STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE RESEARCH SCREENING COMMITTEE

August 26, 2025
10:00 a.m.

California Air Resources Board
Research Division
Cal/EPA Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

California Air Resources Board

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

August 26, 2025
10:00 A.M

Agenda

California Air Resources Board

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753

April 7, 2025
10:00 A.M.

Minutes

Research Screening Committee Members in Attendance via Teleconference:

Dr. Aly M. Tawfik
Dr. Sam Silva
Dr. Francesca Hopkins
Dr. Roya Bahreini
Dr. Michael Schmeltz

I. Approval of Minutes of Previous Meeting

January 27, 2025

II. Discussion of Draft Final Reports

1. "Improved Assessment and Tracking of Health Impacts for California Communities Most Burdened by Pollution," University of California, Los Angeles, $499,971, Contract No. 21RD005

   A Committee member provided the following comments:

   - The report has been much improved, as had been requested, especially the causal analysis section.

   - In the "Limitations and Gaps" section of the final report, additional information and clarification is needed on what CalHealthMap provides that other web resources do not. That is, why would one use CalHealthMap instead of, say, Tracking California or CalEnviroScreen?

   - Similarly, within the CalHealthMap tool, add a sentence or two, prominently called out in a bullet point or box, providing information on what CalHealthMap provides that other web resources do not.

Motion: Move to recommend that California Air Resources Board (CARB) accept the report, subject to the inclusion of revisions based on comments from staff and the Committee.

The Committee voted to approve the motion.

2. "HIFIVE - Health Impacts of Filtration ImproVements in Elementary Schools," University of California, Irvine, $840,000, Contract No. 20RD015

   The Committee expressed that the findings of the study were interesting and that the Draft Final Report (DFR) was well written and easy to follow. The Committee had minor comments and requested the following clarifications:

   - Provide more clarity about the actual number of school classrooms involved in the study. Many times, the number of 435 was mentioned, but this is not the true number of classrooms involved in the study due to the problems that occurred, and control classrooms. Perhaps a table could be provided to summarize this information. In particular, in the last section on page 23, the 435 number should be checked.

   - The attendance analysis at the classroom level was treated as the percentage of students attending. How many students were actually participating in the attendance analysis? It seems that this would be relevant statistically. Please clarify how many students were actually measured for the attendance records.

   - Provide a little more visibility to the number of asthmatic students that participated in Health Impacts of Filtration ImproVements (HIFIVE) - Child's Asthma and Respiratory Events and Symptoms (CARES) The low number was a bit buried and should be explained earlier.

   - No real information about the compliance level of the teacher surveys. If possible, information about the instructions to teachers (responses to the survey provided in Appendix E) should be provided in the report.

   - The raw data should be very interesting and informative. Is there any information in the data that would support the hypothesis that the air purifiers could have a large effect during an exceptional event, such as wildfire.

- The raw data should be available freely to the public given the importance of the dataset.

- If the data supports that analysis, could the Principal Investigators (PI) add some discussion about what the impacts of the added filtration are on the higher levels of particulate matter (PM) in classrooms.For example, at the 95th percentile of concentrations in the study.

- PM2.5 observations – how were the challenges of using the low-cost sensors (PAII, Clarity Node) addressed regarding data bias. Was there an assessment of data quality from the sensors? Please add information about any sensor calibrations or corrections that were done. Do not need to do a big analysis, just an update to the text to clarify.

Motion: Move to recommend that CARB accept the report, subject to the inclusion of revisions based on comments from staff and the Committee.

The Committee approved the motion.

III. Other Business

1. Update on Research Planning

- FY25-26
  - CARB has just put out the first solicitation for funding year 2025-2026. CARB hosted a pre-proposal solicitation informational meeting on April 1. At the meeting CARB staff discussed the pre-proposal submission process, went over some FAQs and provided information on the two projects out for solicitation. The meeting recording is now available on CARB's *solicitation landing page*. Pre-proposals are due on May 2. Another solicitation will come out in early May.

