA analysis described in the California Supreme Court's decision. In this report, Ramboll presents one method that can be used to correlate project-related mass emissions totals for criteria pollutants to estimated health-based consequences. More specifically, in order to estimate the health impacts of the increases of criteria pollutants for the

[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 and 10 microns and ozone. Precursor pollutants to criteria pollutants include oxides of nitrogen (NOx), oxides of sulfur (SOx), and volatile organic compounds (VOCs).

[2] USEPA's default health effect functions in BenMAP for PM use fine particulate ($PM_{2.5}$) as the causal PM agent, so the health effects of PM_{10} are represented using $PM_{2.5}$ as a surrogate.

proposed Project, Ramboll applied a photochemical grid model (PGM), Comprehensive Air Quality Model with extensions (CAMx),[3] to estimate the small 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. We then applied a USEPA-authored program, the Benefits Mapping and Analysis Program (BenMAP)[4], to estimate the resulting health impacts from the small increases in concentration. Only the impacts of ozone and $PM_{2.5}$ are estimated, as those are the pollutants that USEPA uses in BenMAP to estimate the impact of emissions of NOx, VOCs, CO, SO_2, and $PM_{2.5}$. Ozone and $PM_{2.5}$ have the most critical health impacts and thus are the emissions evaluated to determine the Project's health impacts.

[3] Comprehensive Air Quality Model with Extensions.

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

2. TECHNICAL APPROACH

The first step in the process is to run the PGM with appropriate information to assess the small 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 database for Southern California, which contains base emissions, was developed by the South Coast Air Quality Management District (SCAQMD) in support of its adopted 2016 Air Quality Management Plan (AQMP)[5] and was adapted for use in this analysis. This PGM database is tailored for Southern California (including Los Angeles County) using California-specific input tools (e.g., the Emission FACtors (EMFAC)[6] 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.

Project emissions included NO_X, SO_2, CO, respirable (PM_{10}) and fine ($PM_{2.5}$) primary particulate matter (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.

The USEPA's air quality modeling guidelines (Appendix W[7]) and ozone and $PM_{2.5}$ modeling guidance[8] 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[9] and the Community Multiscale Air Quality (CMAQ[10]) PGMs have been used extensively in the past and would be acceptable PGMs. As such, the USEPA has prepared a memorandum[11] documenting the suitability for using CAMx and CMAQ for ozone and secondary $PM_{2.5}$ modeling of single-sources or group of sources.

To estimate the potential impacts of the proposed Project's emissions on ambient air concentrations, the Project's emissions were added to the CAMx 4-km annual PGM modeling database.[12] Operational and construction emissions from the Project were estimated as described in the Air Quality Section of the Draft EIR.[13] For almost all pollutants, for any year, the maximum operational emissions at full buildout were greater than construction emissions. The exception is VOCs from architectural coatings during one year of construction. In order to estimate the worst-case impacts, the emissions from the highest year of construction VOCs were added to the full buildout emissions of all other pollutants. By

[5] https://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp.

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

[7] https://www3.epa.gov/ttn/scram/appendix_w/2016/AppendixW_2017.pdf.

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

[9] http://www.camx.com/.

[10] https://www.epa.gov/cmaq.

[11] https://www3.epa.gov/ttn/scram/guidance/clarification/20170804-Photochemical_Grid_Model_Clarification_Memo.pdf.

[12] SCAQMD 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.

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

doing this, the results below present a worst-case analysis for the construction years and operational years.

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 total unmitigated emission inventory for the Project was used in the analysis. This includes architectural coatings, VOCs in consumer products, natural gas combustion, landscaping, and emissions associated with motor vehicle use. The emissions from architectural coatings, consumer products, natural gas combustion, and landscaping are located onsite, and were therefore allocated to the grid cells representing the Project site (the University campus). The mobile source category includes both passenger vehicles and trucks. The mobile sources are also spatially distributed in both the site's grid cells, as well as the immediately adjacent grid cells. While it is expected that passenger vehicles and trucks may travel some distance outside of the Project site, they were conservatively distributed near the site's grid cells based on 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 Operating Kernel Emissions (SMOKE) emissions modelling system supported by the USEPA. The emissions inventory, spatial allocation, and SMOKE inputs and outputs are shown in Appendix A.

As discussed above, the SCAQMD's Southern California 2016 AQMP modeling database was used for this Project. The Southern California 4-km CAMx modeling databases is based on a 2012 base meteorological year and includes future year emission scenarios. The 2023 future year projections were used for this analysis, as that is the nearest future year with base emissions available as of the date of this report. The Project's emissions were tagged for treatment by the source apportionment tools in CAMx to obtain the incremental ozone and $PM_{2.5}$ concentration impacts due to the Project's emissions. More details and inputs for the PGM modeling are included in Appendix B.

Following completion of the CAMx source apportionment modeling, Ramboll used the USEPA's BenMAP[14, 15] program to estimate the potential health impacts of the Project's contribution to ozone and $PM_{2.5}$ concentration. 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 impacts of a project's emissions. We used the USEPA default BenMAP health effects C-R functions that are typically used in national rulemaking, such as the health effects impact assessment[17] for the 2012 $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS). The health effects that we used for $PM_{2.5}$ include mortality (all causes), hospital admissions (respiratory, asthma, cardiovascular), emergency room visits (asthma), and acute myocardial infarction (non-fatal). For ozone, the endpoints are mortality, emergency room visits (respiratory) and hospital admissions (respiratory). Details on the BenMAP inputs and outputs and definitions for the health outcomes are shown in Appendix C.

[14] https://www.epa.gov/benmap/how-benmap-ce-estimates-health-and-economic-effects-air-pollution.

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

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

[17] https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf.

3. RESULTS

This section presents the results of the health impact analysis for the incremental increases in $PM_{2.5}$ and ozone resulting from primary and precursor emissions for these constituents[18].

$PM_{2.5}$-related health outcomes attributed to Project-related increases in ambient air concentrations included asthma-related emergency room visits (4.38 incidences per year), asthma-related hospital admissions (0.38 incidences per year), all cardiovascular-related hospital admissions (not including myocardial infarctions) (1.05 incidences per year), all respiratory-related hospital admissions (2.44 incidences per year), mortality (10.31 incidences per year), and nonfatal acute myocardial infarction (less than 0.53 incidences per year for all age groups).

Ozone-related health outcomes attributed to Project-related increases in ambient air concentrations included respiratory-related hospital admissions (0.67 incidences per year), mortality (0.28 incidences per year), and asthma-related emergency room visits for any age range (lower than 3.38 incidences per year for all age groups).

For all these health endpoints, the number of estimated incidences is less than 0.0058% of the background health incidence. The "background health incidence" is the actual incidence of health effects as measured in the local population in the absence of additional emissions from the Project. When taken into context, the small increase in incidences and the very small percent of the number of background incidences indicate that these health impacts are negligible in a developed, urban environment. Because the health impacts from ozone and PM2.5 were negligible in light of background incidences, and health impacts from other criteria pollutants would be even smaller, the health impacts of those other criteria pollutants were not quantified.

UNCERTAINTY

Analyses that evaluate the increases 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 increase in concentration to a specific health impact in an individual; however, it does use scientific correlations of certain types of health impacts from pollution to estimate increases in effects to the population at large.

There is a degree of uncertainty in these results from a combination of the uncertainty of the increase in concentration resulting from the PGM and the uncertainty of the application of the C-R increase. All simulations of physical processes, whether ambient air concentrations, or health impacts 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 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 in the results, the results provide sufficient information to the public to allow them to understand the health effects of increases or decreases in air pollution. In addition, the health impacts estimation using this method presumes that impacts seen at large concentration differences can be linearly scaled down to small increases in concentration. This

[18] Health outcomes presented above also conservatively utilize maximum daily emissions, assumed to occur for an entire year. Should average daily emissions be used, results would be even lower. Specifically for mortality impacts from $PM_{2.5}$ emissions, average daily emissions would be approximately 20% lower, and the corresponding morality incidence rate would be similarly lower.

methodology of linearly scaling impacts is broadly accepted for use in regulatory evaluations and is considered as being health protective.[19] These health impacts are conservatively estimated, and the actual impacts may be zero.

[19] USEPA (2010). Quantitative Risk Assessment for Particulate Matter – Final Report. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-452/R-10-005. June 2010. Available: https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf.

APPENDIX A
EMISSIONS INVENTORY, SPATIAL ALLOCATION, AND SMOKE SETUP

APPENDIX A

EMISSIONS INVENTORY, SPATIAL ALLOCATION, AND SMOKE SETUP
CALIFORNIA STATE UNIVERSITY – DOMINGUEZ HILLS
CARSON, CALIFORNIA

1. INTRODUCTION

As set forth in the Project's Draft Environmental Impact Report (EIR), construction and operational emissions from the Project were estimated using methodologies consistent with the California Emissions Estimator Model (CalEEMod®) and Project-specific data, where available. 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 CalEEMod® need to be spatially gridded, temporally allocated, and chemically speciated to be used for photochemical grid modeling. The Sparse Matrix Operating Kernel Emissions (SMOKE) emissions modeling system (Coats, 1996; Coats and Houyoux, 1996)[1] is used for this process.

Development of the gridded Project emissions is described in detail in Section 0.

2. PROJECT EMISSIONS AND SPATIAL ALLOCATION

Emissions were estimated for the Project to support the photochemical grid model (PGM) and are allocated into 4 kilometer (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 gridded emission inventory. The total incremental emission inventory for the Project is below in Table 2-1. Mobile source emissions were split into categories based on the EMFAC2014 emission rates. For particulate matter, less than 2.5 microns in diameter ($PM_{2.5}$) emissions are used in the modelling; less than 10 microns in diameter (PM_{10}) emissions are presented for information below.

Table 2-1. Maximum Daily Criteria Air Pollutant Emissions Estimates

Emission Category	ROG	NOx	PM_{10}	$PM_{2.5}$	SO_2	CO
	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Mobile	38.4	220.2	284.2	76.8	2.6	499.2
Diurnal	2.4	0.0	0.0	0.0	0.0	0.0
Hotsoak	5.8	0.0	0.0	0.0	0.0	0.0
Idling Exhaust	0.2	1.3	0.0	0.0	0.0	2.0
Brakewear	0.0	0.0	1.0	1.0	0.0	0.0
Tirewear	0.0	0.0	0.2	0.1	0.0	0.0
Resting Loss	2.4	0.0	0.0	0.0	0.0	0.0
Road Dust	0.0	0.0	283.0	75.7	0.0	0.0
Running Exhaust	5.1	181.4	0.0	0.1	2.5	381.7
Running Loss	19.6	0.0	0.0	0.0	0.0	0.0
Starting Exhaust	2.8	37.5	0.0	0.0	0.1	115.5
Energy	2.0	17.4	1.4	1.4	0.1	12.1
Consumer Products	93.9	0.0	0.0	0.0	0.0	0.0

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

Landscaping	6.5	2.5	1.2	1.2	0.0	216.3
Architectural Coatings	341.9	0.0	0.0	0.0	0.0	0.0
Operational	9.9	0.0	0.0	0.0	0.0	0.0
Construction (2024)	332	0.0	0.0	0.0	0.0	0.0

Abbreviations:
CO - Carbon Monoxide
lbs – Pounds
NOx - Nitrogen Oxides
$PM_{2.5.}$ - Particulate Matter less than 2.5 microns in diameter
$PM_{10.}$ - Particulate Matter less than 10 microns in diameter
ROG - Reactive Organic Gas
SO_2 - Sulfur Dioxide

All emissions listed in Table 2-1 represent the maximum daily operational emissions estimated for the proposed Project's 2035 buildout scenario, aside from the construction architectural coatings emissions (labeled as such). This analysis utilizes the 2035 operational emissions as they constitute the highest maximum daily emissions for the Project, with the exception of 2024 Reactive Organic Gas (ROG) emissions from architectural coatings during construction. Those emissions were also included as a conservative approach, as they represent the highest maximum daily total Volatile Organic Compounds (VOC)[2] emissions for the Project. The analysis presented here conservatively assumes maximum daily emissions occur over an entire year. Should average daily emissions be used, corresponding results would be approximately 20% lower.

Mobile emissions include light, medium, and heavy-duty vehicles. Table 2-2 below provides a summary of the spatial distribution of mobile emissions broken down by major freeway. Values in this table were calculated based on estimated average vehicle miles traveled (VMT) during the operational phase of the Project. VMT were estimated based on peak hour traffic demands on various freeway routes located near the Project site, using data provided in the proposed Project's Transportation Impact Study[3] (Appendix F of the Draft EIR).

Table 2-2. Mobile Emission Distribution

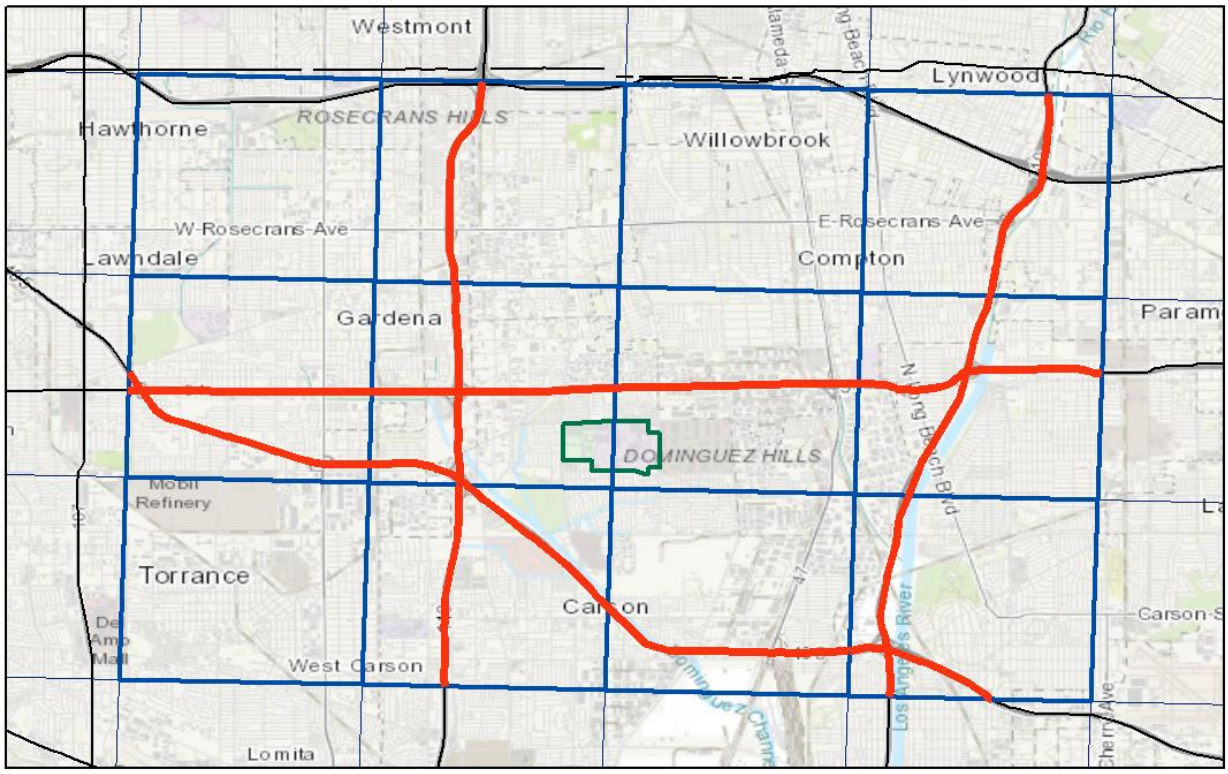
Freeway	Distribution (%)
State Route 91	25.0%
Interstate 110	46.6%
Interstate 405	26.8%
Interstate 710	1.6%

Project emissions are allocated evenly across the Project site into 4 km x 4 km grid cells for the PGM. Figure 2-1 below shows the Project boundary overlay with the 4-km grid. The Project site is shown in

[2] 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", which is based on USEPA's exempt list, which is slightly different from ARB's list.
[3] Appendix F of the Draft Environmental Impact Report for the 2018 Campus Master Plan. Available at: https://www.csudh.edu/Assets/csudh-sites/fpcm/docs/campus-master-plan/csudh-cmp-deir-2019-appendices-updated.pdf. Accessed: June 2019.

green, and the major roadways are shown in red. The 4x3 grid is presented on the figure with 12 blue grid cells. For major roadways that cross into multiple cells, emissions were allocated proportionally based on the length of roadway within each cell.

Figure 2-1. Overlap of Model Grid Cells on Project Site



2.2 Convert 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 the SCC assigned to each Project source.

Table 2-3. Assigned SCC to Project Emission Sources

Emission Source	SCC	SCC Description
Energy	2102006000	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
Landscaping	2265004010	Mobile Sources; Off-highway Vehicle Gasoline, 4-Stroke; Lawn and Garden Equipment; Lawn Mowers (Residential)
Fugitive Dust	2294000000	Mobile Sources; Paved Roads; All Paved Roads; Total: Fugitives
Architectural Coating	2401001000	Solvent Utilization; Surface Coating; Architectural Coatings; Total: All Solvent Types
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	2460200000	Solvent Utilization; Miscellaneous Non-industrial: Consumer and Commercial; All Household 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
Mobile -LDA	220100111B	Mobile Sources; Highway Vehicles - Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural[4] Interstate: Brake Wear
Mobile -LDA	220100111R	Mobile Sources; Highway Vehicles - Gasoline; Light Duty Gasoline Vehicles (LDGV); Rural Interstate: Resting Loss
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

[4] Rural and Urban mobile designations provide equivalent chemical speciation and temporal distributions, as the EMFAC mobile emissions model does not distinguish between the two.

Emission Source	SCC	SCC Description
Mobile -LDT1	220102011B	Mobile Sources; Highway Vehicles - Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Brake Wear
Mobile -LDT1	220102011R	Mobile Sources; Highway Vehicles - Gasoline; Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5); Rural Interstate: Resting Loss
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
Mobile -HHDT	220107011B	Mobile Sources; Highway Vehicles - Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Brake Wear
Mobile -LHDT1	220107011I	Mobile Sources; Highway Vehicles - Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 2B; Rural Interstate: Idling
Mobile -HHDT	220107011R	Mobile Sources; Highway Vehicles - Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Interstate: Resting Loss
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
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 -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	220107013R	Mobile Sources; Highway Vehicles - Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Resting Loss
Mobile -OBUS	220107013S	Mobile Sources; Highway Vehicles - Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Start
Mobile -OBUS	220107013T	Mobile Sources; Highway Vehicles - Gasoline; Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV); Rural Other Principal Arterial: Tire Wear

Emission Source	SCC	SCC Description
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 -MCY	220108011B	Mobile Sources; Highway Vehicles - Gasoline; Motorcycles (MC); Rural Interstate: Brake Wear
Mobile -MCY	220108011R	Mobile Sources; Highway Vehicles - Gasoline; Motorcycles (MC); Rural Interstate: Resting Loss
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 -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	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	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 -MHDT	2230072110	Mobile Sources; Highway Vehicles - Diesel; Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, & 5; Rural Interstate: Total
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

Emission Source	SCC	SCC Description
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 -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 -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

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,[5] 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 cells where the Project is located as shown in Figure 2-1. The mobile sources are 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 Southern California 4-km modeling grid shown in Figure 2-1. A representative week from each month (seven days a month) was used to represent

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

the entire month's emissions. Holidays were modeled separately as if they were a Sunday. SMOKE was applied to perform following tasks:

1. Chemical Speciation: Emission estimates of criteria pollutants were speciated for the SAPRC07 AERO6 chemical mechanism employed in Community Multiscale Air Quality (CMAQ) in SMOKE processing. We used speciation profiles compatible with the SAPRC07 AERO6 mechanism from the SCAQMD's modeling system to be consistent with the regional modeling emissions. We then converted those emissions into Comprehensive Air Quality Model with extensions (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 the SCCs to provide the appropriate temporal resolution. The temporal profiles were also obtained from the BAAQMD's emissions modeling system, as they were unavailable from South Coast Air Quality Management District (SCAQMD).
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 the 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. We carefully reviewed the SMOKE log files 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. We also compared SMOKE input and output emissions: 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. We merged the daily emissions 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 2-4 summarizes the Project emission inventory data input to SMOKE from the FF10 data files in pounds per day by source type. Table 2-5 presents the emissions data after SMOKE processing. The consistency in data in Tables 2-4 and 2-5 offer confidence in the correct operation of the SMOKE emissions processing for CAMx.