- FY26-27
  - CARB has started the very early stages of research planning for FY26-27. The priorities highlighted will be drawn heavily from the proposed Five-Year Plan. More information on that process will be available in April or May.

- Five-Year Plan
    - The Research Program has drafted a Five-Year Strategic Research Plan that will cover years 2025-2030. The draft document is currently being reviewed by staff in other programs. Staff anticipate that the Plan will be available for a 30-day public comment period in mid-August and that it will be presented to the Board in late September.

The Committee had no major comments. No motion or vote was required for this item.

Item No.: II.1
Date: August 26, 2025
Proposal No.: 2891-317

Staff Evaluation of a Research Proposal

Title:	Improving estimates of CO_2 and CH_4 emissions from southern California coastal wetlands and BVOC emission estimates from all California landscapes
Contractor:	University of California, Irvine
Subcontractor:	University of California, Santa Cruz
Principal Investigators:	Alex Guenther, Ph.D. Adina Paytan, Ph.D.
Budget:	$799,992
Contract Term:	36 Months

For further information, please contact Dr. Toshihiro Kuwayama at (279) 842-9873.

I. Summary

CARB, under AB 1279, tracks California's path to carbon neutrality by developing inventories of greenhouse gas (GHG) emissions and ecosystem carbon stocks. While current inventories focus on the San Joaquin Delta wetlands, this project will expand efforts to Southern California coastal wetlands to measure carbon dioxide (CO_2) and methane (CH_4) fluxes and soil carbon accretion/subsidence rates using eddy covariance and dated soil cores to fill critical data gaps in the carbon and GHG emission inventories. Furthermore, to refine regional air quality and climate impact predictions, this research project will also include measuring biogenic volatile organic compound (BVOC) emissions to improve vegetation emission factors and enhance the biogenic model with refined growth form inputs, leaf area index, and species data. The Model of Emissions of Gases and Aerosols from Nature (MEGAN) will be updated with the latest chemical mechanisms. It advances climate resilience and air quality equity by focusing on vulnerable Southern California communities. CARB will track outcomes

with metrics and community engagement to ensure benefits for disproportionately affected areas. Results will support future CARB's Scoping Plan updates, broaden wetland types in scenario modeling, inform the State Implementation Plan, and inform Assembly Bill 1757 requirements on natural carbon sequestration targets and nature-based climate solutions.

II. Technical Summary

Objective

The objectives include measuring CO_2 and CH_4 fluxes and soil carbon accretion/subsidence rates in a Southern California saltwater wetland using eddy covariance and dated soil cores to fill critical data gaps in the Natural and Working Lands (NWL) Carbon Inventory. The project will measure species-specific BVOC emissions to better quantify emission factors for dominant California plant species. Biogenic emission estimates will also be improved by developing improved landcover products to better estimate the Leaf Area Index distributions, growth form fractions, and plant species composition variables that drive BVOC emission models.

Background

Pursuant to AB 1279, CARB is responsible for identifying and tracking the state's pathway to achieving carbon neutrality by mid-century. To support this broader mission, CARB develops inventories of GHG emissions originating from human industrial activities and annual to decadal changes in statewide ecosystem carbon stocks. In wetland ecosystems, the NWL Carbon Inventory quantifies GHG emissions of CO_2 and CH_4 along with soil organic carbon (SOC) stocks over time. In coastal wetlands, almost all flux towers are in northern California, concentrated within the San Joaquin Bay Delta (The Delta). In fact, the Delta has the most flux towers of any landscape in all of California. A large data gap exists in Southern California's coastal saline wetlands. These systems and the environmental conditions (climate and vegetation) in southern California are sufficiently different from those of northern California and the Delta, so using that data to estimate or model emissions in southern

California is not scientifically sufficient. For this reason, this project will focus its data collection and analysis on southern California coastal wetlands.