Table 2-4. Project Emission Inventory Data Input to SMOKE by Source Type (lbs/day)

Type	CO	NO_X	VOC	SO_2	PM_{10}	$PM_{2.5}$
Mobile	499.2	220.2	38.4	2.6	284.2	76.8
Energy	12.1	17.4	2.0	0.1	1.4	1.4
Consumer Products	0.0	0.0	93.9	0.0	0.0	0.0

Landscaping	216.3	2.5	6.5	0.0	1.2	1.2
Architectural Coatings	0.0	0.0	341.9	0.0	0.0	0.0
Total	727.6	240.1	482.6	2.7	286.8	79.5

Abbreviations:
CO - Carbon Monoxide
NOx - Nitrogen Oxides
$PM_{2.5.}$ - Particulate Matter less than 2.5 microns in diameter
$PM_{10.}$ - Particulate Matter less than 10 microns in diameter
SO_2 - Sulfur Dioxide
VOC - Volatile Organic Compounds

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

Type	CO	NO_X	VOC	SO_2	PM_{10}	PM_{2_5}
Mobile	499.2	220.2	38.4	2.6	284.2	76.8
Energy	12.1	17.4	2.0	0.1	1.4	1.4
Consumer Products	0.0	0.0	93.9	0.0	0.0	0.0
Landscaping	216.3	2.5	6.5	0.0	1.2	1.2
Architectural Coatings	0.0	0.0	341.9	0.0	0.0	0.0
Total	727.6	240.1	482.6	2.8	286.8	79.4

Abbreviations:
CO - Carbon Monoxide
NOx - Nitrogen Oxides
$PM_{2.5.}$ - Particulate Matter less than 2.5 microns in diameter
$PM_{10.}$ - Particulate Matter less than 10 microns in diameter
SO_2 - Sulfur Dioxide
VOC - Volatile Organic Compounds

Spatial displays of the gridded emissions data are presented below. We examined the gridded emissions in 4-km grid 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 CO Emissions (in lbs/day) for the Project in the Southern California 4-km Domain

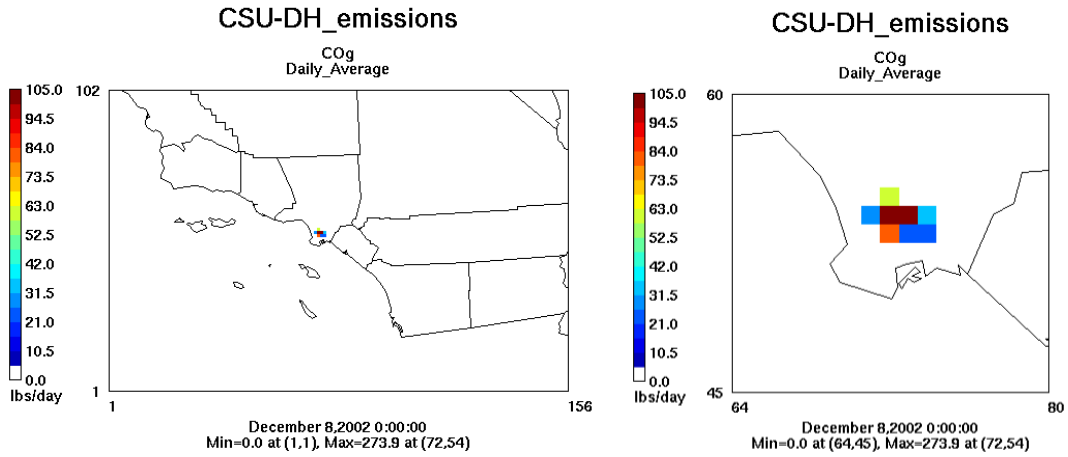


Figure 2-3. Spatial Distribution of NO_x Emissions (in lbs/day) for the Project in the Southern California 4-km Domain

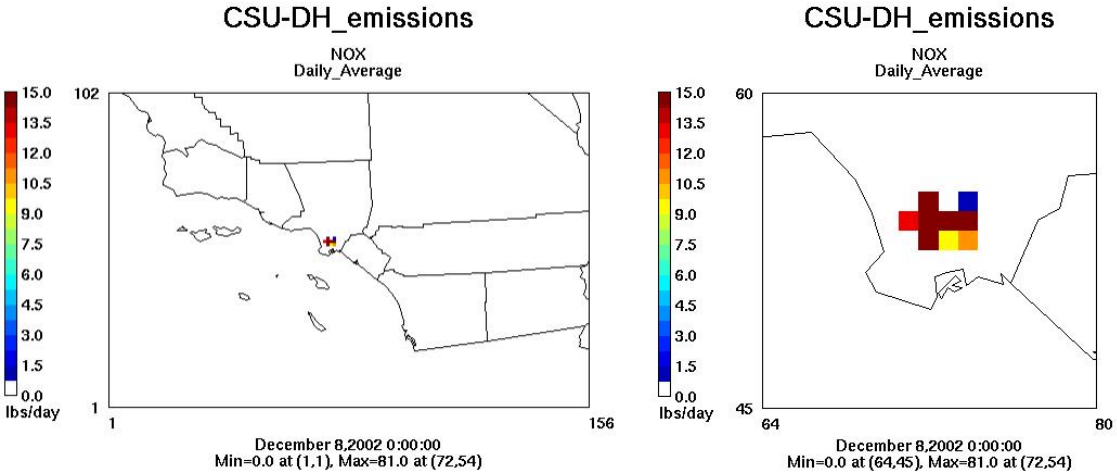


Figure 2-4. Spatial Distribution of VOC Emissions (in lbs/day) for the Project in the Southern California 4-km Domain

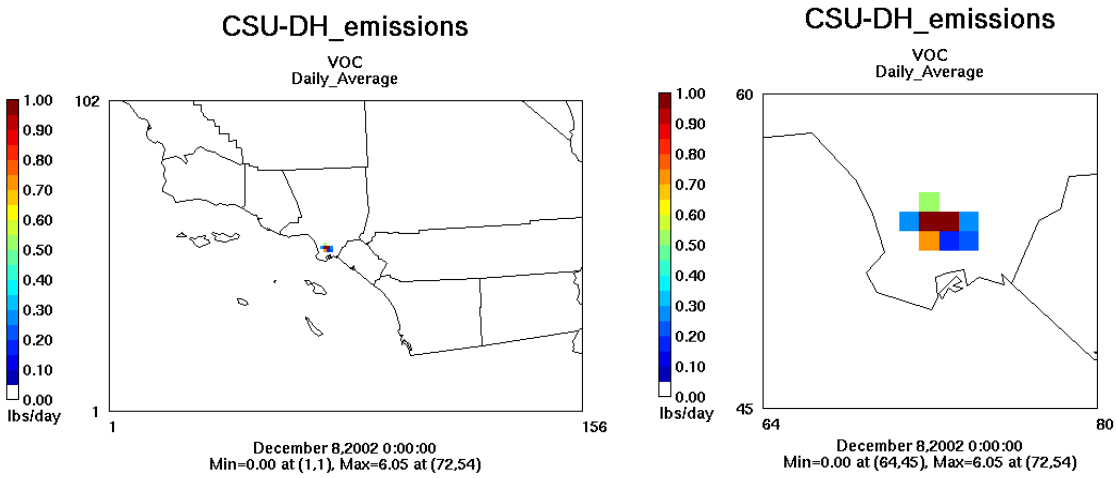


Figure 2-5. Spatial Distribution of SO_2 Emissions (in lbs/day) for the Project in the Southern California 4-km Domain

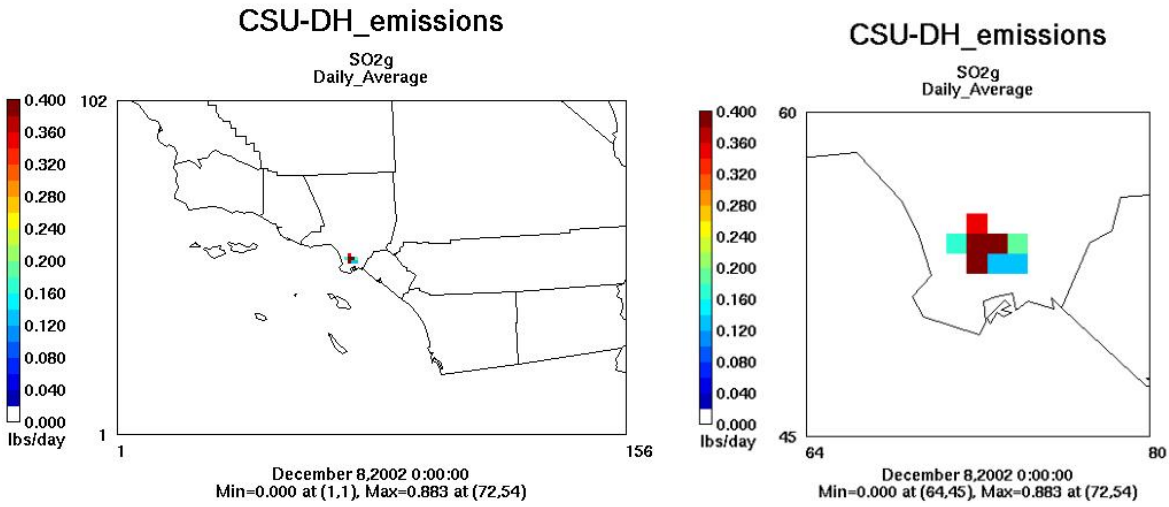


Figure 2-6. Spatial Distribution of PM_{10} Emissions (in lbs/day) for the Project in the Southern California 4-km Domain

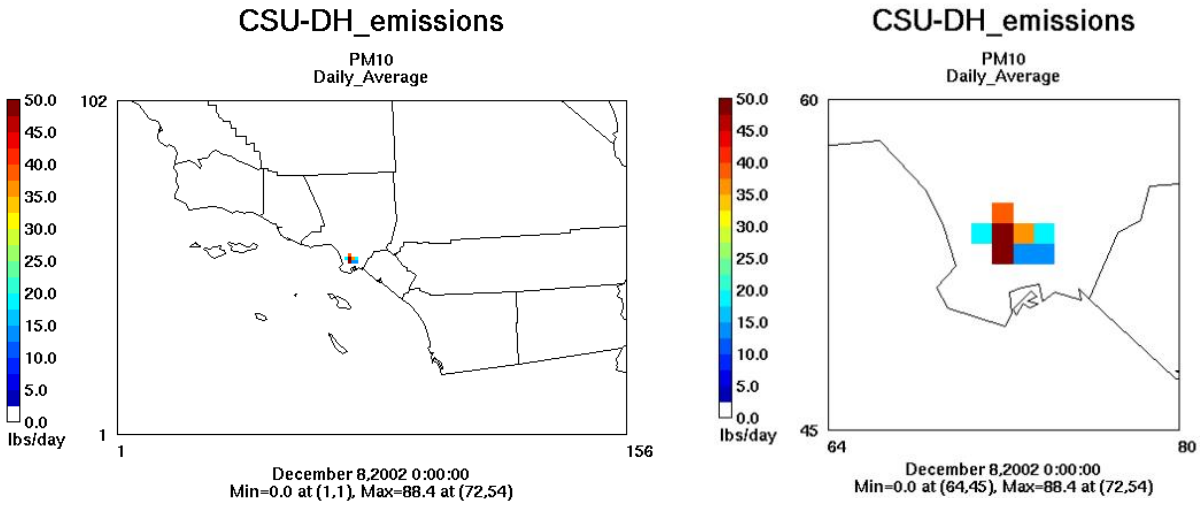
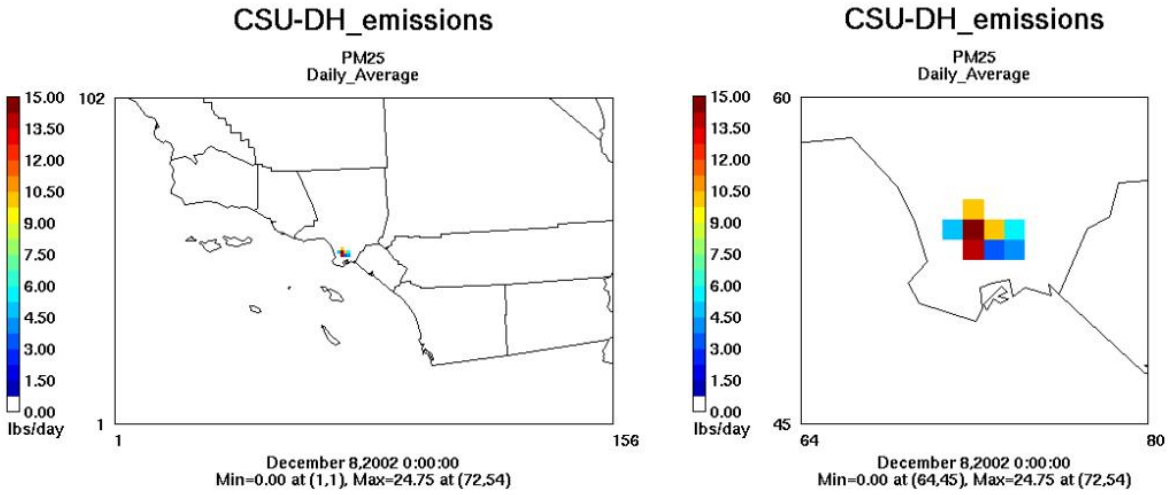


Figure 2-7. Spatial Distribution of $PM_{2.5}$ Emissions (in lbs/day) for the Project in the Southern California 4-km Domain



3. REFERENCES

/1/ Coats Jr., C.J., 1996. High-performance algorithms in the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. Proc. Ninth AMS Joint Conference on Applications of Air Pollution Meteorology with AWMA. Amer. Meteor. Soc., Atlanta, GA, 584-588.

/2/ Coats Jr., C.J., Houyoux, M.R., 1996. Fast Emissions Modeling with the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System. The Emission Inventory: Key to Planning, Permits, Compliance, and Reporting, Air & Waste Management Association. New Orleans, Louisiana.

/3/ USEPA, 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002.

APPENDIX B
PGM INPUTS, OUTPUTS, AND ASSUMPTIONS

APPENDIX B

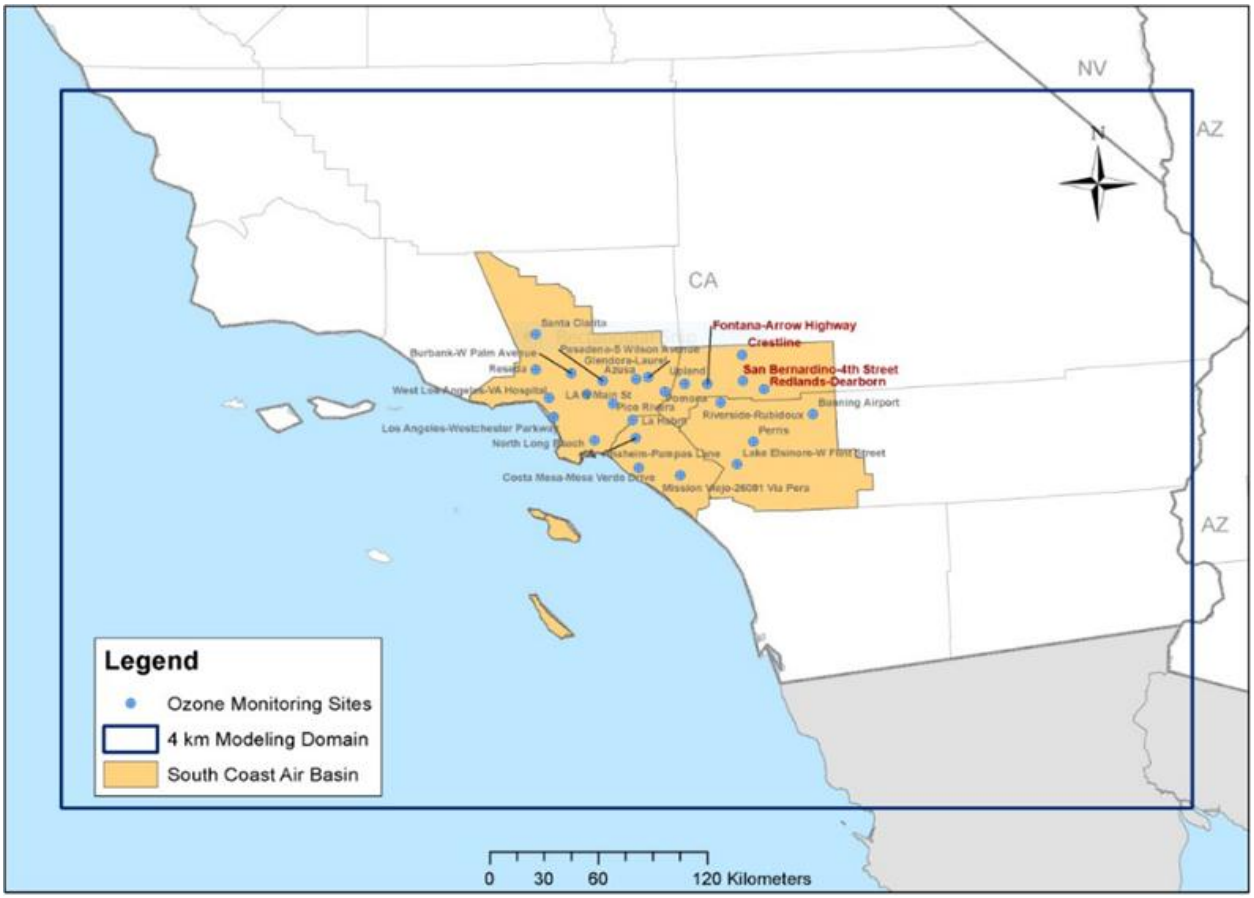
PGM INPUTS, OUTPUTS, AND ASSUMPTIONS
CALIFORNIA STATE UNIVERSITY – DOMINGUEZ HILLS
CARSON, CALIFORNIA

1. REGIONAL AIR QUALITY MODELING PLATFORM

The Southern California 2012 4- kilometer (km) Comprehensive Air Quality Model with extensions (CAMx) modeling database and a projected 2023 emissions database were used in this assessment. The 2012 base case is based on a Photochemical Grid Model (PGM) database developed by the South Coast Air Quality Management District (SCAQMD) as part of the modeling and attainment demonstration for their 2016 Air Quality Management Plan[1]. This PGM database is tailored for Southern California and reflects updated emissions estimates, new technical information and enhanced air quality modeling techniques. The database 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's) national modeling platforms[2] used for national rulemakings (e.g., transport rules such as CSAPR[3] or defining new National Ambient Air Quality Standards [NAAQS]) that use a coarser 12-km horizontal grid resolution.

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

Figure 1-1. Air Quality Modeling Domain for Southern California[4]



[1] http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp.
[2] https://www.epa.gov/air-emissions-modeling/2014-2016-version-7-air-emissions-modeling-platforms.
[3] https://www.epa.gov/csapr.
[4] https://ww3.arb.ca.gov/research/cabots/docs/9a-cabots-baaqmd-20170419.pdf.

2. REGIONAL GRID MODELING

In this section, we describe the regional PGM modeling setup to assess the impact of the Project emissions on the ambient Particulate Matter less than 2.5 microns in diameter ($PM_{2.5}$) levels in the region. The 2012 base case modeling databases were developed by the SCAQMD 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 SCAQMD. The SCAQMD CMAQ and WRF 2012 4-km data were then processed to generate a 2012 4-km annual PGM modeling database suitable for the CAMx. The following paragraphs describe how Ramboll developed the CAMx 2012 4-km annual database used in this study, starting with the SCAQMD CMAQ and WRF 2012 4-km data.

2.1 Model Inputs and Configuration

The SCAQMD emissions database has both 2012 and 2023 future year projections for CMAQ area and in-line point emissions. Ramboll converted both years' emissions to corresponding CAMx area and point-source emissions files using the CMAQ2CAMx interface program[5]. Sea salt emissions were developed using an emissions processor that integrates published sea spray flux algorithms to estimate sea salt PM emissions for input to CAMx. The CAMx sea salt emissions were then merged with area emissions files.

The most commonly used prognostic meteorological models to provide meteorological fields for air quality modeling are the WRF model (Skamarock et al., 2005) and the Fifth-Generation Mesoscale Model (MM5; Grell et al, 1994). MM5 is a nonhydrostatic, prognostic meteorological model developed in the 1970s by Pennsylvania State University and the National Center for Atmospheric Research (NCAR) and has been widely used for urban- and regional-scale photochemical, fine particulate, and regional haze regulatory modeling studies. However, development of MM5 ceased in 2006, and WRF has become the new standard model used in place of the older MM5 for regulatory air quality applications in the US. Developed jointly by NCAR and the National Center for Environmental Prediction in late 1990s, WRF has been under continuous development, improvement, testing and open peer-review for more than 10 years and used world-wide by hundreds of researchers and practitioners around the globe for a variety of mesoscale studies. SCAQMD adopted WRF version 3.6 for the 2012 simulations. For the current application, the meteorology remains unchanged for the future year simulation and SCAQMD WRF 2012 4-km model outputs were processed using the WRFCAMx[6] 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.

[5] http://www.camx.com/download/support-software.aspx.
[6] 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
30	19260	18	19260	4769	0.0000
29	17456				
28	15900				
27	14492	17	14492	6027	0.0788
26	13185				
25	11945				
24	10755				
23	9597				
22	8465	16	8465	4906	0.2930
21	7345				
20	6237				
19	5177				
18	4295				
17	3559	15	3559	1560	0.6254
16	2944				
15	2430				
14	1999	14	1999	358	0.7733
13	1641	13	1641	300	0.8107
12	1341	12	1341	251	0.8431
11	1090	11	1090	209	0.8709
10	881	10	881	175	0.8946
9	706	9	706	146	0.9148
8	561	8	561	121	0.9319
7	439	7	439	101	0.9463
6	338	6	338	85	0.9585
5	253	5	253	70	0.9688
4	183	4	183	59	0.9774
3	124	3	124	49	0.9846
2	75	2	75	41	0.9907
1	34	1	34	34	0.9958
0	0		0	0	1

The SCAQMD data set provided the lateral boundary conditions (BCs) for the 4-km state-wide modeling grid. The SCAQMD simulated a 12-km domain whose boundary concentrations 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, and simulates chemistry and transport of tropospheric gases and bulk aerosols. The 12-km outputs were saved and used to derive the boundary conditions for the 4-km domain. The CMAQ2CAMX processor was used to convert the CMAQ 4-km boundary conditions to suitable CAMx BCs. The model was initialized from clean initial concentrations and five days of spin-up period were used for the 4-km grids to minimize their influence.