Alongside GHGs, terrestrial vegetation also emits BVOCs into the atmosphere, which play important roles in the formation of ozone and secondary components of fine particulate matter (PM2.5). BVOC emissions are naturally occurring and, therefore, cannot be regulated, but they can have a significant effect on atmospheric chemistry and air quality. BVOC emissions are functions of the leaf mass of a plant or tree species, emission factors, temperature, and light conditions. A recent study indicates that many of the emission factors used to model BVOCs are based on decades-old studies of trees. In addition, BVOC emission factors for many dominant Californian species are based on limited measurements, and most of those data may not fully represent the conditions that plants typically experience.

California's biogenic emissions inventory is based on estimates from MEGAN, which is a model capable of estimating the emissions of over a hundred BVOCs. The currently available landcover inputs for California are based on global satellite data products that are reasonable for global modeling but have biases in specific areas. Recently, MEGAN has been updated to accept high-resolution, user-specified vegetation data to improve biogenic emission estimates. Such results differed from values estimated using the standard MEGAN land cover by about a factor of two, on average, and by more than a factor of three in some urban landscapes. In summary, the estimates of BVOC emissions can be substantially improved with the new landcover data as well as updated emission factors.

This research project can also benefit priority communities by providing crucial information to inform strategies for adapting to climate change, particularly through improved coastal resilience and additional knowledge on the air quality impact of BVOC sources in their community. At the project location (Southern California), priority communities typically overlap with impacted wetland ecosystems and well-vegetated regions susceptible to environmental degradation. This research project will provide

information relevant to the design of safer and more sustainable living environments, especially for communities vulnerable to extreme weather events like storm surges and droughts. By better understanding wetland carbon, carbon stock changes, and BVOCs, the state can better assess the ecosystem function, health, and resilience of wetlands and vegetated regions across the state.

Proposal Summary

Under AB 1279, CARB tracks California's carbon neutrality progress through GHG emissions and ecosystem carbon inventories. The NWL Carbon Inventory measures carbon in biomass, soils, and wood, tracking changes from disturbances and climate. This project expands Southern California wetland studies to fill data gaps, measuring CO_2/CH_4 fluxes and soil carbon stocks using eddy covariance and soil cores. It also collects BVOC emissions by plant species to refine air quality and climate models and update vegetation inputs and MEGAN model mechanisms. These measurement and modeling tools will be used to carry out the following four major research tasks.

Task 1: Measurement and Model Development Plan

In collaboration with CARB, PIs will select a Southern California saline wetland and design a two-year field campaign to measure CO_2 and CH_4 fluxes via eddy covariance and determine SOC accumulation using dated soil cores. The plan for BVOC enclosure measurements will identify agricultural and urban plant species that are either known to be dominant California BVOC emission sources or are highly uncertain and potentially important. The plan will also include:

- Leaf Area Index (LAI) measurements using canopy analyzers, Normalized Difference Vegetation Index sensors, and Sentinel satellite calibration.
- BVOC emission factor and heat stress studies for dominant California plant species using enclosure techniques.
- Selection of location for eddy covariance tower installation
- Documentation of site access, safety, and permits

- A field plan targeting spatial, temporal, and biogeographic gaps, including socioeconomic considerations and underrepresented wetland types.
- SOC site selection informed by the Smithsonian Coastal Carbon Atlas.
- Soil core sampling within flux tower footprints and other priority sites.

Deliverable: An interim report with literature review, finalized methodology, research design, and plans for flux tower, SOC, LAI, and BVOC measurement targets.

Task 2: Initiate Measurements and Site Characterization

PIs will conduct site characterizations for tower and SOC sampling, considering safety, access, ecosystem type, meteorology, vegetation, and priority communities. Eddy flux tower installation will support continuous 30-min interval CO_2/CH_4 and meteorological data over two years. Instrumentation will include gas analyzers, meteorological sensors, networking devices, and secure power systems. SOC sampling will stratify and date the upper 30 cm of soil. BVOC sampling plans will cover emission factor collection under optimal and heat-stress conditions.

The key activities will involve:

- Installation of an eddy covariance tower for 2 years, measuring CO_2/CH_4 fluxes, meteorology (wind, temperature, etc.), and soil parameters.
- Sampling SOC (30 cm depth, 1 cm strata) in understudied coastal wetlands.
- Measuring BVOC emissions under optimal/heat-stressed conditions.
- Ensuring site safety, accessibility, and minimal impact on priority communities (per CalEnviroScreen).