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[7]. The CAMx O3MAP program reads the OMI ozone column txt 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 land use 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. In the past, the Carbon-Bond IV (CB4) chemical mechanism (Gery et al., 1989) has been predominantly used for the California State Implementation Plan (SIP) modeling. In 1999, however, the California Air Resources Board's (CARB's) Reactivity Scientific Advisory Committee recommended switching to the 1999 State-wide Air Pollution Research Center (SAPRC99) chemical mechanism (Carter, 2000) based on a comprehensive review by Stockwell (1999), and SAPRC99 has since been the mechanism of choice for the California SIPs. The 2007 update to the SAPRC chemistry mechanism, called SAPRC07 (Carter, 2010), replaced the dated SAPRC99 mechanism. The version implemented in CAMx is SAPRC07TC, which includes additional model species to explicitly represent selected toxics and reactive organic compounds and uses numerical expressions of rate constants that are compatible with the current chemistry mechanism solver. 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.

[7] ftp://toms.gsfc.nasa.gov/pub/omi/data/.

Table 2-2. CAMx Modeling Configuration

Science Option	Configuration	Notes
Model Code	CAMx v6.5	Released June 2010
Horizontal Grid	4-km 1-way nesting	
O3 and PM 4-km	156 x 102 grid cells	
Vertical Grid	18 vertical layers extending up to ~19 km AGL	Collapsed from 30 WRF layers (see Table 3-1)
Initial Conditions	Clean initial conditions	5-day spin-up for 4-km domain
Boundary Conditions	CMAQ 4km lateral concentrations converted to CAMx	
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 Model 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 Appendix 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 Los Angeles County is the region most impacted along with the southern portion of Imperial County. Annual $PM_{2.5}$ concentrations in these counties range between 10 and 20 micrograms per cubic meter ($\mu g/m^3$) with isolated regions that could reach up to 25 $\mu g/m^3$. Contributions of the Project emissions to annual average $PM_{2.5}$ are about 0.16 $\mu g/m^3$ at the most impacted areas and contributions to the maximum 24-hour average are as large as 0.42 $\mu g/m^3$ at the most impacted areas. Figure 2-2 presents increases in annual average and maximum 24-hour average $PM_{2.5}$ due to the Project by $PM_{2.5}$

component 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.

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 and right panels);
Annual Averages (top panels);
Maximum 24-hour Averages (bottom panels)

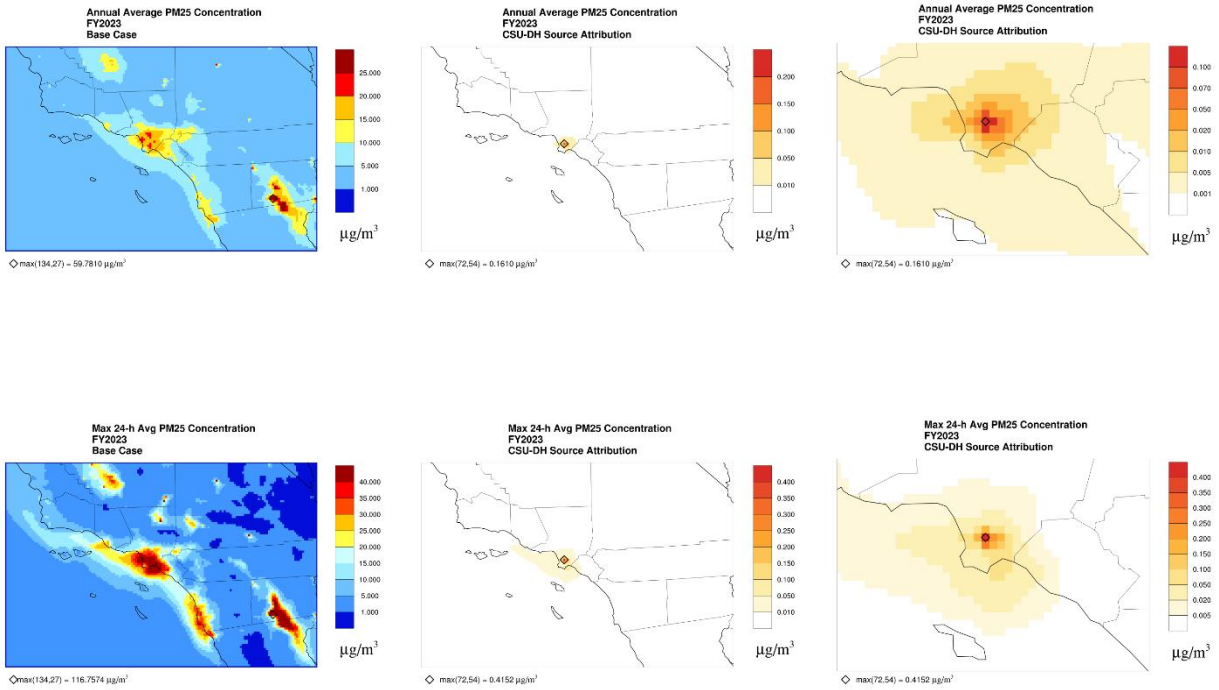
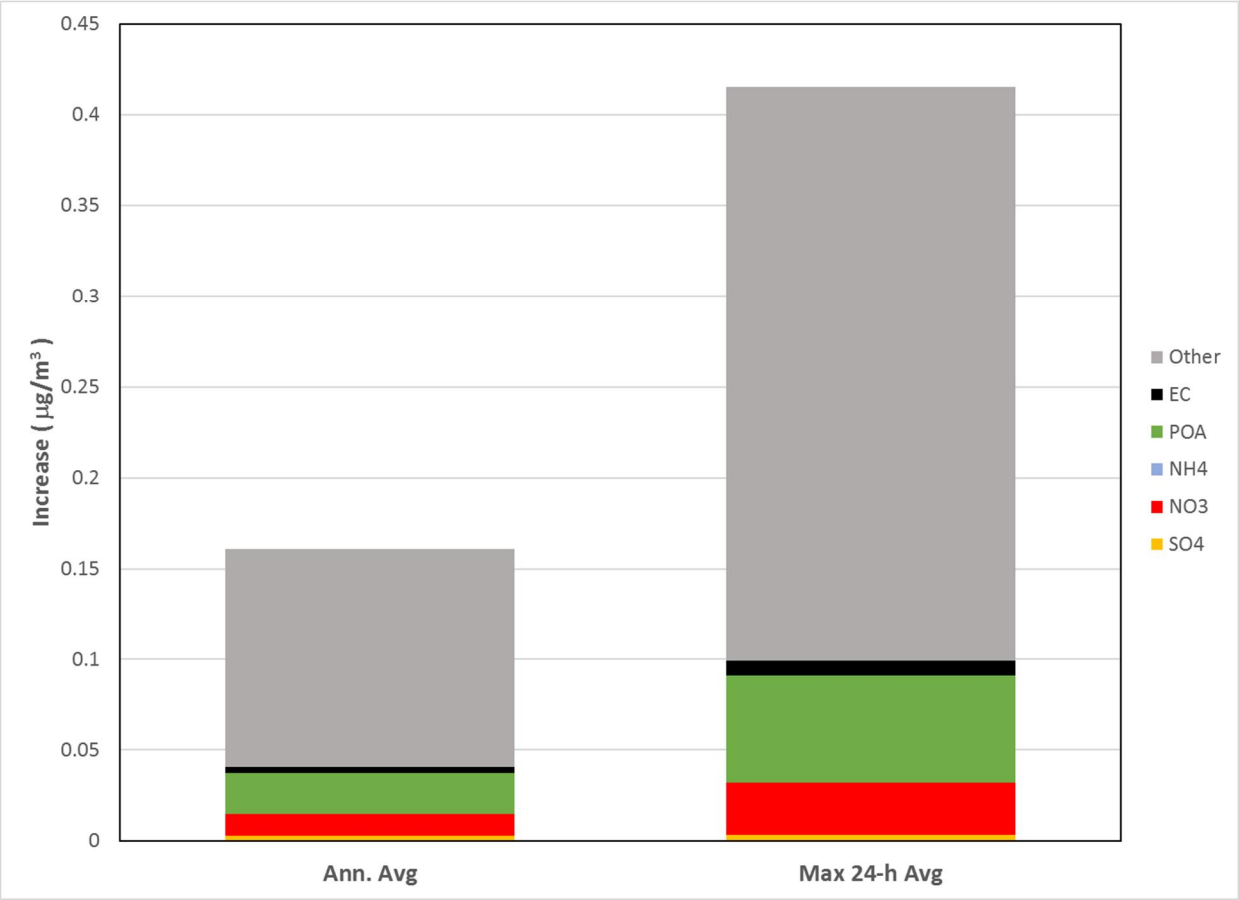


Figure 2-2. Increases in Annual Average and Episode Maximum 24-hour Average $PM_{2.5}$ Concentrations due to the Project by $PM_{2.5}$ Component: fine particulate sulfate (SO4), nitrate (NO3), ammonium (NH4), primary organic aerosol (POA), elemental carbon (EC), and other primary PM (Other); Where the Maximum Impact of the Project's Emissions Occurred



The metrics relevant to the ozone health effects selected in this study are consistent with the ozone NAAQS (see Appendix 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 highest MDA8 ozone for the 2023 emissions scenario and the increases in highest MDA8 ozone concentrations due to the Projects emissions. In the 2023 base case emissions scenario, the western Los Angeles, northern Orange, southern San Bernardino and eastern Riverside counties show the highest MDA8 ozone concentration between 90 and 100 ppb. The maximum increase in the highest MDA8 ozone concentrations due to the Project is 0.112 ppb in southern Los Angeles County.

Figure 2-4 displays MDA8 ozone for the base case and increases in MDA8 ozone due to the project on August 13, the day that the Project has the highest ozone contribution. The highest MDA8 ozone contribution due to the Project is 0.121 ppb (Figure 2-4, right) that occurs in southern Los Angeles County where total MDA8 ozone concentrations are 75 ppb.

Figure 2-3. Highest MDA8 Ozone Concentrations from the Base Case Scenario (left) and Increases in Highest MDA8 Ozone Concentrations due to the Project (right) for the Annual Modeling of the 2023 Emissions Scenario

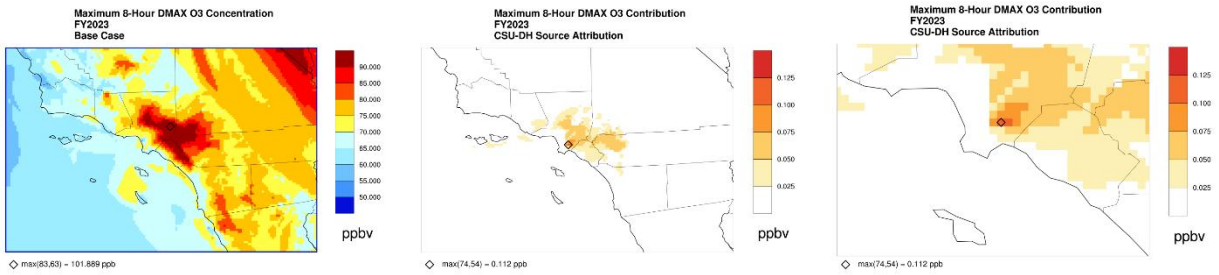
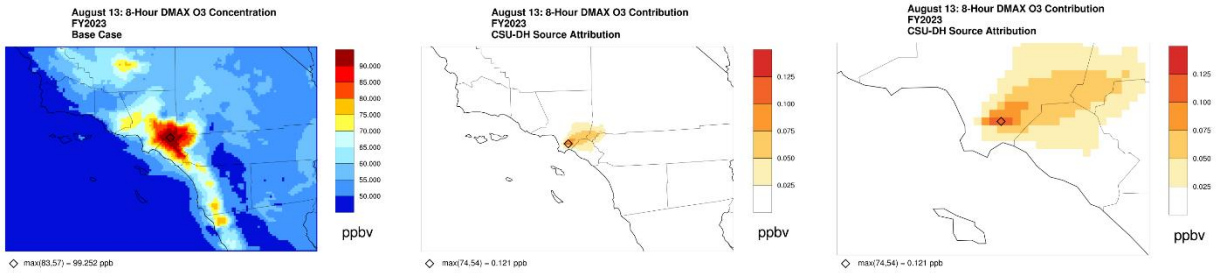


Figure 2-4. MDA8 Ozone Concentrations from the Base Case Scenario (left) and Increases in MDA8 Ozone Concentrations due to the Project (right) on August 13, the Day with the Highest Project Ozone Contributions for the Annual Modeling of the 2023 Emissions Scenario



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APPENDIX C
BENMAP AND HEALTH OUTCOMES

APPENDIX C

BENMAP AND HEALTH OUTCOMES
CALIFORNIA STATE UNIVERSITY, DOMINGUEZ HILLS
CARSON, CALIFORNIA

1. HEALTH IMPACT 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 v1.4 (July 2018).[1] BenMAP, originally developed by the United States Environmental Protection Agency (USEPA), is a powerful and flexible tool that helps users estimate human health impacts and economic benefits resulted 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 formula to relate changes in ambient air pollution to certain health endpoints (AAI, 2018):

Health Effect = Air Quality Change × Health Effect Estimate × Exposed Population × Background Health Incidence

- 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 functions (CRFs), 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. Census population to a user-defined grid.[2]
- Background Health Incidence - An estimate of the average number of people that die (or suffer from some adverse health effect) in a given population over a given period of time. For example, the health incidence rate might be the probability that a person will die in a given year. Health incidence rates and other health data are typically collected by the government as well as the World Health Organization.

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

2. HEALTH IMPACT ANALYSIS

This section presents the health impact of the Project emissions on the population in the southern California domain, estimated by the BenMAP model. The Comprehensive Air Quality Model with extensions (CAMx) modeling results are processed to generate aggregated daily averages $PM_{2.5}$ and maximum daily 8-hour ozone 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 CRF derived from previously published epidemiological studies. BenMAP often provides multiple CRFs based on different epidemiological studies for a given health endpoint. We used the USEPA default CRFs when evaluating health impacts. This analysis uses

[1] http://www.epa.gov/air/benmap/

[2] https://www.epa.gov/benmap/benmap-community-edition

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 Project buildout year.

2.1 $PM_{2.5}$ Health Impact

Although there are a large number of potential health endpoints that could be included in the analysis as described above, we selected the key health endpoints that have been the focus of recent United States Environmental Protection Agency (USEPA) risk assessments (e.g., USEPA, 2010; USEPA, 2014). 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 concentration-response relationship (USEPA, 2014).

The health endpoints and associated CRFs examined in this study are presented in Table 2-1. Each CRF is based on a certain age range for the given health endpoint depending on the underlying 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 2-2. These values reflect the total health impact in California across the Project domain.

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

Health Endpoint	Age Range	Daily Metric	Seasonal Metric	Annual Metric	CRF Selected
Emergency Room Visits, Asthma	0-99	24-hr mean			Mar et al., 2010[1]
Mortality, All Cause	30-99	24-hr mean	Quarterly mean	Mean	Krewski et al., 2009[1]
Hospital Admissions, Asthma	0-64	24-hr mean	-	-	Sheppard, 2003[1]
Hospital Admissions, All Cardiovascular (less Myocardial Infarctions)	65-99	24-hr mean	-	-	Bell, 2012[1]
Hospital Admissions, All Respiratory	65-99	24-hr mean	-	-	Zanobetti et al., 2009[1]
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] CRFs available in BenMAP (AAI, 2018)

The results show that the highest impact is for all-cause mortality, with an estimated mean increased incidence of 10.31 deaths per year due to the Project emissions. Smaller mean increased incidences per year were estimated for other relevant $PM_{2.5}$-related health outcomes: 4.38 increase in incidence of asthma related emergency room visits, 2.44 increase in incidence of respiratory hospital admissions, and 1.05 increase in incidence of cardiovascular hospital admissions.

It should be noted, however, that the estimated increased incidence in those health effects are quite minor compared to the background health incidence values (shown in Table 2-2 as percent of Background Health Incidence). For example, for mortality, the increase of 10.31 deaths per year due to Project emissions represents 0.0032% of the total all-cause mortality for people ages 30 to 99.

It is also important to note the uncertainty and conservative nature of the results presented, particularly for all-cause mortality. These estimates are based on a single epidemiological study that found an association between $PM_{2.5}$ concentrations and mortality. While similar studies suggest that such an association exists, there remains uncertainty regarding a clear causal link. This uncertainty stems from the limitations of epidemiological studies, such as inadequate exposure estimates and the inability to control for many factors that could explain the association between $PM_{2.5}$ and mortality such as lifestyle factors like smoking. In addition, the components of PM that may be associated with adverse health effects are yet unknown, but the analysis assumes that all PM is equally toxic, making it very conservative.

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

Health Endpoint[2]	Incidences (Mean)	Percent of Background Health Incidence (%)
Emergency Room Visits, Asthma [0-99]	4.38	0.0033%
Mortality, All Cause [30-99]	10.31	0.0032%
Hospital Admissions, Asthma [0-64]	0.38	0.0021%
Hospital Admissions, All Cardiovascular (less Myocardial Infarctions) [65-99]	1.05	0.00047%
Hospital Admissions, All Respiratory [65-99]	2.44	0.0013%
Acute Myocardial Infarction, Nonfatal [18-24]	0.00044	0.0012%
Acute Myocardial Infarction, Nonfatal [25-44]	0.024	0.0013%
Acute Myocardial Infarction, Nonfatal [45-54]	0.068	0.0013%
Acute Myocardial Infarction, Nonfatal [55-64]	0.13	0.0014%
Acute Myocardial Infarction, Nonfatal [65-99]	0.53	0.0013%

[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.

2.2 Ozone Health Impact

As noted above, although a larger number of health endpoints could be evaluated, we selected the health endpoints based on recent USEPA risk assessments (USEPA, 2010; USEPA, 2014). The health endpoints and associated CRFs examined in this study are presented in Table 2-3. Each CRF 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 impact in California across the Project domain.

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

Health Endpoint	Age Range	Daily Metric	Seasonal Metric	Annual Metric	CRF Selected
Hospital Admissions, All Respiratory	65 - 99	MDA8	-	-	Katsouyanni et al., 2009[1]
Mortality, Non-Accidental	0 - 99	MDA8	-	-	Smith et al., 2009[1]
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] CRFs available in BenMAP (AAI, 2018)

For this Project, asthma-related emergency room visits are associated with the highest health impacts due to the Project emissions in the southern California domain (3.38 incidences per year for adults ages 18 to 99 and 2.92 incidences per year for children ages 0 to 17). Hospital admissions due to respiratory issues for adults age 65-99 and non-accidental mortality have lower incidence increases (0.67 and 0.28 incidences per year, respectively).

It should be noted, however, that the estimated increases in those health effect incidences are quite minor 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 represents 0.0058% of the total asthma-related emergency room visits for children.

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

Health Endpoint[2]	Incidences (Mean)	Percent of Background Health Incidence (%)
Hospital Admissions, All Respiratory [65-99]	0.67	0.00034%
Mortality, Non-Accidental [0-99]	0.28	0.00013%
Emergency Room Visits, Asthma [0-17]	2.92	0.0058%
Emergency Room Visits, Asthma [18-99]	3.38	0.0042%

[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.

2.3 Conclusion

The $PM_{2.5}$ and ozone concentration changes modeled by CAMx were converted to impacts on various health endpoints including premature mortality, hospitalizations, and emergency room visits, using the BenMAP health impact assessment model and USEPA defaults for health endpoints. Estimated changes in the health effect incidences are presented across the California grids in the southern California domain. For the $PM_{2.5}$-related health endpoints, the health impact on mortality is the highest

(Incidence = 10.31). For ozone-related health endpoints, asthma-related emergency room visits are most affected (Incidence = 3.38 for adults ages 18 to 99 and Incidence = 2.92 for children ages 0 to 17). Other health effect incidences are lower. Across the board, the estimated increases in those health effect incidences are quite minor compared to the background health incidence values with the largest $PM_{2.5}$ health impact (all-cause mortality) representing only 0.0032% of the total of all deaths, and the largest impact for ozone (asthma related emergency room visits by adults) representing 0.0042% of all emergency room visits.

Health outcomes presented above conservatively utilize maximum daily emissions, assumed to occur for an entire year. Should average daily emissions be used, results would be even lower. Specifically for mortality impacts from $PM_{2.5}$ emissions, average daily emissions would be approximately 20% lower, and the corresponding morality incidence rate would be similarly lower. Overall, the estimated health impacts from the Project are low and represent only a very small fraction of the total background health incidence.

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APPENDIX D
RESUMES OF TECHNICAL STAFF

RAMBOLL

ENVIRONMENT & HEALTH

SHARI BETH LIBICKI, PHD

Principal
Air Quality Service Line Leader

Dr. Shari Beth Libicki, Ramboll Environ's global Air Quality Service Line Leader, has over 25 years of chemical fate and transport experience, as applied to managing greenhouse gas (GHG) emissions, odor evaluations, and estimating air emissions and dispersion from chemical processes, landfills and new developments. Her experience includes providing technical expertise to entitlement and litigation teams, negotiating complex technical agreements and permits with agencies and assisting facilities with compliance programs. She is an expert on GHG evaluations for California Environmental Quality Act (CEQA) documents, and is at the forefront of developing regulations in California, having served on the Regional Targets Advisory Council. She has conducted extensive air quality regulatory assessments for New Source Review/Prevention of Significant Deterioration (NSR/PRD) permitting and compliance auditing. Shari has lectured widely on evaluating climate change impacts for new developments and estimating chemical exposure for risk assessments. She currently serves as a Lecturer in the Department of Chemical Engineering at Stanford University.



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EDUCATION

PhD, Chemical Engineering, Stanford University, 1985
MS, Chemical Engineering, Stanford University, 1981
BSE, Chemical Engineering, University of Michigan, 1979

EXPERIENCE HIGHLIGHTS

Land Use Entitlement

- Project director for online tool to display risks from rail and freeways for the SMAQMD. The tool is designed to provide a first tier analysis of traffic and rail risks for land use decision making.
- Project director for air quality and greenhouse gas analyses for a new marine terminal in Northern California. Critical evaluation issues included risks from diesel exhaust of maritime vessels and GHG emissions reductions from a "green cement" production plant.
- Prepared comprehensive air quality analysis for two large municipal solid waste landfills in Southern California. Evaluation included impact of exhaust from non-road heavy equipment, dust from waste operations, and emissions from landfill gas escaping the collection system, and flares and turbines used to destroy the landfill gas. Projects included public testimony on results of analysis.

- Analyzed the impacts of potential accident scenarios prior to the construction of several new industrial facilities. The results of the analyses were used to make recommendations as to how to improve the safety and minimize the risks to the surrounding community.
- Project director for the Chevron Renewal Project Revised Environmental Impact Report. The Revised EIR is intended to fulfill the requirements of a court decision with specific focus on the Climate Change and Air Quality sections of the EIR. The revision of the Climate Change section will describe mitigation measures and quantification of the efficacy of those mitigation measures. The Air Quality section will address a range of process alternatives in the refinery.
- Project director for the development of the California Air Pollution Control Officer's Association (CAPCOA) manual on quantifying mitigation for a wide variety of carbon reduction measures that can be used for residential and commercial development.
- Project director for CalEEMod®, a new software package to estimate GHG, air toxics and criteria pollutant emissions from new development projects in California.
- Evaluated climate change impacts of dozens of new projects under CEQA and National Environmental Policy Act (NEPA). Specific types of projects include large, multi-use developments, landfill expansions, and transportation hubs.
- Provided innovative air quality services for entitlement activities, including evaluating the impacts of freeways on air quality, the estimation of emissions from complex industrial facilities, and the impact on public health of those emissions. Provided testimony at public hearings in support of technical analyses.

Monitoring

- Conceptualized, designed and implemented a mobile application to characterize, locate, obtain meteorological data for, and time-stamp odor observations. The OdorApp allows the management of odor observations, and also allows easy display of odor observations in a manner that allows for analysis of odor complaints.
- Directed a yearlong ambient air-monitoring program to measure particulate matter and diesel particulate matter (DPM) at the boundary of a large landfill in Los Angeles and a nearby school. The results of the monitoring program were analyzed temporally and as a function of meteorology. The results of the program showed that nearby freeways provided an overwhelming fraction of the measured DPM.
- Designed a complex fourteen-station ambient air monitoring network around a co-disposal landfill to measure the concentrations of 19 toxic chemicals in both gaseous and particulate phase for risk assessment purposes and negotiated approval with local, state and federal regulators.
- Analyzed the results of a complex multi-year total suspended particulate monitoring program to understand the sources of arsenic in the ambient air, and to evaluate the health risks of the arsenic levels that could be related to nearby facility emissions.
- Designed and conducted the compliance ambient air monitoring program for a large hazardous waste facility. The ongoing program collects whole air and total suspended particulate samples at five stationary sites. Prepared risk assessment based on the program, and quarterly reports for review by the local air district and the California Environmental Protection Agency's (EPA')s Department of Toxic Substances and Control (DTSC).
- Designed, negotiated and managed a novel cost-effective ambient air monitoring program that yielded real-time information on the health impacts of a site remediation. This study is the basis of a well-received paper.

Permitting and Enforcement

- Provided nationwide compliance assistance to six iron and steel mini-mills. Work conducted includes: preparation of Title V permit applications and supporting emissions estimates; preparation of PSD permits and associated emissions and dispersion modeling; evaluation of RACT controls for mini-mills.
- Managed PSD permit applications for two aluminum smelting facilities. This work included preparation of the emissions inventories, managing the Class I and Class II modeling effort, conducting the best available control technology (BACT) analysis, and preparing the technical document. She also negotiated permit conditions with the agencies, and assisted with cross-border discussions with other impacted agencies.
- Assisted a large landfill in Southern California respond to a series of Notices of Violation surrounding odor issues. Ramboll Environ conducted computational fluid dynamic (CFD) modeling study to evaluate the sources of odors at the landfill, as well as to predict where odors might occur in the neighborhood and under what conditions. Ramboll Environ also conducted a surrogate sampling study where it was found that ethanol was a surrogate for odors. Finally, Ramboll Environ assisted in the negotiations which allowed the landfill to continue operations.
- Managed the preparation of an application for an Authority to Construct for a state-of-the-art hazardous waste treatment storage and disposal facility, which included a risk assessment for the project, and successfully negotiated permit conditions with state and local agencies. Currently working with facility and regulators to implement permit conditions.
- Worked as a technical advisor to the Imperial County Air Pollution Control District (ICAPCD) for the permitting of a rail-haul landfill. This landfill is proposed to be the largest landfill in the United States, and had monitoring, modeling, and enforceability issues associated with the permit. Of particular interest was a phased permitting approach that allowed the landfill operator to take advantage of newer technologies that could reduce emissions of criteria pollutants over time.
- Prepared and submitted several Federal Operating Permit Applications under Title V of the Clean Air Act for industrial facilities. Currently working on ongoing negotiation for permits.

Other

- Evaluated the transport of perfluorooctanoic acid (PFOA) in the air and in the ocean as a part of a large multiphase study being carried out by DuPont. The study resulted in a poster presentation at the American Geophysical Union and centered on how the chemical properties of PFOA impact its transport.
- Provided support to a large shipping company in evaluating the effectiveness of its emissions reduction programs; oversaw design of an automated database system to track fuel use and emissions reductions from a variety of innovative programs to improve reporting and streamline the program.
- Conducted preliminary evaluation of whether patterns of measured lead in soil supported contention that lead resulted from airborne emissions from a lead emitting stack located at the site. Concluded that insufficient data was available for analysis.
- Designed a protocol for estimating the quantities of specific hazardous chemicals disposed of in California by region and waste type, and worked with the Department of Health Services to verify protocol.

Prior to joining Ramboll Environ, Shari held the following positions:

- Physical Sciences Officer, Bureau of Oceans and Environmental and Scientific Affairs, US Department of State
  - Developed and implemented a successful negotiation strategy for cooperative scientific projects with Japan and the Soviet Union.
  - Worked with Japan's Science and Technology Agency to initiate a Japanese funding organization for innovative international biotechnological studies.
- Staff Scientist, Alza Corporation

  - Led teams that created, designed, tested, and patented controlled release transdermal and osmotic pump drug delivery systems.
  - Studied the correlation between drug physical chemical data and dermal transport and absorption.
  - Designed and implemented systems to provide effective membrane thickness control in the manufacture of miniature osmotic pumps.
- Lecturer, Department of Chemical Engineering, Stanford University
  - Taught courses in Chemical Engineering Laboratory and Technical Speaking and Writing.

CREDENTIALS

Awards and Honors

American Association for the Advancement of Sciences Diplomacy Fellow, 1987-1988

United States Department of State Meritorious Honor Award, March 1989

PROFESSIONAL AFFILIATIONS AND ACTIVITIES

Member, American Institute of Chemical Engineers

Member, Air & Waste Management Association

PATENTS

H.F. Sanders, Y.L. Cheng, D.J. Enscore, S.B. Libicki. Transdermal Drug Composition with Dual Permeation Enhancers. Patent Number: 4,820,720. April 11, 1989.

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PUBLICATIONS & PRESENTATIONS

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Bowie, T.; S.B. Libicki, K.L. Davis, C. Emery. 2011. “Strategies for Designing an Odor Monitoring Program for Municipal Solid Waste Landfills.” Presented at Air & Waste Management Association Conference and Exposition. June 22, 2011.

Keinath, M.T. and S.B. Libicki. 2010. “Preventing GHG Leakage: Benchmarking Emissions to Design a Fair Cap and Trade System under AB32.” Presented at the 2010 California Construction and Industrial Materials Association (CalCIMA) Educatoin Conference. San Diego, CA. September.

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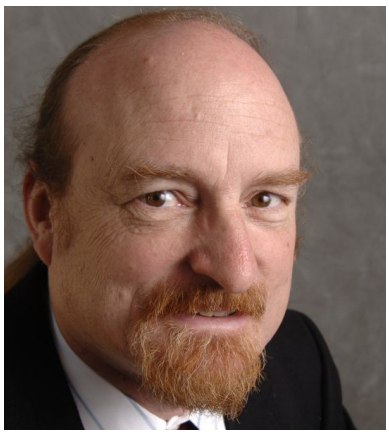
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RAMBOLL

ENVIRONMENT & HEALTH

RALPH E MORRIS

Managing Principal



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Ralph Morris is the Managing Principal at Ramboll's North California, Utah and Colorado Offices, where he directs air quality modeling and analysis, emission inventory development, control strategy evaluation and regulatory air issues projects. With almost 40 years of air quality experience, Ralph is one of the original developers of many of the photochemical air quality models that are being or have been used for regulatory decision making in the United States and around the world, including co-developer of Ramboll's Comprehensive Air Quality Model with extensions (CAMx) as well as the UAM and UAM-V models.

In the late 1970s and 1980s, Ralph was one of the pioneers in modeling air pollution in Los Angeles using one of the first ever photochemical grid models (PGM), the Urban Airshed Model (UAM). The UAM was used to identify the optimal emissions control strategies for reducing ozone in Los Angeles targeting reducing ozone precursors that most efficiently reduce ozone and avoid reducing emissions from sources that would increase ozone. In the late 1980s, Ralph performed the EPA Five Cities UAM Study for the United States Environmental Protection Agency (USEPA) that demonstrated the use the UAM PGM for ozone air quality planning culminating in the delivery of the UAM to USEPA in 1990 as the USEPA-recommended ozone model. In the late 1980s and early 1990s, Ralph developed the next generation variable grid PGM (UAM-V) that treats urban city and regional transport issues within the same model and was used by the Ozone Transport Assessment Group (OTAG) to define the first regional control strategies designed to reduce the contributions of transport in the eastern U.S. (i.e., NOx SIP Call). Ralph also led the development of ozone and $PM_{2.5}$ State Implemental Plans (SIPs) for numerous cities to allow them to achieve clean air. After joining Ramboll Environ in 1994, Ralph was one of the leaders in the development of the Comprehensive Air-quality Model with extensions (CAMx) PGM that is being used today around the world for air quality planning, including for USEPA's transport rules. During the 1990s Ralph was involved in numerous ozone and PM2.5 SIP modeling studies and analyzed long-range transport of air pollutants.

In the 2000s, Ralph directed the development of an updated Pollutants in the ATmosphere for Hong Kong (PATH) air quality modeling system for the Hong Kong Environmental Protection Department (HKEPD) and applied it to southeast Asia to assess regional transport and urban ozone and particulate matter formation. During this time he directed the application of regional particulate matter (PM), ozone and visibility modeling using CMAQ and CAMx photochemical grid models for the southeastern (VISTA/ASIP), western (WRAP) and central (CENRAP) US Regional Planning Organizations (RPOs) for the development of the first round of regional haze State Implementation Plans (SIPs) that were due in 2007.

For the last decade Ralph has been leading regional air quality modeling for Alberta Environment and Park for a variety of issues including to assess the impacts of oil sands, development of modeling databases for various regions in Alberta and most recently to model the high winter PM2.5 occurrences in Edmonton and Red Deer. He led or is leading the application of the CMAQ and CAMx models to address numerous ozone and $PM_{2.5}$ State implementation Plans (SIPs), as well as to address other air quality and air quality-related value (AQRV) issues associated with oil and gas development projects. Ralph has also addressed NO_2 and SO_2 issues including SIPs. Ralph was an original member of USEPA's ozone and fine particulate guidance workgroup and the CMAS Models-3/CMAQ External Advisory Committee (EAC).

CAREER

1994-Present
Managing Principal
Ramboll (formerly Ramboll Environ and ENVIRON), Northern California, United States

1979-1994
Manager Advanced Modeling Group and Director of Model Development Program
ICF/Systems Applications International, San Rafael, California, United States

1977-1979
Associate Professor
University of California, Davis, California, United States

EDUCATION

1977-1979
MA, Mathematics
University of California, Davis, California, United States

1974-1976
BA, Mathematics
University of California, Berkeley, California, United States

1972-1974
University of California, San Diego, California, United States

EXPERIENCE

Over the last 39 years, Ralph has been involved in thousands of air quality studies. These studies include the development of clean air plans for cities and states so that they attain the health-based air quality standards and the evaluation of the air quality impacts of numerous types of sources. A few examples for some of Ralph's more recent projects are provided below.

- WRAP Regional Haze Photochemical Modeling. Ralph is currently leading the development of photochemical modeling databases for western states to be used in the next round of reginal haze SIPs due July 2021. For the Western Regional Air Partnership (WRAP), Ralph has set up the CMAQ and CAMx models for the 2014 calendar year and conducted model performance evaluations.
- Denver 2020 and 2023 Ozone Attainment Demonstration Modeling. Ralph is currently leading the next round of Denver ozone attainment demonstration modeling. The CAMx and CMAQ models are being set-up for the 2016 summer ozone season and 2020 and 2023 future year attainment demonstration modeling is being conducted to address attainment of the 2008 and 2015 ozone NAAQS, respectively.
- Allegheny County Annual $PM_{2.5}$ State Implementation Plan. Project Director for performing the air quality modeling to define emissions control strategy to demonstrate that Allegheny County

(Pittsburgh), Pennsylvania will attain the annual PM2.5 National Ambient Air Quality Standard (NAAQS). Performed 36/12/4/1.30.444 km WRF meteorological modeling for the 2011 year. SMOKE emissions modeling for 2011 and 2021. CAMx regional 36/12 km modeling to provided boundary conditions for mesoscale 4/1.33 km PM source apportionment modeling for 2011 base and 2021 future years. 2021 PM control strategy evaluation.

- Evaluation of USEPA's 2011 National Air Toxics Assessment (NATA). Evaluated and assessed USEA's 2011 NATA modeling approach and results for modeling hundreds of air toxics compounds on a national scale. The 2011 NATA combined CMAQ national modeling results for reactive and non-reactive pollutants at 12 km grid cell resolution with AERMOD local-scale non-reactive modeling results by using the AERMOD results for receptors in the 12 km grid cell in a relative fashion to scale the CMAQ 12 km average concentrations. This unique method of model fusion of the CMAQ and AERMOD modeling results overcomes some of the issues associated with other techniques (e.g., CMAQ zero-out runs) when combining modeling results with disparate formulations.
- Dynamic Evaluation of Ozone Models for the South Coast (Los Angeles) Air Basin (SoCAB). Project Manager for conducting a dynamic evaluation of the CMAQ photochemical grid model in the SoCAB (Los Angeles, California region) using a 2008 and 2012 CMAQ modeling database. The dynamic evaluation compared the CMAQ modeled ozone trends over a long time period (1990-2015) with the observed ozone trends and found the CMAQ model underestuimat6ed the observed rate of ozone reductions over time. Potential reasons for this included the likely underestimation of VOC or overestimation of NOx emissions in the region.
- Denver 2017 Ozone SIP Modeling. For over a decade, Ralph has led the Denver ozone SIP modeling for the 2003, 2008 and ow the 2017 Denver ozone SIPs. For the Denver 2017 ozone SIP modeling we developed 2011 CAMx PGM modeling database using WRF meteorological and SMOKE emissions modeling. This included high-resolution mobile source emissions for the Denver region using link-based activity data from a Transportation Demand Model (TDM) and mobile source emission factors from MOVES2014. Conducted CAMx 2011 base case modeling and model performance evaluation. Projected emission to 20017 and 2023 and conducted emission reduction control strategy modeling to demonstrate attainment of the ozone standard.
- Allegheny County 1-Hour SO_2 State Implementation Plan. Project Manager for performing the air quality modeling to define emissions control strategy to demonstrate that Allegheny County (Pittsburgh), Pennsylvania will attain the 1-hour SO_2 National Ambient Air Quality Standard (NAAQS). Perform 36/12/4/1.3 km WRF meteorological modeling for multiple years. Conduct model shoot-out using multiple models (e.g., AERMOD, CALPUFF and SCICHEM) and model configurations to determine best performing model for simulating SO_2 and use model to demonstrate attainment of the SO2 NAAQS.
- BLM Environmental Impact Statement and Resource Management Plan for Oklahoma, Texas and Kansas. Project Manager for preparing the air quality and climate change sections of the Environmental Impact Statement (EIS)/ Resource Management Plan (RMP) for the U.S. Bureau of Land Management (BLM) and Bureau of Indian Affairs (BIA) to guide the management of BLM- and BIA-administered lands in the states of Oklahoma, Texas and Kansas
- Navajo Generating Station Environmental Impact Statement. Project Manager for coordinating the Environmental Impact Statement (EIS) required under the National Environmental Policy Act (NEPA) for the Navajo Generating Station coal-fired power plant and Kayenta Coal Mine Complex in Arizona. Technical services include air quality modeling and analysis of air monitoring data for criteria and hazardous air pollutants, assessments of human health risk and ecological risk due to atmospheric deposition from the emission sources, and preparation of Technical Support Documents for the EIS.
- Western Air Quality Study (WAQS). Project Manager for WRF meteorological, SMOKE emissions and CMAQ/CAMx air quality modeling of the western U.S. to develop the next generation air quality modeling databases to address ozone, $PM_{2.5}$, visibility and deposition issues in the western U.S.. Develop new 2008, 2011 and 2014 regional modeling platforms and distribute using the Intermountain West Data Warehouse (IWDW). Assess the role of regional transport on ozone, PM and visibility issues in western U.S. states.
- Air Quality Impacts of Off-Shore Oil and Gas Production. Ralph is currently leading two studies for BOEM to estimate the on-shore air quality impacts due to off-shore oil and gas development in the

Arctic Sea near Alaska and the Gulf of Mexico. This multi-year multi-million dollar study will project future year emissions and air quality impacts and develop emission exception screening thresholds.

- Air Quality Impacts of Fires. Project Manager of studies to assess the contributions of wildfires, prescribed burns and agricultural burning to ozone and PM air quality throughout the USA. Develop fire emission inventories and use the CAMx photochemical grid model source apportionment tool to calculate the contributions of fires to ozone and PM air quality. Results are used to identify exceptional events and assist planners in fire management practices.
- BLM Montana/Dakotas Photochemical Grid Model Modeling Study. Project Manager for the BLM Montana/Dakotas PGM modeling study to assess the air quality and AQRV impacts due to oil and gas development. The Bakken Shale formation in the Montana/Dakotas region is the most rapidly growing oil and gas development area in the U.S. Under this study, Ramboll is developing a comprehensive oil and gas emissions inventory and performing base year 2012/2013 and future year 2032 modeling using the CAMx photochemical grid model.
- Allegheny County $PM_{2.5}$ SIP Modeling. The $PM_{2.5}$ problem in Allegheny County (Pittsburgh), Pennsylvania is due to a combination of regional transport from upwind states and local sources within a river valley complex terrain environment. Ralph Morris led the Allegheny County $PM_{2.5}$ SIP modeling effort that used the CAMx photochemical grid model with a 36 km CONUS, 12 km Midwest, 4 km southeastern Pennsylvania and 0.8 km Allegheny County grid nests to demonstrate the area would achieve the 24-hour $PM_{2.5}$ standard by 2010. CAMx was run on the 36/12/4/0.8 km grids using two-way grid nesting. Local sources were treated using the CAMx subgrid-scale Plume-in-Grid treatment.
- Development of Air Quality Modeling System for Hong Kong. Ralph was Project Manager and led the development of a new air quality modeling system for Hong Kong. The WRF/MM5 meteorological, SMOKE/CONCEPT emissions and CMAQ/CAMx air quality models were set up for a 27/9/3/1 km modeling domain with the 36 km domain covering Asia and the 1 km domain focused on Hong Kong. The modeling system was delivered to the HKEPD as a turn-key system.
- St. Louis Ozone and PM2.5 SIP. Ralph led the air quality modeling efforts for the development of clean air plans for St. Louis, Missouri that were included in the St. Louis ozone and PM2.5 State Implementation Plans (SIPs). He worked with the states of Missouri and Illinois to identify the optimal control plan for the region and performed air quality modeling to demonstrate that St. Louis would achieve the ozone and $PM_{2.5}$ standards.
- Air Quality Assessments in Alberta, Canada. For almost a decade, Ralph Morris has been leading air quality studies for Alberta Environment to address Canada wide standards and Province air quality goals and objectives. These activities have included developing emission inventories for the Alberta oil sands region and urban areas, conducting meteorological modeling and performing air quality modeling using the CMAQ model to address ozone, $PM_{2.5}$, SO_2, NO_2, exposure and deposition issues in the Province.
- Expert Testimony for Air Quality Related Issues. Because of Ralph's vast expertise in air quality issues and in particular air quality modeling, over the last two decades he has served as an expert witness in numerous litigation cases.
  - Ameren Rush Island: Ralph was an expert witness and testified at trial in St. Louis April 2019 in a case where the Rush Island coal-fired power plant was accused of causing health effect impacts due to alleged illegal emissions since it failed to obtain a PSD permit and install BACT.
  - LG&E Cane Run Class Action Suit: Starting in 2015, Mr. Morris is serving as an expert witness led by Hunton and Williams in a case involving nuisance dust deposition from the Louisville Gas and Electric Cane Run coal-fired EGU.
  - Minnesota Power Plant Damage Assessment: During 2015, Ralph performed air quality modeling of the potential damages and costs associated with fossil-fueled power generation in Minnesota and prepared testimony.
  - Mead Westvaco Luke Mill: Expert witness and testify at trial in a case where a Maryland paper mill was accused of violating the Clean Air Act (CAA) and emitting illegal emissions (2012-2016).