Deliverable**:** Interim report detailing sampling protocols, researcher training, site photos, approach for measuring BVOC rates under various conditions, and summary of comparisons to literature values.

Task 3: Data Collection, QA/QC, and Archiving

PIs will collect high-frequency GHG and meteorological data using standardized quality assurance/quality control (QA/QC) protocols. SOC samples will be collected at underrepresented wetland sites and processed for depth-specific accretion and carbon content. BVOC measurements will cover species across agricultural, urban, and rural settings. Vegetation mapping will use satellite imagery and machine learning, integrating datasets like NAIP, Cropscape, FIA, and LANDFIRE. PIs will develop LAI and vegetation input files for MEGAN modeling across all CA land covers. Key activities include:

- Eddy Covariance: Regular calibration, 10 Hz gas/wind measurements, and biweekly QA/QC data delivery.
- SOC: Dated core sampling in understudied wetlands.
- BVOC: Emission factor compilation for MEGAN model inputs.
- LAI: 10-m/300-m satellite calibration using field data.

Deliverable: Monthly flux reports, QA/QC'd data, BVOC emission rates, and formatted MEGAN inputs (growth form, LAI, species composition).

Task 4: Data Analysis

GHG flux data will be analyzed to determine annual/monthly budgets and primary flux drivers, with ecosystem exchange partitioning. SOC core results will be compared to Smithsonian Atlas data to identify carbon dynamics and drivers. MEGAN input validation will use ground LAI data and airborne flux campaign comparisons (CABERNET, RECAP-CA). Key Tasks include:

- Flux Data: Partition CO_2/CH_4 fluxes, identify drivers, and compare with state wetland data.
- SOC: Analyze accretion/subsidence rates.
- BVOC: Validate MEGAN inputs with aircraft flux data (CABERNET/RECAP).
- Train CARB staff on data pipelines.

Deliverable: Documentation of uncertainty, draft analyses for feedback, reproducible code, and input datasets for MEGAN, including speciation files (SAPRC22, CARCMM).

At the conclusion of the project, PIs will provide CARB with all data developed through this project and remove the eddy covariance tower and all related infrastructure. The primary deliverable will be a final report describing the background, experimental and analytical methods, and results. The final report will be amended based on CARB comments and submitted to CARB before the agreement's end date.

III. Staff Comments

Staff from CARB's Air Quality Planning and Science Division (AQPSD), Industrial Strategies Division, and Research Divisions (RD) reviewed an earlier version of the University of California, Irvine (UCI) proposal, and the current version has incorporated staff comments to improve its clarity. The reviewers generally recognized the quality of the proposed research effort and the practical importance of the results. The reviewers stated that the assembled team has extensive experience and resources to apply to the project, and the results will be well worth the resources.

Dr. Guenther will serve as the PI, coordinating all aspects of this project. Dr. Guenther is an internationally recognized leader in atmospheric and terrestrial ecosystem research. His expertise stems from over 40 years of experience measuring and modeling biogeochemical trace gas fluxes. He is particularly known as the lead developer of MEGAN, a widely used model in atmospheric research. He will supervise two postdoctoral scientists working on the BVOC component of this project (one focused on emission measurements and the other on land cover inputs). By analyzing BVOC emissions from wetlands, the state can better understand their contribution to regional air quality and inform land management decisions.

Dr. Paytan (Co-PI) is leading a significant research effort focused on understanding GHG fluxes from saltwater wetlands. The Biogeochemistry lab at UCSC, led by Dr. Paytan, is actively involved in monitoring GHG emissions and carbon fluxes in coastal

wetlands. Dr. Paytan will supervise two graduate students, one focused on the eddy covariance data and the other on the soil data, and a field technician who will service the towers regularly. By combining eddy covariance measurements with soil carbon accretion data, Dr. Paytan and her team aim to develop a comprehensive understanding of the role of saltwater wetlands. By better understanding wetland carbon and carbon stock changes, the state can better assess the ecosystem function, health, and resilience of wetlands and vegetated regions across the state.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee (RSC) recommend that CARB approve this proposal for a total amount not to exceed $799,992, subject to inclusion of any changes and additions specified by the Committee.