  - DTE Energy Monroe: In 2010-2011 Ralph was retained as an expert witness by Hunton and Williams and prepared expert report and attended trial in Detroit for the USDOJ NOV case against then Monroe coal-fired power plant in the Detroit, Michigan region.
  - AEP NOV: Ralph was an expert witness for American Electric Power (AEP) from 2003-2006 through Sidley Austin in the US DOJ NOV charges against 9 coal-fired power plants in the Midwestern US.
  - Illinois Power/Dynegy Baldwin NOV: Ralph was an expert witness for Illinois Power through Akin Gump in the US DOJ Notice of Violation case against the Baldwin Power Plant in Illinois. Ralph prepared expert reports and was deposed on the ozone and PM impacts of the alleged excess emissions including a review and critique of the plaintiffs CALPUFF modeling that found errors and omissions.
  - First Energy Sammis: Expert witness for the Sammis coal fired power plant in Ohio NOV case.
  - Louisiana Generating Big Cajun 2: Ralph was an expert witness for a USDOJ NOV case against the Big Cajun 2 coal-fired power plant in Baton Rouge, Louisiana during 2012.
  - WE Energies Power the Future: In 2004, Ralph performed air quality modeling using CAMx and testified in front of a judge in Madison, WI on the Wisconsin Electric's plans to retire an old and build a new coal fired power plant at the Oak Creek facility. Testimony also included a critical review of CALPUFF modeling performed by the opponents.
  - Minnesota Acid Rain Legislation: In the early 1980s Ralph performed modeling and testified in Minneapolis, MN in front of a judge for Northern States Power regarding the impacts of local sources in Minnesota on acid deposition in Minnesota.
- Oil and Gas Environmental Impact Statements. Ralph has led the air quality modeling component of several oil and gas Environmental Impact Statements to assess the air quality, visibility and deposition impact of oil and gas development in Colorado, Utah, Wyoming and New Mexico
- Air Quality Permitting Studies. As part of the permitting process, Ralph has conducted numerous air quality modeling studies to demonstrate that new sources would be compliant with air quality standard and thresholds of concern. Sources evaluated include coal and natural gas powered electricity generation; cement plans and oil and gas production, distribution and refining.
- Air Quality Impacts of Mobile Sources. Ralph has performed numerous studies to assess the air quality impacts of alternative engine technologies and fuels. In the 1980s he modeled the air quality impacts of alternative fuels in five cities for the USEPA. In the 1990s he led the air quality modeling component of the $20M Auto/Oil Program for the automobile manufacturers and oil companies. He also led the assessment of the air quality impacts of hybrid vehicles for a joint study by General Motors and Toyota. More recently he evaluated air quality impacts of passenger vehicles for Toyota and the air quality impacts in California due to the use of biodiesel in on-road and non-road diesel engines.
- Technical Assistance to USEPA. For over three decades, Ralph has provided technical assistance to the USEPA to assist them in implementing their air program and developing the USEPA air quality modeling guidelines. This assistance included demonstrating how photochemical grid models (PGMs) can be used in ozone air quality planning and delivering the UAM PGM to USEPA in 1990 as a turn-key PGM ozone modeling system. In 2012 Ralph evaluated six long range transport (LRT) models using atmospheric field study tracer tests, evaluated chemical dispersion models using aircraft data and demonstrated how a PGM can be used for single-source modeling that helped EPA formulate their new July 2015 air quality modeling guidelines. More recently he is assisting USEPA to update the chemical mechanisms in the CAMx and CMAQ models and implement improved aqueous-chemistry and secondary organic aerosol modules.
- Various Clients. Prior to joining ENVIRON, Ralph worked for over 15 years at Systems Applications International (SAI) in San Rafael (now part of ICF Consulting), California, where he was Director of the Advanced Modeling Program, managed model development activities and air quality modeling and analysis studies. His work at SAI included the development and application of the RPM, UAM, UAM-V and REMSAD modeling systems.

PEER-REVIEWED PUBLICATIONS

Posner, L.N., G. Theodoritsi, A. Robinson, G. Yarwood, B. Koo, R. Morris, M. Mavko, T. Moore and S. Pandis. 2019. "Simulation of Fresh and Chemically-Aged Biomass Burning Organic Aerosol." Atmos. Env. 196 (2019) 27-37.

Karamchandani, P., R. Morris, G. Yarwood, B. Brashers, D. Henn, I. Sykes, E. Knipping and N. Kumar. "SCICHEM: An Alternative Photochemical Model to Calculate Single Source Impacts of Ozone and Fine Particulate Matter." A&WMA EM Magazine, October 2018.

Karamchandani, P., R. Morris, A. Wentland, T. Shah, and J. Lester. 2017. "Dynamic evaluation of photochemical grid model response to emission changes in the South Coast Air Basin in California." Atmosphere,2017,8, 145;doi:10.3390/atmos8080145.

Brashers, B., R. Morris and J. Maranche. 2017. "The Challenges of Modeling Air Quality in Allegheny County, Pennsylvania." A&WMA EM Magazine, June 2017.

Koo, B., P. Piyachaturawat, R. Morris and E. Knipping. 2012. "Evaluation of the Variability in Chemical Transport Model Performance for Deposition and Ambient Concentrations of Nitrogen and Sulfur Compounds." Atmosphere, V3, pp 400-418. August.

Cho, S., R. Morris, P. McEachern, T. Shah, J. Johnson and U. Nopmongcol. 2012. "Emission Sources Sensitivity Study for Ground-Level Ozone and PM2.5 Due to Oil Sands Development Using Air Quality Modeling System: Part I – Model Evaluation for Current Year Base Case Simulation." Atmos. Env., V55, pp 533-541.

Cho, S., R. Morris, P. McEachern, T. Shah, J. Johnson and U. Nopmongcol. 2012. "Emission Sources Sensitivity Study for Ground-Level Ozone and PM2.5 Due to Oil Sands Development Using Air Quality Modeling System: Part II – Source apportionment modeling." Atmos. Env., V55, pp 542-556.

Emery, C.A., J. Jung, N. Downey, J. Johnson, M. Jimenez, G. Yarwood, R.E. Morris. 2012. "Regional and Global Modeling Estimates of Policy Relevant Background Ozone Over the United States." Atmos. Env., V47, pp 206-217. February.

Emery, C.A., E. Tai, R.E. Morris and G. Yarwood. 2011. "Investigation into Approaches to Reduce Excessive Vertical Transport Over Complex Terrain in a Regional Photochemical Grid Model." Atmos. Env., V45, Issue 39, pp 7341-7351. December.

Koo, B., C. Chien, G. Tonnesen, R.E. Morris, J.R. Johnson, T. Sakulyanontvittaya, G. Yarwood. 2010. "Natural Emissions for Regional Modeling of Background Ozone and Particulate Matter and Impacts on Emissions Control Strategies." Atmos Environ., 44 (2010) 2372-2382, (doi:10.1016/j.atmosenv.2010.02.041) June.

Koo, B., G. M. Wilson, R. E. Morris, A. M. Dunker, and G. Yarwood. 2009. Comparison of Source Apportionment and Sensitivity Analysis in a Particulate Matter Air Quality Model. Environ. Sci. Technol., 43, 6669-6675.

Wagstrom, K., M. Spyros, N. Pandis, G. Yarwood, G.M. Wilson and R.E. Morris. 2008. "Development and Application of a Computationally Efficient Particulate Matter Apportionment Algorithm in a Three-Dimensional Chemical Transport Model." Atmos Env, 42: 5650-5659. July.

Morris, R.E., B. Koo, A. Guenther, G. Yarwood, D. McNally, T. Tesche, G. Tonnesen, J. Boylan and P. Brewer. 2006. "Model Sensitivity Evaluation for Organic Carbon Using Two Multi-Pollutant Air Quality Models that Simulate Haze in the Southeastern United States." Atmos. Env. 40 (2006) 4960-4972.

Morris, R., T.W. Tesche, G. Tonnesen, D. McNally, J. Boylan and P. Brewer. 2006. "CMAQ/CAMx Annual 2002 Performance Evaluation Over the Eastern U.S." Atmos. Env. 40 4906-4919.

Morris, R., B. Koo and G. Yarwood. 2005. "Evaluation of Multisectional and two-Section Particulate Matter Photochemical Grid Models in the Western United States." J. Air & Waste Man. Assoc., V55, No. 11, pp1683-1693. November.

Morris, R., D. McNally, T.W. Tesche, G. Tonnesen, J. Boylan and P. Brewer. 2005. "Preliminary Evaluation of the Community Multiscale Air Quality Model for 2002 Over the Southeastern United States." J. Air & Waste Man. Assoc., V55, No. 11, pp1694-1708. November.

Morris, R.E., B. Koo, Alex Guenther, G. Yarwood, D. McNally, T.W. Tesche, G. Tonnesen, J. Boylan, P. Brewer. 2004. "Diagnostic Model Performance Evaluation Using Multiple Air Quality Models For

Simulating Ozone, Particulate Matter and Regional Haze in the Southeastern United States." Atmos Env., March.

Morris, R.E., and R.D. Scheffe. 1993. "A Review of the Development and Application of the Urban Airshed Model." Atmos Env. V27B, No. 1, pp 23-39.

PRESENTATIONS

Morris, R. 2019. Single-Source Visibility Ranking and Modeling Techniques for Regional Haze SIPs. Presented at A&WMA 112th Annual Conference and Exhibition, Quebec City, Canada. June 25-28, 2019.

Morris, R., M. Zatko, B. Brashers and J. Maranche. 2019. PM2.5 Precursor Insignificance Demonstration for Allegheny County, Pennsylvania. Presented at A&WMA Guideline on Air Quality Models: Planning Ahead. Durham, North Carolina. March 19-21, 2019.

Morris, R., 2019. Air Quality Modeling of the Gulf of Mexico Region. Presented at A&WMA Guideline on Air Quality Models: Planning Ahead. Durham, North Carolina. March 19-21, 2019.

Morris, R. and B. Brashers. Introduction to CAMx. Half Day Course Presented at A&WMA Guideline on Air Quality Models: Planning Ahead. Durham, North Carolina. March 19-21, 2019.

Morris, R., L. Parker and T. Stoeckenius. 2019. Analysis of Recent Observed Ozone Increases in the South Coast Air Basin in 2016-2018 While Emissions Are Reduced. Presented at Coordinating Research Council (CRC) 29th Real World Emissions Conference, Long Beach, California. March 11-13, 2019.

Morris, R. Denver Ozone Modeling Update. Presented at David Graham and Stubbs Air Quality Summit, Denver, Colorado. September 13, 2018.

Morris, R., L. Parker and T. Stoeckenius. 2018. Effects of Meteorology and Other Processes on Observed and Modeling Ozone in the SoCAB. Presented at Southern California Ozone Research Symposium (SCORES), UC Riverside, California. June 6-7, 2018.

Morris, R. 2018. Contributions of International Emissions to Ozone Attainment in the United States. Presented at 111th A&WMA Conference and Exhibition, Hartford, Connecticut. June 25-28, 2018.

Morris, R. 2018. Assessment of the Air Quality Impacts due to Oil and Gas Development in the Gulf of Mexico Region. Presented at 111th A&WMA Conference and Exhibition, Hartford, Connecticut. June 25-28, 2018.

Morris, R. and U. Nopmongcol. 2018. Source Contribution to Secondary PM2.5 in Central Alberta. Presented at 2018 A&MA CPANS Conference -- Western Canada: Environment State of the Union. Calgary, Alberta. May 9, 2018.

Morris, R., L. Parker and T. Stoeckenius. 2018. Analysis of Recent Ozone Increases in the South Coast Air Basin. Presented at CRC 28th Real World Emissions Conference, Garden Grove, California. March 18-21, 2018.

Morris. 2017. Fires and International Uncontrollable Emissions. Presented at Regional Haze Planning Workshop, Denver, CO. December 5-7, 2017.

Morris, R. and D. McNally. 2017. Preliminary Future Ozone Projections and Source Contributions. Regional Air Quality Council Board Meeting. Denver, CO. November 3, 2017.

Morris, R. and D. McNally. 2017. Modeling Sensitivities Overview. Denver Ozone Modeling Forum. Denver, CO. November 2, 2017.

Morris, R. and D. McNally. 2017. Local Source 2017 Ozone Source Apportionment Modeling. Denver Ozone Modeling Forum. Denver, CO. November 2, 2017.

Morris, R. and D. McNally. 2017. Ozone Contributions of International Emissions using 2011 Modeling Platform. Denver Ozone Modeling Forum. Denver, CO. November 2, 2017.

Morris, R. and D. McNally. 2017. 2023 Preliminary Modeling: 2023 Ozone Projections and VOC/NOx Sensitivity. Denver Ozone Modeling Forum. Denver, CO. November 2, 2017.

Morris, R. BOEM Photochemical Modeling of Offshore Oil and Gas Development in the Arctic. Presented at U.S. Canada Northern Oil and Gas Research Forum, Anchorage, Alaska. October 11-13, 2017.

Morris, R. 2017. Evaluation of Visibility Metrics for Demonstrating Reasonable Progress Goals under the Regional Haze Rule. Presented at 4th Biannual Western Modeling Workshop, Boulder, Colorado. September 6, 2017.

Morris, R., Z. Adelman, T. Moore and R. Bates. 2017. Southern New Mexico Ozone Modeling Study and the Section 179B Option. Presented at 4th Biannual Western Modeling Workshop, Boulder, Colorado. September 6, 2017.

Morris, R., J. Jung, M. Zatko and D. McNally. 2017. Zero-Out Global Emissions Modeling Analysis of the Denver/NFR Ozone Nonattainment Area. Presented at 4th Biannual Western Modeling Workshop, Boulder, Colorado. September 6, 2017.

Morris, R. 2017. Windows Version of CAMx. Presented at A&WMA Guideline on Air Quality Models: A New Path, Chapel Hill, North Carolina. November 14-16, 2017.

Morris, R. and B. Brashers. Introduction to CAMx with Single-Source Discussion. Half Day Course Presented at A&WMA Guideline on Air Quality Models: A New Path, Chapel Hill, North Carolina. November 13, 2017.

Morris, R., P. Karamchandani, A. Wentland, T. Shah and J. Lester. 2017. Measured versus Modeled Ozone Trends in California's South Coast Air Basin and Effects on Mobile Source Controls. Presented at CRC 27th Real World Emissions Conference, Long Beach, California. March 26-29, 2019.

Morris, R., J. Jung, B. Brashers and J. Maranche and A. Sadar. 2017. Hybrid Grid/Plume Modeling for the Allegheny County 24-Hour PM2.5 Attainment Demonstration. Presented at 110th Annual Conference and Exhibition, Pittsburgh, Pennsylvania. June 5-8, 2017.

Morris, R. 2017. Measurements, Emissions and Modeling. Presented at the Critical Review in the 110th Annual Conference and Exhibition, Pittsburgh, Pennsylvania. June 5-8, 2017.

Morris, R., Z. Adelman, and T. Moore. Development and Application of Photochemical Modeling Systems to Address Ozone, Particulate Matter, Visibility and Deposition Issues in the Rocky Mountain Region. Presented at the 2-17 Air Quality Conference of the Rocky Mountain States Section of the A&MA, Denver, Colorado. April 13, 2017.

Kemball-Cook, S., R. Morris and G. Yarwood. 2016. Identifying the Influence of Exceptional Events and International Transport – An Overview of When and How to Apply Clean Air Act Provisions for Background Ozone. Presented at the American Fuel and Petrochemical Manufactures 2016 Annual Conference, San Francisco, California. March 13-15, 2017.

Vijayaraghavan, K., Beardsley, R., Jung, J., Yarwood G. & Morris, R. 2016. "The Contribution of Emissions Sources and Atmospheric Deposition to Mercury in South Florida and the Everglades." Society of Environmental Toxicology and Chemistry. Orlando, FL. November.

Morris, R.. 2016. SMOKE-MOVES Processing – Incorporate Travel Demand Model Data in Denver Ozone Modeling. Presented at 15th Annual CMAS Conference, Chapel Hill, NC, October 24-36.

Morris, R. 2016. "Modeling of Single-Source Secondary Impacts using the Higher Order Direct Decoupled Method Sensitivity." Presented at 15th Annual CMAS Conference, Chapel Hill, NC, October 24-36.

Nopmongcol. U., R. Morris, C. Archuleta, J. Adlhoch. 2016. "A Conceptual Approach to Address Anthropogenic / Non-Anthropogenic Emission Sources to Help Develop a More Accurate Regional Haze Program Glidepath." Presented at the A&WMA Visibility Conference, Jackson Hole, WY, September 27-30.

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Morris, R. E., M. A. Yocke, T. C. Myers, and R. C. Kessler. 1991. "Development and Testing of a Nested-Grid Version of the Urban Airshed Model." Presented at the Air and Waste Management Association Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R. E. 1991. "Evaluation of the Sensitivity of Emissions Controls to Grid Resolution Using the Urban Airshed Model." Presented at the Air and Waste Management Association Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R. E., G. Z. Whitten, and S. M. Greenfield. 1991. "Preliminary Assessment of the Effects of Global Climate Change on Tropospheric Ozone Concentrations." Presented at the Air and Waste Management Association Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R. E., T. C. Myers, S. G. Douglas, M. A. Yocke, and V. Mirabella. 1991. "Development of a Nested-Grid Urban Airshed Model and Application to Southern California." Presented at the 84th Annual AWMA Meeting and Exhibition, Vancouver BC. June.

Morris, R. E. and R. C. Kessler. 1991. "Mesoscale Simulation of Photochemical Air Quality in the San Joaquin Valley of California." Presented at the 84th Annual AWMA Meeting and Exhibition, Vancouver BC. June.

Morris, R. E. and A. K. Pollack. 1991. "Methodology for Evaluation of the Air Quality Impacts of Auto/Oil Reformulated and Alternative Fuels Using the Urban Airshed Model." Presented at the AWMA Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R. E., T. C. Myers, and M. A. Yocke. 1991. "Effects of Grid Resolution in the UAM on the Evaluation of Emission Control Strategies." Presented at AWMA Specialty Conference: Tropospheric Ozone and the Environment II, Atlanta, GA. November.

Morris, R. E. and others. 1990. "Use of the Urban Airshed Model to Assess the Effects of Ethanol Blended Fuels on Ozone Concentration in New York and St. Louis." Presented at the 83rd Annual AWMA Meeting and Exhibition, Anaheim, CA. June.

TEACHING EXPERIENCE

1977-1979

Calculus, University of California at Davis

MEMBERSHIPS

Air and Waste Management Association (AWMA)
Air Quality Modeling Subcommittee (AQMS) of the Science Advisory Board (SAB)
EPA Fine Particulate Modeling Guidance Workgroup
EPA UAM Guidance Workgroup
Modeling Peer-Review Group for the Los Angeles SIP Air Quality Modeling

RAMBOLL

ENVIRONMENT & HEALTH

TEJAS SHAH

Managing Consultant



Tejas Shah has over 15 years' experience with air pollution analyses. His expertise includes emission modeling, air quality modeling, emission inventory development, spatial analysis with GIS, database tool development, control-measure evaluation and economic impact analysis. He provided GIS support to developing oil and gas emissions inventories for current and future years in the western US for the Western Regional Air Partnership (WRAP). He has recently managed a review of available emission inventories for Mexico that are used in photochemical modeling studies of North America in which we used satellite-derived data products for sulfur dioxide (SO2), nitrogen dioxide (NO2) and natural gas flaring to evaluate spatial characterization and magnitude of the emissions inventories. Tejas has managed photochemical modeling studies for the US and other world regions in which key model inputs, such as the emission inventories and landuse inputs, depend on GIS analyses of geospatial data. Additionally, he has extensive experience using the RPOs emissions inventory, the USEPA's national emissions inventory (NEI) and the Environment Canada national inventory. Tejas' work at Ramboll includes Sparse Matrix Operator Kernel Emissions (SMOKE) processing of regional and project-level emission inventories for various oil and gas EIS projects in the Intermountain West; preparing gridding surrogates and speciation profiles for the SMOKE model input; augmenting SPECIATE—a repository of speciation profiles; spatial analyses and preparing landuse/landcover files for the Comprehensive Air Quality Model with extensions (CAMx) and MEGAN models using GIS; and developing database tools.

CONTACT INFORMATION

Tejas Shah

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7250 Redwood Boulevard
Suite 105
Novato, CA 94945
United States of America

EDUCATION

2000-2003
MS, Chemical Engineering
Lamar University, Beaumont, Texas, United States

1996-2000
BS, Chemical Engineering
Mumbai University, Mumbai, India

SELECTED RELEVANT EXPERIENCE

Ozone Air Quality Modeling of the Arabian Gulf

- Managed emission inventory modeling for a confidential air quality study in the Middle East. Ramboll developed a photochemical ozone modeling system based on the Comprehensive Air quality Model with extensions (CAMx).
- Developed a comprehensive emission inventory of ozone precursors (NOx, VOC and CO) for the Kingdom of Bahrain. The inventory was compiled using publicly-available data to characterize

stationary sources, mobile sources and area sources and support photochemical ozone modeling.

- Managing emission inventory modeling for a confidential study in the Middle East to assess the environmental impacts of changes to transportation infrastructure and emissions.

Air Quality and Emissions Modeling Support to EPA OAQPS

- Developed ancillary files for processing oil and gas emissions for use in the EPA's national modeling platform. Work included development and assignment of speciation profiles for WRAP Phase III oil and gas source categories, development and assignment of spatial surrogates, and preparation of inventory input files for SMOKE.

BOEM Air Quality Impacts of Off-Shore Oil and Gas Production

- Currently managing regional emissions modeling for analyzing the on-shore air quality impacts of outer continental shelf oil and gas development in the Arctic Sea near Alaska and the Gulf of Mexico. This multi-year multi-million dollar study will project future year emissions and air quality impacts and develop emission exception screening thresholds.

Allegheny County PM2.5 State Implementation Plans

- Task Manager for developing emissions input for air quality modeling to demonstrate that Allegheny County (Pittsburgh), Pennsylvania will attain the PM2.5 National Ambient Air Quality Standard (NAAQS).

Western Regional Air Partnership (WRAP) Region-Wide Emissions Inventory

- Provided GIS support in developing a region-wide O&G emissions inventory for current and future years in the western US for the Western Regional Air Partnership (WRAP). It includes performing spatial analyses using ARC/GIS tools, preparing map displays using ARC/MAP and developing gridding surrogates based on O&G activities using ARC Macro Language (AML) scripts.

Development of Gridded Ocean-Going Vessel Emissions Inventories

- Prepared gridded Commercial Marine Vessel Emissions Inventory for EPA. Detailed US port emission inventory was spatially allocated into a gridded format. The port emissions were then blended with the STEEM data, which together create the merged, gridded commercial marine vessel emissions inventory. ARC/GIS buffer tool was used to define various distance regions (25, 50, 100, and 200 nautical miles) from the US shore line.

Development of California Emission Estimator Model (CalEEMod)

- Assisted in the development of CalEEMod - a statewide land use emissions computer model designed to provide a uniform platform to quantify potential criteria pollutant and greenhouse gas (GHG) emissions associated with both construction and operational from a variety of land use projects.

Rosebud Mine, Montana EIS

- Emissions modeling Task Manager to develop regional and project-specific emissions inputs for photochemical modeling study to assess direct effects due to the Rosebud mine and indirect effects due to the nearby power plant under NEPA.

BLM Oklahoma-Kansas-Texas (OKT) EIS and Resource Management Plan

- Managed emissions modeling task of the BLM Oklahoma-Kansas-Texas (OKT) modeling study to assess the air quality impacts of oil and gas development and coal mines on federal and non-federal lands and other cumulative regional sources. Emissions of criteria air pollutants from predicted oil and gas development in the three-state area were developed for this study.

BLM Colorado Air Resource Management Modeling Study (CARMMS)

- Emissions Modeling Lead for the BLM CARMMS study that assess the air quality (AQ) and air quality related value (AQRV) impacts of new federal oil and gas and other cumulative sources including non-federal O&G, mining and other regional emissions in each of the BLM Colorado Field Office planning areas, as well as the Mancos Shale area in northwest New Mexico. Air quality modeling emissions inputs were developed for high, medium and low O&G development scenarios for future years 2021 and 2025.

BLM Montana/Dakotas PGM Modeling Study

- Task Manager for developing air quality modeling emissions for the BLM Montana/Dakotas PGM modeling study to assess the AQ and AQRV impacts due to oil and gas development. The Bakken Shale formation in the Montana/Dakotas region is the most rapidly growing oil and gas development area in the U.S. Under this study, Ramboll Environ is developing a comprehensive oil and gas emissions inventory and performing base year 2012/2013 and future year 2032 modeling using the CAMx photochemical grid model.

Navajo Generating Stations (NGS) EIS Assessment

- Task Manager for developing criteria and HAP emission inventory for NGS for lease extension EIS. This was the most comprehensive and complete AQ, ecological and human health assessment ever performed for an EIS.

SMOKE-MOVES Processing for Denver Ozone Modeling

- Developed an approach to use link-based data from TDM models as input to SMOKE-MOVES processing tool. Processed detailed vehicular activity data to prepare model-ready emissions for onroad sources. The pre-gridded activity data was input to the tool for the on-network processing and treated each grid cell and speed class as a pseudo-county. The off-network emissions were spatially allocated using surrogates developed from trip starts (start exhaust) and trip ends (for evaporative processes) by Traffic Analysis Zone (TAZ). This approach takes advantage of detailed link-based spatial and temporal varying activity data available from the TDM model and the robust emissions calculation methodology of SMOKE-MOVES that takes into account temporal and spatial variations in meteorology and has EPA approval and support.

Air Quality Assessments in Alberta, Canada

- Performed emissions modeling of regional emission inventories for North East Alberta modeling studies and North Saskatchewan Region of Alberta.

PRESENTATIONS & PUBLICATIONS

Shah, T. 2017. "Composition of Organic Gas Emissions from Flaring Natural Gas" Presented at the EPA's 2017 International Emissions Inventory Conference. August https://www.epa.gov/sites/production/files/2017-11/documents/organic_gas.pdf

Shah, T., Y. Alvarez, M. Jimenez, R. Morris, A. Brimmer and K. Lloyd. 2016. "Incorporate Traffic Demand Model Data in SMOKE-MOVES Processing for Denver Ozone Modeling" Presented at the 2016 CMAS Conference. October

Nopmongcol, U., J. Grant, E. Knipping, M. Alexander, R. Schurhoff, D. Young, J. Jung, T. Shah, G. Yarwood. 2017. "Air Quality Impacts of Electrifying Vehicles and Equipment across the United States." Environmental Science & Technology. http://dx.doi.org/10.1021/acs.est.6b04868

Karamchandani, P., R. Morris, A. Wentland, T. Shah, and J. Lester. 2017. "Dynamic evaluation of photochemical grid model response to emission changes in the South Coast Air Basin in California." Atmosphere, in review.

Collet, S., T. Kidokoro, P. Karamchandani, T. Shah, and J. Jung. 2017. "Future year ozone prediction for the United States using updated models and inputs." J. Air Waste Manage. Assoc., in review.

Vijayaraghavan, K., C. Lindhjem, B. Koo, A. DenBleyker, E. Tai, T. Shah, Y. Alvarez, G. Yarwood. 2016. "Source Apportionment of Emissions from Light-Duty Gasoline Vehicles and Other Sources in the United States for Ozone and Particulate Matter." Journal of the Air & Waste Management Association, 66, 2, 98-119. doi: 10.1080/10962247.2015.1112316.

Cho, S., R. Morris, P. McEachern, T. Shah, J. Johnson and U. Nopmongcol. 2012. "Emission sources Sensitivity Study for Ground-Level Ozone and PM2.5 Due to Oil Sands Development Using Air Quality Modeling System: Part I – Model Evaluation for Current Year Base Case Simulation." Atmos. Env., Volume 55, pp 533-541.

Cho, S., R. Morris, P. McEachern, T. Shah, J. Johnson and U. Nopmongcol. 2012. "Emission Sources Sensitivity Study for Ground-Level Ozone and PM2.5 Due to Oil Sands Development Using Air Quality Modeling System: Part II – Source Apportionment Modeling." Atmos. Env., Volume 55, pp 542-556.

RAMBOLL

ENVIRONMENT & HEALTH

MARCO A. RODRIGUEZ, PHD

Senior Consultant

Dr. Marco Antonio Rodriguez is a Senior Consultant and recognized expert with 18 years of experience using analytical techniques to solve complex air quality problems. Marco has worked on issues including oil and gas development and Better-than-BART assessments and has provided modeling advice to legal firms in cases involving litigation. He is intimately familiar with CAMx and CMAQ, and has evaluated modeling datasets using R, FORTRAN and Python. He is passionate about applying data science techniques to environmental and air quality issues.



CAREER

2018
Senior Consultant
Ramboll (formerly Ramboll Environ)

2012-2018
Air Quality Scientist, Project Manager
AECOM, Fort Collings, Colorado

- managed photochemical grid modeling projects, including evaluation, application and data analysis
- provided air quality support for impact assessments involving the National Environmental Policy Act (NEPA), oil and gas projects, winter ozone modeling, and regional haze assessment of coal-fired power plants.

2005–2012
Research Scientist, Air Quality Modeler
Cooperative Institute for Research in the Atmosphere, Fort Collins, Colorado

- provided data preparation, model setup and analysis of CAMx modeling for various environmental assessment projects funded by the national park service (NPS).
- performed nitrogen deposition modeling for NPS.
- evaluated air quality impacts from oil and gas on class i areas.
- acted as linux system administrator

2004–2005
Postgraduate Researcher
Advanced Power and Energy Program, University of California, Irvine

CONTACT INFORMATION

MARCO A. RODRIGUEZ

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Novato, 94945
United States of America

- acted as principal air quality modeler of a project funded by the California Air Resources Board to analyze the air quality impacts in the South Coast Air Basin of California (SoCAB) caused by the implementation of distributed power generation.

EDUCATION

2004
Ph.D., Mechanical and Aerospace Engineering
University of California, Irvine, United States

2001
MS, Mechanical and Aerospace Engineering
University of California, Irvine, United States

1997
BA, Physics
Universidad Autónoma Metropolitana Iztapalapa, México

EXPERIENCE (PRIOR TO RAMBOLL)

- **Wyoming Department of Environmental Quality, Wyoming Photochemical Grid.** Assistant project manager and air quality modeler lead for a project studying winter ozone formation in the Upper Green River Basin (UGRB). Elevated levels of ozone have been measured during winter in the UGRB since 2005. Ongoing studies have led scientists to believe that oil and gas development activities combined with specific meteorological conditions are contributing to elevated levels of ozone in winter. The study evaluated the results of two photochemical grid models to determine if the models can reproduce ozone events with sufficient accuracy to be used as a tool for regulatory planning purposes. Drafted all analysis documents and reports.
- **Arizona Public Service Company, Four Corners Power Plant NEPA Services.** Assistant task manager of the ozone modeling effort for a project to retrofit the power plant with emissions controls. Responsibilities included study design and planning efforts, coordinating with the proponent and interagency review team, senior oversight of emissions inventory development, task management, oversight of photochemical modeling, and authoring sections of the air quality technical support document.
- **US Bureau of Land Management - Utah State Office, Air Resource Management Strategy Modeling.** Senior photochemical modeler and data analyst for a regional cumulative air impact assessment. The study was conducted to provide a reusable modeling platform for BLM air management decisions and future NEPA analyses in the Uinta Basin. An evaluation of two photochemical grid models was conducted and the better performing model (CMAQ) was selected for analysis of future year air quality conditions, including winter ozone.
- **Environmental Impact Statement, Casper, Wyoming.** Senior photochemical grid modeler for a programmatic oil and gas development EIS project for an area that covers approximately 1.5 million acres. The proposed development would involve drilling 5,000 new wells on 1,500 new well pads producing from multiple horizons, plus an additional 450 pads for supporting ancillary facilities. The EIS is being developed under the direction of the BLM Casper Field Office as the lead agency. Major issues include air quality (potential ozone impacts); flaring and associated noise; water supply/disposal and water quality; wildlife (impacts to sage grouse); range (impacts to grazing allotments); and transportation impacts associated with increased truck traffic. In addition to numerous cooperating agencies, a key co-operator is the US Forest Service, the federal agency responsible for management of the Thunder Basin National Grasslands that comprise approximately 4% of the surface ownership in the project area
- **Cooperative Institute for Research in the Atmosphere, Rocky Mountain Sulfur and Nitrogen Study, Colorado.** Lead photochemical air quality modeler for the RoMANS project. Responsible for preparation of input datasets required for running CAMx and model performance evaluation with available observations. Excess wet and dry deposition of nitrogen-containing compounds is a concern at a number of national parks. Rocky Mountain National Park provides a

well-documented example of the role of excess nitrogen deposition in sensitive alpine environments. The RoMANS was conducted during the spring and summer of 2006 to identify the overall mix of ambient and deposited sulfur and nitrogen in the park. The Comprehensive Air Quality Model with extensions (CAMx) was used to simulate the fate of gaseous and particulate species subjected to multiple chemical and physical processes during RoMANS. The work presents an operational evaluation with special emphasis on the model performance of reduced nitrogen species. Results showed that there were large negative biases and errors at RMNP and the entire domain for ammonia; therefore, the model was deemed inadequate for source apportionment applications. The CAMx Integrated Processes Rate (IPR) analysis tool was used here to investigate the reasons behind poor model performance. In particular, IPR served as a tool to diagnose the relative contributions of individual physical and chemical processes to the final concentrations of reduced nitrogen species. Finally, guided by the information provided by the process analysis results, a series of sensitivity simulations were performed to investigate the effects of different deposition velocities in the modeled concentrations.

- **Cooperative Institute for Research in the Atmosphere, Oil and Gas Development on Ozone Formation Regional Impacts.** Lead photochemical air quality modeler and performed evaluation of regional impacts of oil and gas development using the Phase I WRAP emissions inventory. The Intermountain West is currently experiencing increased growth in oil and gas production, which has the potential to affect the visibility and air quality of various Class I areas in the region. The project presented an analysis of these impacts using the Comprehensive Air Quality Model with extensions (CAMx). Meteorology and emissions inventories developed by the Western Regional Air Partnership Regional Modeling Center for regional haze analysis and planning were used to establish an ozone baseline simulation for the year 2002. The predicted range of values for ozone in the national parks and other Class I areas in the western US was then evaluated with available observations from the Clean Air Status and Trends Network (CASTNET). The evaluation demonstrated the model's suitability for subsequent planning, sensitivity, and emissions control strategy modeling. An analysis of the model results was performed to investigate the regional impacts of oil and gas development on the ozone concentrations that affect the air quality of Class I areas.
- **California Energy Commission, Distributed Generation Air Quality Impacts.** Lead air quality modeler of a project funded by the California Air Resources Board to understand and analyze the air quality impacts in the South Coast Air Basin of California (SoCAB) caused by the implementation of distributed power generation (DG). Developed a methodology to investigate the spatial effects of placing DG in specific locations within the SoCAB. Distributed energy resources (DER) have the potential to supply a significant portion of increased power demands in California and the rest of the United States. DG is characterized by a dispersion of many stationary power generators throughout an urban air basin. As a result, DG may lead to increased pollutant emissions within an urban air basin, which could adversely affect air quality. The project developed a systematic approach based on land-use GIS data for characterizing the installation of DER in an urban air basin and simulated the potential air quality impacts using a state-of-the-art 3D computer model. Model sensitivity and model uncertainty analyses were developed in the project. The assessment of the air quality impacts associated with DER was made in the South Coast Air Basin (SoCAB) for the year 2010. Results suggest that DER characterization could be systematically applied to urban air basins, and that realistic DER implementation in SoCAB by the year 2010 only slightly affected concentrations of ozone and particulate matter in the basin. However, DG may increase localized exposure to pollutants, and higher levels of DG penetration in years beyond 2010 may lead to more significant air quality impacts than those presented in this study.

PUBLICATIONS

Paine, R. J., Taylor, C. and Rodriguez, M.A. Ozone and PM2.5: Ongoing Challenges for New Source Permitting. Natural Gas & Electricity, 34: 9–14. doi:10.1002/gas.22015, 2017.

Paine, R., Rodriguez, M. A. and Taylor, C. New Source Review Permitting Challenged by Ozone Modeling Requirements. Natural Gas & Electricity, 33: 10–15. doi:10.1002/gas.21935, 2016.

Malm, W.C., Rodriguez, M. A., Bret A. Schichtel, Kristi A. Gebhart, Tammy M. Thompson, Michael G. Barna, Katherine B. Benedict, Christian M. Carrico, Jeffrey L. Collett, A hybrid modeling approach for

estimating reactive nitrogen deposition in Rocky Mountain National Park, In Atmospheric Environment, Volume 126, Pages 258-273, ISSN 1352-2310, 2016.

Thompson, T. M., Rodriguez, M.A., M. G. Barna, K. A. Gebhart, J. L. Hand, D. E. Day, W. C. Malm, K. B. Benedict, J. L. Collett Jr., and B. A. Schichtel. Rocky Mountain National Park reduced nitrogen source apportionment, J. Geophys. Res. Atmos., 120, 4370–4384. doi:10.1002/2014JD022675, 2015

Gebhart, K.A., Malm, W. C., Rodriguez, M.A. et al., Meteorological and Back Trajectory Modeling for the Rocky Mountain Atmospheric Nitrogen and Sulfur Study II, Advances in Meteorology, vol. 2014, Article ID 414015, 19 pages, doi:10.1155/2014/414015, 2014.

Malm, W. C., Schichtel, B.A., Barna, M.G., Gebhart, K.A., Rodriguez, M.A., Collett Jr., J.L., Carrico, C.M., Benedict, K.B. Prenni, A.J., Kreidenweis, S.M. Aerosol species concentrations and source apportionment of ammonia at Rocky Mountain National Park. Journal of the Air & Waste Management Association Vol. 63, Iss. 11, 2013.

Schichtel, B.A., Rodriguez, M.A., Barna, M. G., Gebhart, K. A., M.L. Pitchford, M. L., Malm, W.C. A semi-empirical, receptor-oriented Lagrangian model for simulating fine particulate carbon at rural sites. Atmospheric Environment, Volume 61, 2012, Pages 361-370, 2012.

Rodriguez, M. A., Barna, M. G., Gebhart, K. A., Hand, J. L., Adelman, Z., Schichtel, B. A., Collett Jr., J. L., and Malm, W. C. Modeling the fate of atmospheric reduced nitrogen during the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS): Performance evaluation and diagnosis using integrated processes analysis. Atmospheric Environment, 45, 223–234, doi:10.1016/j.atmosenv.2010.09.011, 2011.

Gebhart, K. A., Schichtel, B. A., Malm, W. C., Barna, M. G., Rodriguez, M. A., and Collett Jr., J. L. Back-Trajectory-Based Source Apportionment of Airborne Sulfur and Nitrogen Concentrations at Rocky Mountain National Park, Colorado, USA, Atmospheric Environment 45, 621–633, doi:10.1016/j.atmosenv.2010.10.035, 2011.

Rodriguez, M. A., Barna, M. G., and Moore, T. Regional Impacts of Oil and Gas Development on Ozone Formation in the Western United States, Journal of the Air&Waste Management Association 59, 1111-1118, doi:10.3155/1047-3289.59.9.1111, 2009.

Rodriguez, M. A., Brouwer, J., Samuelsen, G. S., and Dabdub, D. Air Quality Impacts of Distributed Power Generation in the South Coast Air Basin of California 2: Model Uncertainty and sensitivity analysis, Atmospheric Environment 41, 5618–5635, 2007.

Rodriguez, M. A., Carreras-Sospedra, M., Medrano, M., Brouwer, J., Samuelsen, G. S., and Dabdub, D. Air Quality Impacts of Distributed Power Generation in the South Coast Air Basin of California 1: Scenario Development and Modeling Analysis, Atmospheric Environment 40, 5508–5521, 2006.

Rodriguez, M. A., and Dabdub, D. Monte Carlo uncertainty and sensitivity analysis of the CACM chemical mechanism, Journal of Geophysical Research Atmospheres 108, (D15), 4443, doi:10.1029/2002JD003281, 2003.