Item No.: II.2
Date: August 26, 2025
Proposal No.: 2892-317

Staff Evaluation of a Research Proposal

Title:	Validating Vehicle Choice Surveys
Contractor:	University of California, Davis
Principal Investigator:	Giovanni Circella, Ph.D.
Budget:	$49,999
Contract Term:	24 Months

For further information, please contact Dr. Sarah Pittiglio at (916) 842-9115.

I. Summary

CARB uses surveys to understand the impact of regulatory and incentive programs. For example, surveys have reached thousands of Californians to inquire about their vehicle preferences in order to inform CARB's vehicle incentive programs. Senate Bill 150 requires that at least 25% of California Climate Investment funds be allocated toward disadvantaged communities (DAC, as identified by CalEnviroScreen). By combining survey responses, DMV registration, and other data sources, this project will better interpret past and future survey questions on vehicle choice by examining how responses relate to real-world purchases. With additional insights on past surveys already being used by CARB, programs can make more informed decisions to serve DACs and Californians more generally. Guidance for surveyors will improve future surveys by identifying styles of questions with the most useful responses and ways to ensure surveys are more inclusive and representative.

II. Technical Summary

Objective

This project will compare past CARB-funded survey results on consumer vehicle purchasing preferences with real-world data on vehicle purchases. Results will provide guidance to improve the design, interpretation, and utility of future surveys. The project will also analyze how survey participants compare to the broader population and explore the representation of racial groups and communities. This comparison will help to determine if survey samples reasonably represent the populations they are used to model. This project will allow CARB to better incorporate survey responses into air quality planning and incentive funding programs while advancing environmental justice goals.

Background

CARB has funded public surveys to investigate consumer vehicle choices. These surveys aim to answer questions such as: What vehicles or technologies will participants choose in the future? The answers to these questions are important to multiple CARB programs. For example, CARB's Emission Factor model (EMFAC) estimates air pollutant emissions from California's on-road vehicles. EMFAC uses survey data to predict future emissions from the transportation sector. Air quality planning programs at CARB rely on tools like EMFAC to create State Implementation Plans (SIPs) that meet Federal Ambient Air Quality Standards. Correct estimates of air pollutant emission reductions from the transportation sector are essential to meeting the state's air quality goals. Survey results are also used by light-duty incentive programs that aim to increase the adoption of zero-emission electric vehicles (ZEV). Surveys help identify the policies and incentives that encourage the adoption of ZEVs. This is especially important in areas with low ZEV adoption, such as overburdened communities.

Applying survey results to policies and programs can be challenging due to potential gaps between survey responses and consumer behavior. Factors influencing the discrepancy between hypothetical purchases and actual consumer behavior include a

participant's vehicle preferences changing when they are ready to purchase. Survey responses may also be interpreted differently by participants and researchers. Responses like "somewhat likely to consider purchasing a ZEV" could indicate a 30%, 50%, or other arbitrarily chosen chance of purchase. The term "consider purchasing an electric vehicle" is also difficult to define and quantify, making the results highly dependent on untestable assumptions by the researchers.

Surveys typically aim to collect samples of survey participants that reflect the demographics of the state or overburdened populations. While CARB surveys typically collect demographic data to compare the sample to the population, no study has examined how well Californians are represented across multiple CARB-funded surveys on consumer vehicle choices. Vehicle choice surveys often do not examine other characteristics of their sample, such as vehicle ownership rates and ZEV ownership rates. Surveys will provide biased results if the samples systematically differ from the intended population.

Proposal Summary

Task 1: Literature Review

The contractor will conduct a literature review and present a summary of the findings to CARB. The contractor will focus on how vehicle choice surveys have been conducted both when funded by CARB and in the literature more broadly, as well as a review of recruiting representative samples for surveys. The review will discuss how researchers have interpreted responses to vehicle choice questions and how government bodies, including CARB, use surveys to inform programs. In addition to published literature, the contractor should include input from the researchers who conducted surveys for CARB to address how their vehicle choice questions were interpreted.