RAMBOLL

ENVIRONMENT & HEALTH

CHAO-JUNG CHIEN, PHD

Senior Consultant



Dr. Chien is an Atmospheric Scientist with over 18 years of experience in the air quality field. Dr. Chien is an expert in atmospheric chemistry and has comprehensive knowledge of primary and secondary air pollutants formation and their chemistry and transport in complex 3-dimensional urban and regional air quality models. He has performed photochemical grid models (PGMs) such as CMAQ and CAMx, and has extensive experience in processing/evaluating/validating input and output data for all components of air quality modeling studies, including meteorology, e.g. WRF, emissions, e.g. SMOKE, MOVES, MEGANS, etc., and pre-processors of each respective model. He has developed and implemented a model performance software package tool to create comprehensive statistical and graphical results to evaluate model performance.

CAREER

2018
Senior Consultant
Ramboll (formerly Ramboll Environ)

2009-2018
Senior Air Quality Scientist
AECOM, Fort Collings, Colorado

Technical lead on all aspects of emissions processing, photochemical grid modeling (CAMx and CMAQ) and dispersion modeling (AERMOD and CALPUFF) practices, and air quality data analysis:

- Actively participated in developing regional cumulative air quality impact assessment for various Environmental Impact Studies (EIS) related to Oil and Gas development projects located in states of Wyoming and Montana, under supervision of various state (Wyoming) and federal governments (BLM, EPA region 8). Challenges among these projects include studying elevated winter ozone formation due to oil and gas development activities combined with specific meteorological conditions, and areas with pending designation as an ozone non-attainment area.
- Responsibilities included developing spatially-allocated air resource emissions inventories (EIs), conducting PGMs with CMAQ and CAMx, performing model performance evaluation, and authoring sections of various Air Quality Technical Support Documents.
- Maintained and administrated Linux-based HPC clusters to provide computing services for various air quality modeling applications throughout the company.

CONTACT INFORMATION

Chao-Jung (Jung) Chien, PhD

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7250 Redwood Boulevard
Suite 105
Novato, 94945
United States of America

2001–2009

Senior Development Engineer, Research Associate

Center of Environmental Research and Technology (CERT), College of Engineering, University of California, Riverside, California

As a core member of Western Regional Air Partnership (WRAP) sponsored Regional Modeling Center (RMC):

- Configured and performed air quality model simulations including all components of CMAQ, CAMx, SMOKE, in assisting and supporting various Regional Planning Organization (RPOs), including WRAP, CENRAP, VISTAS (now SESARM), and MRPO/LADCO, for their development of SIPS and the regional component of fine particulate and 8-hour ozone SIPs.
- Developed and evaluated observation-based methods for assessing ozone sensitivity to precursor reductions (Smog Chamber Studies).
- Designed and developed model performance evaluation software (UCR_MPE Tool) for data analysis and evaluation of modeling results.

EDUCATION

2001

Ph.D., Atmospheric Chemistry and Organic Analytical Chemistry

University of North Carolina, Chapel Hill, United States

1989

BA, Chemistry

National Cheng Kung University, Taiwan

RELEVANT PROJECT EXPERIENCE

- **Wyoming Department of Environmental Quality (WDEQ), Wyoming Photochemical Grid.** Team lead on performing CMAQ air quality modeling and model shootouts between CMAQ and CAMx for a project studying winter ozone formation in the Upper Green River Basin (UGRB). Elevated levels of ozone have been measured during winter in the UGRB since 2005. Ongoing studies have led scientists to believe that oil and gas development activities combined with specific meteorological conditions are contributing to elevated levels of ozone in winter. The study evaluated the results of two photochemical grid models, CMAQ and CAMx, to determine if the models can reproduce ozone events with sufficient accuracy to be used as a tool for regulatory planning purposes. Assisted and as a reviewer in all analysis documents and reports.
- **US Bureau of Land Management - Utah State Office, Air Resource Management Strategy Modeling.** Team lead on a project for developing a regional cumulative air impact assessment for Utah BLM. Responsibilities included preparing and providing a spatially-allocated Air Resource Emission Inventory (EI) and providing air quality modeling platform using either CMAQ or CAMx to meet the needs of the Utah State Office of BLM for future NEPA and resource management plans (RMP) actions.
- **California Air Resources Board (CARB). Advanced Data Analysis for the Central California Ozone Study (CCOS).** Assisted in developing methods to characterize emissions, meteorology and atmospheric processes affecting the production of ozone in central CA. Performed model predictions for indicator species to observations to validate model processes. Model Inter-comparison was also conducted for SAQM, CMAQ and CAMx with CB4 and SAPRC99.
- **Arizona Public Service Company (APS Co.), Four Corners Power Plant NEPA Services.** Team lead on emissions processing for an ozone modeling project conducted to assess the impacts associated with retrofitting the Four Corners Power Plant with emissions controls. Responsible for the emission inventory processing in SMOKE for the photochemical modeling, and authoring sections of the Air Quality Technical Support Document.
- **Bureau of Land Management (EOG Resources), LaBarge Platform Exploration and Development Project EIS, Wyoming.** Team lead on emissions developing and photochemical

chemical grid modeling for a medium in-fill oil and gas development project in Southwestern Wyoming. This project is anticipated to be particularly challenging due to the area's pending designation as an ozone non-attainment area. Current responsibilities include developing emissions inventory with SMOKE, conducting photochemical grid model with CAMx, analyzing model performance and authoring sections of the Air Quality Technical Support Document

- **Coordinating research Council (CRC). Accuracy of Regional Simulations of Background Ozone and Particulate Matter.** Co-lead in Investigating natural contribution to atmospheric ozone and PM formation. Improved and refined emissions from various natural sources of ozone precursors (such as biogenic, lightning NOx) and PMs, including both direct emissions of primary PM (such as sea salt and volcanautic activities) and emissions of gaseous species that undergo photochemical transformation or condensation to form secondary PM. Conducted annual CMAQ modeling to investigate the effects that natural sources and background concentrations have on the development of ozone and PM attainment emission control strategies.
- **Regional Modeling Center (RMC), WRAP.** Assisted in regional particulate matter, ozone and haze modeling using CMAQ and CAMx for the western (WRAP), central (CENRAP), southeast (VISTAS), and Midwest (MRPO) Regional Planning Organization (RPOs) for the development of Regional Haze State Implementation Plans (SIPs) and the regional component of fine particulate and 8-hour ozone SIPs. Designed and developed model performance evaluation software (UCR_MPE Tool) for data analysis and evaluation of modeling results. Activities include obtaining ambient measurement data from various national ambient monitoring networks, assess the quality and usefulness of these data, and develop procedures of applying these data to validate air quality models.
- **UC-Riverside. Evaluation of Observation Based Methods (OBM) for Assessing the Sensitivity of Ozone to VOC and NOx.** Performed analysis on experimental results from state-of-art smog chamber experiments to determine whether observation based methods (OBMs) can be used reliably to distinguish conditions in which either VOC or NOx controls are more effective for reducing ambient ozone concentrations. More than 40 chamber experiments were carried out and 90 sets of data were accumulated. Key indicator species including H2O2, HNO3, HCHO, NO2, OH and HO2 were also analyzed and compared with computer model simulations using SAPRC-99 photochemical mechanism.

SELECTED PUBLICATIONS

Koo, B., Chien, C.-J., Tonnesen G.S., Yarwood, G., Johnson, J., Sakulyanonitvittaya, T., Piyachaturawat, P., and Morris, R., Natural Emissions for Regional Modeling of Background Ozone and Particulate Matter and Impacts on Emissions Control Strategies., Atmospheric Environment, 44, p2372-2382, 2010.

Wang, Z. S., Chien, C.-J., Tonnesen, G.S., Development of a tagged species source apportionment algorithm to characterize three-dimensional transport and transformation of precursors and secondary pollutants. J. Geophys. Res, 114, D21206, 2009.

Tonnesen, G.S., Wang, Z.S., Omary, M., Chien, C.-J., Formulation and application of regional air quality modeling for integrated assessments of urban and wildland pollution, in Developments in Environmental Science, vol 2, (eds. Bytnerowicz, A., Arbaugh, M., Alonso, R.), pp 1-26. 2008.

Chien, C.-J, Tonnesen, G.S., Wang, Z.S., Omary, M. Bytnerowicz, A., Atmospheric Modeling of Nitrogen Species in San Bernardino Mountain, CA Areas. Presented in 22nd International Meeting for Specialists in Air Pollution Effects on Forest Ecosystems (IUFRO conference), September 10-15, 2006, Riverside, California, USA

Chien, C.-J, Tonnesen, G.S., Wang, Y., Wang, Z.S., Omary, M., Model Performance Evaluations for Fine Particulates Using Unpaired in Space and Time Analysis. Presented in 4th Annual CMAS Models-3 Users' Conference, September 26-28, 2005, Chapel Hill, North Carolina, USA.

Chien, C.-J ; Tonnesen, G.S.; Wang, B. CMAQ Model Performance Evaluation with the Updated CB4-2002. Presented in 2nd Annual US-EPA's Models-3 Users' Workshop, October 27-29, 2003, Research Triangle Park, North Carolina, USA.

SONJA SAX

Managing Consultant

Dr. Sonja Sax is an environmental health scientist with over 20 years of exposure and health risk assessment experience. Dr. Sax has particular expertise in assessing exposures and risks from airborne gases and particles, and has performed indoor and outdoor air quality investigations, managed several large environmental projects, conducted critical evaluations of toxicology and epidemiology studies, and helped prepare technical and expert reports. Dr. Sax has authored and co-authored several publications, presented her research and consulting work at various conferences and testified before scientific panels. Dr. Sax earned an MS and doctorate in environmental health from the Harvard T.H. Chan School of Public Health, where she also served as a postdoctoral fellow.



CAREER

2016->>>

Managing Consultant, Ramboll

Senior manager in charge of multiple exposure and health effects projects. Specific tasks include litigation support for toxic torts, conduct systematic reviews of the health effects literature for a number of chemicals, including bitumen fumes, welding fumes, diesel particulate, and carbon black, and critically review epidemiological and toxicological literature.

2005-2015

Senior Project Manager, Gradient

Managed and worked on multiple projects related to evaluation of human exposures and health risks associated with environmental pollutants; routinely conducted air dispersion modeling and exposure assessments to support health risk assessments; reviewed and interpreted epidemiology and toxicology studies for use in preparing expert reports, peer-reviewed publications, regulatory comments, and risk communications.

2003-2005

Postdoctoral Fellow, Harvard School of Public Health

Managed two large exposure assessment projects, developed study protocols, organized field studies, and managed staff. Additional duties included writing grants, analyzing data, and publishing manuscripts in peer-reviewed journals.

CONTACT INFORMATION

Sonja Sax

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+1 (413) 8354358

Ramboll
28 Amity Street
Suite 2A
Amherst, MA 01002
United States of America

1998-2003
Research/Teaching Assistant, Harvard School of Public Health
Designed, conducted, and managed a large air pollution exposure assessment study of inner-city teenagers in New York City and Los Angeles; measured and analyzed indoor, outdoor, and personal concentrations of volatile organic compounds (VOCs), carbonyls, PM2.5, and particle-associated metals. Teaching assistant for an introductory environmental health course.

1995
Intern, Environmental Protection Agency
Analyzed health effects data to assess the impact of ozone concentrations on hospital admissions in Massachusetts.

1994-1997
Research Assistant, Harvard School of Public Health
Proposed, designed, and implemented an indoor air quality study of a green community of homes.

1991-1994
Research Associate, Repligen Corporation
Managed the peptide chemistry lab. Conducted research to improve the synthesis of peptides. Trained and supervised laboratory staff.

EDUCATION

2003
ScD, Environmental Health Sciences
Harvard T.H. Chan School of Public Health

1996
MS, Environmental Health Management
Harvard T.H. Chan School of Public Health

1991
BA, Biological Chemistry
Wellesley College

COURSES/CERTIFICATIONS

Winner of the HERA Human Risk Assessment Paper of the Year Award, 2008
Probabilistic Analysis of Human Health Risks Associated with Background Concentrations of Inorganic Arsenic: Use of a Margin of Exposure Approach. Human and Ecological Risk Assessment 14:1159-1201.

LANGUAGE SKILLS

Spanish (mother tongue), **English** (mother tongue)

PROJECTS

Cost-benefit Analyses
Conducted cost-benefit analyses of air pollution reductions in the US and Middle East using the US Environmental Protection Agency Benefits Mapping and Analysis (BenMAP) Program.

Litigation Support
Contributed to the preparation of expert reports in litigation projects that involved a variety of different chemical exposures including volatile organic compounds (e.g., vinyl chloride and formaldehyde), asbestos, carbon black, particulate matter, sulfur dioxide, pesticides, and odors.

Critical Reviews and Syntheses
Conducted an extensive literature search on the toxicity and health effects of several different chemical compounds including cobalt and cobalt alloys found in dental materials, diesel exhaust, carbon black, welding fumes, sulfur dioxide, and odors.

Systematic Reviews
Conducted weight-of-evidence evaluation of cardiovascular and respiratory effects from exposures to ozone, diesel particles, and carbon black. Results of the critical evaluation of toxicology, epidemiology, and mode-of-action studies were published in several peer-reviewed manuscripts.

Exposure and Risk Assessment
For numerous projects prepared technical analyses on exposures and potential health effects associated with various pollutants including volatile organic compounds, asbestos, carbon black, particulate matter, sulfur dioxide, pesticides, and odor. Exposure assessments included air dispersion modeling or indoor air modeling.

Regulatory Support
Provided written and oral testimony on several occasions to the Clean Air Scientific Advisory Committee (CASAC) on human exposure, epidemiology, toxicology, and mechanistic studies and their bearing on US EPA's National Ambient Air Quality Standards (NAAQS) for particulate matter and ozone.

Indoor Exposure and Risk Assessment
Conducted exposure and risk assessments of residential exposures to various chemicals including formaldehyde from wood products, emissions of carbon black from industrial sources, vapor intrusion of tetrachloroethylene, exposures to mercury from wallboard and concrete, exposures to flame retardants from various indoor sources, and odor issues from a composting facility.

PUBLICATIONS

2018
Cancer Risk Associated with Exposure to Bitumen and Bitumen Fumes: An Updated Systematic Review and Meta-Analysis.
Journal of Occupational and Environmental Medicine; 2018 Jan;60(1):e6-e54.
Authors: Mundt KA, Dell LD, Crawford L, Sax SN, Boffetta P

2018
Short-term ozone exposure and asthma severity: Weight-of-evidence analysis.
Environmental Research 2018 Jan;160:391-397.
Authors: Goodman JE, Zu K, Loftus CT, Lynch HN, Prueitt RL, Mohar I, Shubin SP, Sax SN.

2017
Particle size distributions of lead measured in battery manufacturing and secondary smelter facilities and implications in setting workplace lead exposure limits.
Journal of Occupational and Environmental Hygiene 2017 Aug;14(8):594-608.
Authors: Petito Boyce C, Sax SN, Cohen JM

2015
Are the Elements of the Proposed Ozone National Ambient Air Quality Standards Informed by the Best Available Science?
Regulatory Toxicology and Pharmacology 2015;72(1):134-140
Authors: Goodman JE, Sax SN, Lange SS, Rhomberg LR

2015
Providing Perspective for Interpreting Cardiovascular Mortality Risks Associated with Ozone Exposures.
Regulatory Toxicology and Pharmacology 2015;72(1):107-116.
Authors: Petito Boyce C, Goodman JE, Sax SN, Loftus CT

2015
Rethinking Meta-analysis: Applications for Air Pollution Data and Beyond.
Risk Analysis 2015;35(6):1017-1039.
Authors: Goodman JE, Petito Boyce C, Sax SN, Beyer LA, Prueitt RL

2015
Ozone Exposure and Systemic Biomarkers: Evaluation of Evidence for Adverse Cardiovascular Health Impacts.
Critical Reviews in Toxicology 2015;45(5):412-452.
Authors: Goodman JE, Prueitt RL, Sax SN, Pizzurro DM, Lynch HN, Zu K, Venditti FJ

2014
Weight-of-evidence Evaluation of Short-term Ozone Exposure and Cardiovascular Effects.
Critical Reviews in Toxicology 2014;44(9):725-790.
Authors: Goodman JE, Prueitt RL, Sax SN, Lynch HN, Zu K, Lemay JC, King JM, Venditti FJ

2014
The dubious benefits of further ozone reductions (Op-ed).
The Wall Street Journal May 11, 2014 at
http://online.wsj.com/news/articles/SB10001424052702304178104579536120366671620?mg=reno64-wsj
Authors: Goodman JE, Sax S

2014
Weight-of-evidence Evaluation of Long-term Ozone Exposure and Cardiovascular Effects.
Critical Reviews in Toxicology 2014;44(9):791-822.
Authors: Prueitt RL, Lynch HN, Zu K, Sax SN, Venditti FJ, Goodman JE.

2014
Letter to the editor Re: Long-Term Residential Exposure to Air Pollution and Lung Cancer Risk.
Epidemiology 2014;25(1):159.
Authors: Sax, SN, Goodman JE

2014
Evaluation of adverse human lung function effects in controlled ozone exposure studies.
Journal of Applied Toxicology 2014;34(5):516-24.
Authors: Goodman JE, Prueitt RL, Chandalia J, Sax SN

2013
Letter re: article, 'Controlled Exposure of Healthy Young Volunteers to Ozone Causes Cardiovascular Effects.'
Circulation 127(4):e432.
Authors: Goodman JE, Sax SN

2013
Evaluation of the causal framework used for setting national ambient air quality standards.
Critical Reviews in Toxicology 2013;43(10):829-49.
Authors: Goodman JE, Prueitt RL, Sax SN, Bailey LA, Rhomberg LR.

2013
Letter to the editor Re: Air pollution and lung cancer incidence in 17 European cohorts: Prospective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE).
The Lancet Oncology 2013;14(11):e439-40.
Authors: Sax SN, Zu K, Goodman JE

2013
Letter re: Equivocal evidence for confounding effects of components of particulate matter on the relationship between ozone and mortality [Letter].
American Journal of Epidemiology 2013;177(12): 1460–1462.
Authors: Sax SN, Goodman JE

2012
Potential indoor air exposures and health risks from mercury off-gassing of coal combustion products (CCPs) used in building materials.
Coal Combustion and Gasification Products 2013;4:68-74.
Authors: Long CM, Sax SN, Lewis AS

2011
Particulate matter in new technology diesel exhaust (NTDE) is quantitatively and qualitatively very different from that found in traditional diesel exhaust (TDE).
Journal of the Air & Waste Management Association 2011;61(9):894-913.
Authors: Hesterberg TW, Long CM, Sax SN, Lapin CA, McClellan RO, Bunn WB, Valberg PA.

2011
Human health hazards of exposure to new technology diesel exhaust (NTDE).
Toxicologist - Supplement to Toxicological Sciences 2011;120(Suppl. 2).
Authors: Hesterberg TW, Long CM, Sax SN, Lapin CA, Bunn WB, Valberg PA, McClellan RO

2011
Non-chemical stressors and cumulative risk assessment: An overview of current initiatives and potential air pollutant interactions.
International Journal of Environmental Research and Public Health 2011;8(6):2020-2073.
Authors: Lewis AS, Sax SN, Wason SC, Campleman SL

2011
Risk characterization of the brominated flame retardant decabromodiphenyl ethane in indoor dust.
Toxicologist - Supplement to Toxicological Sciences 2011;120(Suppl. 2):271.
Authors: Dodge DG, Pollock MC, Sax SN, Petito Boyce C, Goodman JE

2010
Letter re: Xue et al. (2010) article addressing probabilistic modeling of dietary arsenic exposure and dose.
Environmental Health Perspectives 2010;118(8). E-pub ahead of print doi:10.1289/ehp.1002328.
Authors: Petito Boyce C, Lewis AS, Sax SN, Beck BD, Eldan M, Cohen SM

2009
Human exposure to decabromodiphenyl ether, tetrabromobisphenol A, and decabromodiphenyl ethane in indoor dust.
Journal of Environmental Protection Science 3:75-96
Authors: Petito Boyce C, Sax SN, Dodge DG, Pollock MC, Goodman JE

2009
Non-cancer health effects of diesel exhaust: A critical assessment of recent human and animal toxicological literature.
Critical Reviews in Toxicology 2009;39(3):195-227.
Authors: Hesterberg TW, Long CM, Bunn WB, Sax SN, Lapin CA, Valberg PA

2008
Measurement of particle concentrations in a dental office.
Environmental Monitoring and Assessment 2008;137(1-3):351-61.
Authors: Sotiriou M, Ferguson SF, Davey M, Wolfson JM, Demokritou P, Lawrence J, Sax SN, Koutrakis P.

2008
Probabilistic analysis of human health risks associated with background concentrations of inorganic arsenic: Use of a margin of exposure approach.
Human and Ecological Risk Assessment 2008;14:1159-1201. **Winner of the HERA Human Risk Assessment Paper of the Year Award in 2008.
Authors: Petito Boyce C, Lewis AS, Sax SN, Eldan ME, Cohen, SM, Beck BD

2007
Modeling time-location patterns of inner-city high school students in New York and Los Angeles using a longitudinal approach with generalized estimating equations.
Journal of Exposure Science & Environmental Epidemiology 2007;17(3):233-47.
Authors: Decastro BR, Sax SN, Chillrud SN, Kinney PL, Spengler JD.

2007
Trends in the elemental composition of fine particulate matter in Santiago, Chile, from 1998 to 2003.
Journal of the Air & Waste Management Association 2007;57(7):845-855.
Authors: Sax SN, Koutrakis P, Rudolph PA, Cereceda-Balic F, Gramsch E, Oyola P

2006
Integrating studies on carcinogenic risk of carbon black: Epidemiology, animal exposures, and mechanism of action.
Journal of Occupational and Environmental Medicine 2006;48(12):1291-1307.
Authors: Valberg P, Long CM, Sax SN

2006
A cancer health risk assessment of a cohort of inner-city teenagers in New York City and Los Angeles.
Environmental Health Perspectives 2006;114(10):1558-1566.
Authors: Sax SN, Bennett DH, Chillrud SN, Kinney P, Ross J, Spengler JD

2005
Steel dust in the New York City subway system as a source of manganese, chromium, and iron exposures for transit workers.
Journal of Urban Health 2005;82(1):33-42.
Authors: Chillrud SN, Grass D, Ross JM, Coulibaly D, Slavkovich V, Epstein D, Sax SN, Pederson D, Johnson D, Spengler JD, Kinney PL, Simpson HJ, Brandt-Rauf P.

2005
Analysis of PM10, PM2.5, and PM2.5-10 concentrations in Santiago, Chile, from 1989 to 2001.
Journal of the Air & Waste Management Association 2005;55(3):342-351.
Authors: Koutrakis P, Sax SN, Sarnat JA, Coull B, Demokritou P, Oyola P, Garcia J, Gramsch E

2004
Differences in source emission rates of volatile organic compounds in inner-city residences of New York City and Los Angeles.
Journal of Exposure Analysis and Environmental Epidemiology 2004;14 Suppl 1:S95-S109.
Authors: Sax SN, Bennett DH, Chillrud SN, Kinney PL, Spengler JD

2004
Elevated airborne exposures to manganese, chromium and iron from steel dust in New York City's subway system.
Environmental Science & Technology 2004 Feb;38(3):732-737.
Authors: Chillrud SN, Epstein D, Ross JM, Sax SN, Pederson D, Spengler JD, Kinney PL

2002
Exposures to multiple air toxics in New York City.
Environmental Health Perspectives 2002;110(Suppl. 4):539-546.
Authors: Kinney PL, Chillrud SN, (Sax) Ramstrom S, Ross J

OTHER ACTIVITIES

Technical peer reviewer for the following Journals:
Journal of the Air & Waste Management Association
Journal of Exposure Science and Environmental Epidemiology
Environmental Health Perspectives
Atmospheric Environment
Environmental Pollution

MEMBERSHIPS

Air & Waste Management Association (AWMA)
International Society of Exposure Science (ISES)
Society for Risk Analysis (SRA)
Society for Risk Analysis New England Chapter (SRA-NE)

RAMBOLL

ENVIRONMENT & HEALTH

JEAN GUO

Consultant

Jean Guo, a Consultant at Ramboll, is experienced in air quality modeling, climate change assessment, and health impact analysis. She has conducted air quality modeling studies using models including GEOS-Chem, CAMx, CMAQ, and HYSPLIT, and used the results to evaluate the sources and impacts of air pollutants. She also has experience working with observations from surface monitors including the IMPROVE and EPA AQS networks. She has a strong background in atmospheric chemistry, particularly in ozone and particulate matter pollution. Jean is proficient at programing languages including MATLAB, Python, and Linux, and has extensive experience in ArcGIS, BenMAP, and data analysis and visualization.



CAREER

2018-Present
Consultant
Ramboll (formerly Ramboll Environ)

2015-2018
Graduate Research Assistant
Columbia University, Earth and Environmental Sciences Department, New York, United States

2014
Researcher
NASA Student Airborne Research Program, Irvine, California, United States

2012-2015
Research Assistant
Columbia University, Earth and Environmental Sciences Department, New York, United States

CONTACT INFORMATION

Jean Guo

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+1 (415) 8990715

Ramboll
7250 Redwood Blvd
Suite 105
Novato, CA 94945
United States of America

EDUCATION

2017-2018
Master of Philosophy, Earth and Environmental Sciences (Atmospheric Science, Modern and Future Climate, Oceanography)
Columbia University, New York City, New York, United States

2015-2017
Master of Arts, Earth and Environmental Sciences (Atmospheric Science, Modern and Future Climate, Oceanography)
Columbia University, New York City, New York, United States

2011-2015
Bachelor of Arts, Environmental Sciences
Columbia University, New York City, New York, United States

SELECTED PROJECTS

Health Impact Analyses

- Compared the health impacts of various electrification scenarios on human health and converted the impacts to dollar estimates.
- Ran health impact analyses to compare the health effects of criteria air pollutants under various developments as per the requirements of the California Environmental Quality Act (CEQA).
- Visualized the various health impacts of proposed projects on disadvantaged communities.

Climate Change

- Contributed to Environmental Impact Statements for various projects, analyzing the effect of the proposed project on the affected environment and climate.
- Analyzed the future projected impacts of natural hazards such as flooding, wild fires, extreme heat, and water stress on various properties.
- Prepared reports to guide property owners and buyers on the potential risks to their properties from future climate change.

Air Quality Modeling

- Modeled the impact of various pollutants on select regions and quantified the source contributions from different sectors.
- Tracked the source of pollution by activity section and geographic location to determine the impact of each sector on specific regions.
- Determined the source contributions to criteria pollutants during days with bad air quality to determine the drivers of non-attainment days in various parts of the U.S.

PUBLICATIONS

Guo, J. J., Fiore, A. M., Murray, L. T., Jaffe, D. A., Schnell, J. L., Moore, T., and Milly, G.: Average versus high surface ozone levels over the continental U.S.A.: Model bias, background influences, and interannual variability, Atmos. Chem. Phys., https://doi.org/10.5194/acp-2018-115, **2018**.

Young PJ, Naik V, Fiore AM, Gaudel A, **Guo J**, Lin MY, et al. Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability, and trends. Elem Sci Anth. **2018**; 6(1):10. DOI: http://doi.org/10.1525/elementa.265

Guo, J.J.: Interannual Variability in Background Tropospheric O_3 in the U.S.A., **2017**. Abstract.

Guo, J.J.: Seasonal and Regional Variability in the Relationship between Ground-Level Ozone (O_3) and Fine Particulate Matter ($PM_{2.5}$) in the United States, **2015.** Abstract.

RAMBOLL

ENVIRONMENT & HEALTH

TAYLOR A VENCILL

Senior Managing Consultant

Taylor Vencill is a Senior Managing Consultant in the Air Sciences Practice, currently located in the San Francisco, California office. Taylor's experience includes emissions estimation, air dispersion modeling, permitting, regulatory compliance, and greenhouse gas (GHG) emissions analyses and verifications. She has contributed to climate action plan development, climate change technical reports, environmental impact reports (EIRs), permit applications, health risk assessments (HRAs), and litigation support. Taylor's analytical skills include emissions inventories, air dispersion modeling, and data analysis using Microsoft Excel, Microsoft Access, and Geographic Information Systems (GIS). She has experience with a variety of emissions estimation and air dispersion modeling software including CalEEMod, EMFAC, OFFROAD, AERMOD, CAL3QHCR, and HARP. Taylor is a Registered Professional Engineer (Chemical) in California and a California Air Resources Board-Accredited GHG Lead Verifier with Specialty in Oil & Gas and Process Emissions (Executive Order H-18-159).



CONTACT INFORMATION
Taylor A Vencill

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Ramboll
201 California Street
Suite 1200
San Francisco, 94111
United States of America

EDUCATION

MS, Civil and Environmental Engineering, Stanford University, 2014
BS, Chemical Engineering, Cornell University, 2009

EXPERIENCE HIGHLIGHTS

CEQA

- Contributed to and managed GHG, air quality, and energy analyses for various developments under the California Environmental Quality Act (CEQA).
- Prepared GHG, air quality, and energy technical reports in support of EIRs for various types of development.
- Developed inventories for all aspects of developments including construction, energy use of buildings, mobile sources, area sources, municipal sources and vegetation change.
- Used the California Emissions Estimator Model (CalEEMod), the Emission Factor Model (EMFAC), OFFROAD2007 and the In-Use Off-Road Equipment Model (2010 and 2011), and the Urban Emission Model (URBEMIS) to evaluate construction, area, and mobile emission inventories.

Climate Change

- For various projects, have evaluated and presented mitigation options and potential offsets, showing potential GHG reductions and related costs of implementation.
- Evaluated the significance of development emissions in relation to established thresholds.
- Led the development of baseline and future GHG inventories for the Port of San Diego in support of their climate action plan (CAP). Incorporated the effect of California regulations on future emissions.
  - Following the CAP development, helped evaluate the Port's progress towards meeting the CAP goals and assisted the Port in implementation efforts.
- Provided technical analyses for several GHG verifications under the California Air Resources Board (ARB) Mandatory Reporting Regulation. Verifications have included a poultry processing facility (general stationary combustion source), a transportation fuel supplier, an electricity importer, and an underground natural gas storage facility. Served as Lead Verifier on a set-aside verification from Reporting Year 2014 for an onshore petroleum and natural gas production facility.

Emissions Estimation

- Assisted with the development of emissions inventories for various industrial sites for litigation support, permit applications and permit compliance.
- Specifically assisted in preparing emissions inventories for complex industrial facilities in support of an initial Title V application as well as Title V Renewal applications.
- Managed development of a Facility-wide emissions inventory for a California refinery.
- Assisted in historical emissions estimations and emission source identification for litigation support. Included extensive review of historical documents.
- Assisted in development of emissions inventories for proposed modifications to industrial facilities.
  - Related permitting efforts included New Source Review (NSR), Prevention of Significant Deterioration (PSD) and Title V applicability analyses.
  - Used Hotspots Analysis and Reporting Program (HARP) to manage the facilities' emissions and assess the facilities' prioritization score.

Air Dispersion Modeling

- Conducted AERMOD, ISCST3, CAL3QHCR and SCREEN3 dispersion modeling for HRAs, permit applications and regulatory compliance.
- Performed the following tasks in relation to air dispersion modeling:
  - Meteorological data processing
  - Surface parameter analysis
  - Model and receptor setup using GIS tools
  - Post-processing of model results to analyze the magnitude and location of potential risks
- Performed reconciliation of air dispersion modeling and offsite monitoring results to determine source strengths of potential fugitive emission sources.
- Managed large-scale air dispersion modelling for traffic and maritime impacts (city-wide scale), to determine $PM_{2.5}$ and health risk impacts.

Specialized Modeling

- Used Automated Data Inquiry for Oil Spills (ADIOS2) in support of litigation.

Regulatory Compliance

- Assisted a Class I Hazardous Waste Treatment, Storage, and Disposal Facility (TSDF) with air permit compliance, including an ambient air monitoring program (AAMP) and annual health risk evaluation (HRE).
- Conducted performance audits to evaluate the organic and inorganic sampling procedures, on-site meteorological station, spike test analyses and calibration procedures.
- Conducted onsite compliance assistance for a biotechnology company, including tracking for continual air permit compliance and the development of related tools to assist in the tracking efforts.
- Assisted industrial clients with their annual Toxics Release Inventory (TRI) reporting requirements, including applicability determinations and release quantifications.
- Assisted various clients with the ARB In-Use Off-Road Diesel-Fueled Fleets Regulation and LSI Fleet Requirements Regulation, including navigation through the regulations, evaluation of current and future fleet compliance to assist in purchasing and retrofit decisions, and assistance with the Diesel Off-Road Online Reporting System (DOORS).
  - Attended four related ARB training classes: Course #504 – In-Use Off-Road Diesel Vehicle Regulation Training, Course #505 – Large Spark-Ignition Fleet Regulation, Course #520 – How to Comply with CARB Diesel Regulations, Course #521.8 – Diesel Truck Regulation Compliance Course
- Project manager for the preparation of an Air Toxics Hot Spots Information and Assessment Act (AB 2588) HRA for an industrial client, using HARP to assess potential inhalation and multipathway health risk impacts.
- Assisted an industrial facility with evaluation of impact areas and preparation of warnings under Proposition 65.

Prior to joining Ramboll, Taylor held the following positions:

- Intern, Rhodia Inc, Martinez, California
  - Used Ultrapipe software to analyze pipe measurements for effects of corrosion, oversaw several maintenance routines while shadowing a process engineer, and was present for the two-week plant shutdown when various inspections took place.
- Intern, ENVIRON, Emeryville, California
  - Assisted in preparing a Title V Renewal Application, developing carbon footprint analyses and emission inventories, and preparing technical memos, inventory management plans, and technical reports.

CREDENTIALS

Registrations and Certifications

California Air Resources Board-Accredited Greenhouse Gas (GHG) Lead Verifier with Specialty in Oil & Gas and Process Emissions (Executive Order H-18-159)

Registered Professional Engineer (Chemical), California

B.5 Friant Ranch Interim Recommendation

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Friant Ranch
Interim Recommendation

Background

The California Supreme Court in the case of *Sierra Club v. County of Fresno* (2018) 6 Cal. 5th 502 regarding the proposed Friant Ranch project determined the air quality analysis in the environmental impact report (EIR) was inadequate because it did not make "a reasonable effort to substantively connect the project's air quality impacts to likely health consequences." The Court determined that "the EIR should be revised to relate the expected adverse air quality impacts to likely health consequences or explain in meaningful detail why it is not feasible at the time of drafting to provide such an analysis."

Need

Lead agencies and practitioners preparing documents to comply with the California Environmental Quality Act (CEQA) have requested guidance from the Sacramento Metropolitan Air Quality Management District (Sac Metro Air District) on implementing the Friant Ranch decision in the review and analysis of proposed projects in Sacramento County.

Interim Recommendation

The Sac Metro Air District does not currently have a methodology that would correlate the expected air quality emissions of projects to the likely health consequences of the increased emissions. The Sac Metro Air District is in the process of developing a methodology to assess these impacts, and anticipates releasing it in the fall of 2019. In the interim, agencies should follow the Friant Court's advice to explain in meaningful detail why this analysis is not yet feasible.

This explanation should describe the background underlying air regulations, the regional nature of the regulatory approach, and why the approach is not amenable to project level assessments. This should include a discussion of the public health impact analyses that form the basis for the state and federal health-based pollutant concentration standards, and the application of the standards to regions that were established based upon a commonality of factors impacting air quality. Air districts, in turn, have focused on reducing regional emissions from all sectors to meet the health-based concentration standards, thereby reducing the pollutant specific health impacts for the entire population. For example, the Sac Metro Air District prepared plans to attain and maintain the ozone and particulate matter ambient air quality standards. These attainment plans include emissions inventories, air monitoring data, control measures, modeling, future pollutant-level estimates, and general health information. Attainment planning models rely on regional inputs to determine ozone and particulate matter formation and concentrations in a regional context, not a project specific context. Because of the complexity of ozone formation, the pounds or tons of emissions from a proposed project in a specific geographical location does not equate to a specific concentration of ozone formation in a given area, because in addition to emission levels, ozone formation is affected by atmospheric chemistry, geography, and weather. Secondary formation of particulate matter is very similar to the complexity of ozone formation, and localized impacts of directly emitted particulate matter do not always equate to local particulate matter concentrations due to transport of emissions. The analysis should explain that because air district attainment plans and supporting air model tools are regional in nature, they do not allow for analysis of the health impacts of specific projects on any given geographic location. More information is included in the threshold justification documents developed by the Sac Metro Air District, and available at our website at www.airquality.org.

The analysis should also discuss the current models[i] used in CEQA in air quality analyses, which, in contrast to attainment models, are designed to calculate and disclose the mass emissions expected from the construction and operation of a proposed project (pounds/day and tons/year). The estimated emissions are then compared to significance thresholds, which are in turn keyed to reducing emissions to levels that will not interfere with the region's ability to attain the health-based standards. The Sac Metro Air District adopted operational emission thresholds for ozone precursors, nitrogen oxides (NOx) and reactive organic gasses (ROG), with the goal of obtaining 0.45 tons/year of NOx and 0.49 tons/year of ROG reductions from new

development projects exceeding the thresholds by including emission reducing design features as mitigation.[ii] More recently, the Sac Metro Air District adopted particulate matter thresholds, PM10 and PM2.5, to align with the new source review permit offset levels, which are designed to prevent new emission sources from affecting attainment progress.[iii] Sac Metro Air District thresholds are set at 65 pounds/day NOx (11.8 tons/year), 65 pounds/day ROG (11.8 tons/year), 80 pounds/day PM10 (14.6 tons/year), and 82 pounds/day PM2.5 (15 tons/year).[iv] CEQA thresholds are a tool Sac Metro Air District uses to obtain emission reductions from development projects to support attainment of the Federal and State ambient air quality standards. This protects public health in the overall region, but there is currently no methodology to determine the impact of emissions on concentration levels in specific geographic areas.

The CEQA analysis should consider the degree to which various other tools, such as CalEEMod, EMFAC, OFFROAD, AERMOD, and HARP and CAMx, could assist in assessing specific health impacts of a project, and, where those tools would not be useful, explain why. For example, while CalEEMod may be useful in comparing emissions to significance thresholds, it is not able to assess transport of pollutants or the impacts of external factors (weather, terrain, etc.) on pollutant concentrations at particular locations.

In Sacramento, concentration modeling of ozone has not been an analytical tool used for project level emissions due to the complex nature of pollution concentration formation and numerous regional influences (multiple emission sources, meteorology, atmospheric chemistry and geography). Although some particulate matter concentration modeling has been conducted for project specific emissions for stationary source permitting purposes, concentration modeling has mainly been used to support ozone attainment demonstration.

Outside of these tools, neither the Sac Metro Air District nor any other air district currently have methodologies that would provide Lead Agencies and CEQA practitioners with a consistent, reliable, and meaningful analysis to correlate specific health impacts that may result from a proposed project's mass emissions.

An expanded discussion of health impacts resulting from specific air pollutants may also be warranted for projects with emissions exceeding the Sac Metro Air District's thresholds of significance. There is an array of information on health impacts related to exposure to ozone[v] and particulate matter[vi] emissions published by the US EPA and the California Air Resources Board. Health studies are used by these agencies to set the Federal and State ambient air quality standards. A more general discussion of health impacts related to air pollution is also available on www.spareheair.com and in the Sac Metro Air District's *Guide to Air Quality Assessment in Sacramento County.*[vii] None of the health-related information can be directly correlated to the pounds/day or tons/year of emissions estimated from a single, proposed project.

Developing Guidance

The interim recommendation is in place to assist lead agencies and practitioners with CEQA document preparation until Sac Metro Air District develops a methodology that provides a consistent, reliable and meaningful analysis to address the Court's direction on correlating health impacts to a project's emissions.

Sac Metro Air District staff have initiated discussions with the other air district's in the Sacramento Federal Ozone Nonattainment area regarding developing guidance in response to Friant Ranch since we share air quality issues and use the same growth assumptions, mobile source emissions, and modeling efforts to support our ozone and particulate matter attainment plans.

One potentially useful tool in developing a methodology is the US EPA's BenMap tool[viii]. According to US EPA's website, BenMap is an "open-source computer program that calculates the number and economic value of air pollution-related deaths and illnesses. The software incorporates a database that includes many of the concentration-response relationships, population files, and health and economic data needed to quantify these impacts." BenMap may be able to provide the detailed health information needed for the guidance under development.

Sac Metro Air District is working with its engineering and environmental technical support consultant, Ramboll USA Corporation, to develop a methodology that will provide a consistent, reliable, efficient, and meaningful analysis that correlates health impacts from proposed projects' emissions for the Sacramento region. The current strategy will analyze how various levels of emissions (the CEQA tonnage estimates) impact attainment pollutant concentration levels, and use BenMap to correlate increases in concentration levels to health impacts. Once a methodology is available, Sac Metro Air District staff will inform interested stakeholders and provide updated guidance in this document and in its *Guide to Air Quality Assessment in Sacramento County*.

Contact Information

Lead agencies and CEQA practitioners may contact Mr. Paul Philley, CEQA and Land Use Section Program Supervisor at 916-874-4882 or pphilley@airquality.org regarding Sac Metro Air District's recommendations.

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[i] CalEEMod, Road Construction Emissions Model, EMFAC, OFFROAD

[ii] Foundation for a Threshold, Justification for Air Quality Thresholds of Significance In the Sacramento Federal Nonattainment Area, August 15, 2001, Adopted March 28, 2002.

[iii] Proposed Particulate Matter CEQA Thresholds of Significance, March 19, 2015, Adopted May 28, 2015.

[iv] Sac Metro Air District, Guide to Air Quality Assessment in Sacramento County, December 2009 (latest update September 2018), Chapter 2, Thresholds of Significance table. http://www.airquality.org/LandUseTransportation/Documents/CH2ThresholdsTable5-2015.pdf

[v] https://www.epa.gov/ozone-pollution-and-your-patients-health/health-effects-ozone-general-population

[vi] https://www.arb.ca.gov/research/health/pm-mort/PMmortalityreportFINALR10-24-08.pdf

[vii] Sac Metro Air District, Guide to Air Quality Assessment in Sacramento County, December 2009 (latest update September 2018), Chapter 1. http://www.airquality.org/LandUseTransportation/Documents/Ch1IntroAq%20FINAL12-2016.pdf

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