Task 2: Pre-Analysis Plan

The pre-analysis plan (PAP) will identify the specific research questions for the analysis, compare DMV data to survey responses, and characterize the representativeness of the

survey sample. When feasible, the PAP will include specifications, subgroups, and the tests that will be analyzed, in addition to power analyses that account for multiple hypothesis testing when applicable. The PAP should build on the literature review's discussion of the survey data and how responses have been interpreted.

Task 3: Data, Code, and Data Dictionaries

The contractor will compile and clean past survey data and work with CARB to integrate survey data with DMV, CalEnviroScreen, and census data. The contractor will create data dictionaries, well-documented code, and any additional resources needed for transparent replication, subject to confidentiality. Aggregated datasets will be provided when feasible if data sharing is restricted. Interim data, code, and documentation will be regularly shared with CARB.

Task 4: Draft Final Report

The contractor will provide a DFR that includes the literature review, background, PAP, data, code, data dictionaries, methods, results, discussion/interpretation, conclusions, and guidance for how CARB and the contractor can improve the formation and interpretation of vehicle choice survey questions and make surveys more inclusive and representative. Data and code should be delivered along with the DFR, allowing researchers unfamiliar with the project to understand the analysis and reproduce the findings, subject to confidentiality.

III. Staff Comments

CARB developed this research project to evaluate how well survey responses about future vehicle choices align with actual vehicle purchases. The research builds on survey data on vehicle choice collected by CARB-funded researchers, particularly those at UC Davis (UCD). CARB and UCD have coordinated closely to ensure the research design is both scientifically rigorous and relevant for real-world application. Staff from Mobile Source Control Division and AQPSD reviewed the proposal and concluded that the project can support programs in increasing efficiency and refining planning efforts,

while also informing the design of future surveys. The reviewers also noted that the project is cost-effective.

Investigator Qualifications

Giovanni Circella, Director of the 3 Revolutions Future Mobility Program at the UCD Institute of Transportation Studies (ITS), is well-qualified to lead this project. His research focuses on travel behavior, vehicle technology adoption, and the impacts of emerging transportation trends, with extensive experience designing and analyzing large-scale surveys. He has led numerous CARB-funded projects and has a strong track record of linking survey data to real-world outcomes, making him uniquely positioned to evaluate how well vehicle choice surveys reflect actual purchasing behavior. His access to ITS survey data, connections to the researchers who conducted past surveys, and understanding of the survey process make him an exceptional partner for analyzing and improving survey techniques and interpretation.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $49,999, subject to inclusion of any changes and additions specified by the Committee.

Item No.: II.3
Date: August 26, 2025
Proposal No.: 2894-317

Staff Evaluation of a Research Proposal

Title:	Accelerated Evaluation of Ambient PM2.5 in Regions Affected by the 2024 National Ambient Air Quality Standards (NAAQS) Update
Contractor:	University of California, Davis
Subcontractor:	Georgia Institute of Technology
Principal Investigators:	Qi Zhang, PhD Sally Ng, PhD
Budget:	$1,000,000
Contract Term:	36 Months

For further information, please contact Dr. Morteza Amini at (279) 842-9160.

I. Summary

To address the regulatory challenges introduced by the United States Environmental Protection Agency's (U.S. EPA) revised annual PM2.5 standard, lowered from 12 μg/m³ to 9 μg/m³, CARB is significantly expanding its monitoring capability through the CARB High-resolution Advanced Monitoring Program (CHAMP). This program involves deploying a statewide instrument network of eight Aerosol Chemical Speciation Monitors (ACSM) to generate continuous, high-time-resolution measurements of PM2.5 chemical composition, including concentrations of organic aerosols (OA), nitrate (NO_3), sulfate (SO_4), ammonium (NH_4), and chloride (Chl). ACSMs will be co-located with Scanning Mobility Particle Sizers (SMPS) and black carbon analyzers (AE33 or AE36) to enable comprehensive characterization of PM2.5 at each site. Source apportionment will be performed using the Positive Matrix Factorization (PMF) model to identify and quantify key PM2.5 sources. In addition to deploying and operating ACSMs and co-located instruments, this contract will focus on capacity building within

CARB through training in instrument operation, data processing, and analysis. The contractors will develop Standard Operating Procedures (SOPs) and QA/QC protocols to support long-term sustainability of the network and enable CARB staff in RD, Monitoring and Laboratory Division (MLD), and AQPSD to take over operations and data analysis responsibilities by the end of the contract. ACSM data storage and workflows will be centralized and streamlined, with CARB exploring a user-friendly dashboard for real-time data visualization and comparison. The contractors will also perform ACSM data analysis from the Atmospheric Science and Chemistry mEasurement NeTwork (ASCENT) sites in California and compare the results with the CHAMP network, whenever applicable, to assess regional and statewide PM2.5 trends. A DFR summarizing key results and recommendations will be submitted six months prior to the end of the contract, followed by a publicly available final report. Acquired datasets from CHAMP will inform CARB's emission inventory and SIPs to guide targeted mitigation strategies.

II. Technical Summary

Objective

This project will operationalize the CHAMP PM2.5-Captuire Vaporizer (CV)-ACSM network by establishing a robust framework for reliable instrument deployment, sustained long-term operation, and high-quality data generation. It will also advance scientific understanding of PM2.5 sources across California's nonattainment areas through source apportionment analyses using ACSM datasets from both the CHAMP and ASCENT platforms. In addition, this project will assess the reliability of NO_3 measurements in California by conducting comparisons between ACSM and filter-based methods and thermodynamic modeling.

Background

Several regions in California are designated as non-attainment areas under the NAAQS for PM2.5. The San Joaquin Valley (SJV) is particularly notable for experiencing some of the most severe and persistent PM2.5 pollution in the state. This is largely due to a combination of complex emission sources and meteorological conditions that promote the accumulation of airborne pollutants. To better understand and address these challenges, CARB has deployed two ACSMs in the SJV through research contracts 17RD008 and 22RD038. As part of these contracts, a Time-of-Flight ACSM (ToF-ACSM) has been operational in Fresno since 2018, and a Quadrupole ACSM (Q-ACSM) in Bakersfield since 2023. Both ACSMs are equipped with a CV and PM2.5 lens and provide continuous and high-time resolution (10-20 minutes) chemical speciation data for the non-refractory components of PM2.5, including OA, NH_4, NO_3, SO_4, and Chl. These data offer valuable insights into the PM2.5 chemical composition, sources, and trends. Additionally, acquired ACSM datasets are compatible with source apportionment models, such as rolling-window PMF, and enable identification of major PM2.5 pollution sources and key atmospheric processes.

Due to the revised annual average PM2.5 NAAQS of 9 μg/m³, many areas in California that were previously in compliance are expected to be in non-attainment, posing new challenges for developing effective air quality management strategies. In many of these non-attainment areas, lack of high-resolution speciated PM2.5 data limits our ability to characterize PM2.5 sources. While a network of advanced monitoring instruments, such as ACSMs, can address these data gaps, the deployment and sustained operation of such advanced instruments involve considerable technical and logistical complexity. This operation will require regular calibrations, establishing standardized protocols to ensure consistent performance, rigorous QA/QC protocols, and interpreting complex mass spectral data. Therefore, strategic planning and robust knowledge transfer are required for the effective operation of such an advanced air monitoring network and for building technical capacity.

Proposal Summary

The proposal consists of the following tasks:

Task 1: Operationalize ACSMs Across the CHAMP Network to Ensure Continuous, High-Quality Data Collection Over a Three-Year Period

Under this task, the contractors will ensure the smooth operation of eight ACSM units (seven Q-ACSM units and one ToF-ACSM unit) across the state for three consecutive years. The contractors will oversee the analyzers' deployment, operation, maintenance, calibration, and troubleshooting. In addition, the contractors will validate the data quality and build a robust QA/QC protocol to ensure data reliability and accuracy across the network. The contractors will also establish a comprehensive operational framework for CHAMP by developing best practices for ACSM functionality, training CARB staff on instrument operations, and developing SOPs and checklists that include clear directions for calibration, maintenance, troubleshooting, and routine checks. In addition, the contractors are also expected to train CARB staff on the QA/QC of the raw ACSM data, establish routine data check protocols, and develop a data processing SOP.

Task 2: Compare ACSM measurements against co-located measurements

As part of this project, the contractors are expected to compare PM2.5 speciated data from the CHAMP network with co-located regulatory filter-based PM samples collected at selected sites. These comparisons will be utilized to assess the accuracy of filter-based methods for different species, apply thermodynamic modeling to investigate discrepancies, and potentially develop independent correction schemes. Additionally, the contractors will leverage supplemental co-located measurements, such as trace metals and BC data, to evaluate and validate the total PM2.5 measurements reported by the air monitoring sites. The contractors will coordinate with CARB staff to gather ancillary co-located measurement datasets and provide regular updates on intercomparison analysis.

Task 3: Conduct data analysis and PM2.5 source apportionment of the CHAMP dataset

The contractors will perform advanced analyses for at least one year of the collected data from all eight ACSM instruments in the CHAMP network and co-located measurements from these sites to investigate the ambient PM2.5 composition and chemical characteristics across the state and identify major drivers of PM2.5 ambient levels. After QA/QC of the data, the contractors will conduct source apportionment of PM2.5 to quantify the source contributions to the PM2.5 composition. These analyses will include rolling-window PMF source apportionment analysis using the Multilinear Engine (ME-2) approach to identify major PM2.5 sources and examine the diurnal and seasonal variations of PM2.5 concentration and composition. As part of this task, the contractors are also expected to develop a data processing SOP and train CARB staff in ACSM data analysis.

Task 4: Conduct data analysis and PM2.5 source apportionment of the ASCENT dataset

ASCENT is a nationwide high-time-resolution, long-term aerosol speciation measurement network. ASCENT currently operates three ToF-ACSMs accompanied by Xact (for trace metals), AE33 (for BC), and SMPS (for aerosol number size distribution and concentration) in three South Coast Air Basin (SoCAB) sites, namely Pico Rivera, Joshua Tree, and Rubidoux. During this contract, the contractors will continue ToF-ACSM monitoring at these three ASCENT sites and perform at least one year of detailed analyses of the collected datasets, including advanced source apportionment analyses using the PMF model. Preferably, the analysis periods for both CHAMP and ASCENT datasets should coincide to allow for a more direct comparison of PM2.5 emission sources throughout the state.

Task 5: Summary, evaluation, and final report

The contractors will submit a comprehensive DFR to the CARB contract manager six months before the end of the project, detailing the research findings and their recommendations. This report should include a thorough analysis of the methods and data collected, along with actionable suggestions for future applications and studies. The contractors will revise the report based on feedback from CARB staff and the RSC.

By the end of the contract period, the contractors will deliver the final report and the finalized data collected during the study. To ensure transparency and accessibility, CARB will publish publicly available detailed project reports outlining the findings, methodologies, and their impacts on racial equity, ensuring accessibility for diverse audiences.

III. Staff Comments

CARB staff from RD, MLD, and AQPSD reviewed the draft proposal. The reviewers supported the project and provided constructive comments. The contractors fully addressed the comments and provided the final version of the proposal.

Drs. Zhang and Ng will oversee the research and ensure that all objectives of the project, including instrument deployment, calibration, troubleshooting, data sharing, and analysis, are met. Drs. Zhang and Ng are distinguished experts in the field of air quality and aerosol chemistry, with extensive experience and a proven track record of successful deployment and operation of ACSMs. Dr. Zhang has a history of delivering high-quality data and findings to CARB through past and current contracts, while Dr. Ng is currently serving as the PI for the nationwide ASCENT network. Their familiarity with these instruments and ability to troubleshoot and calibrate them ensures the timely and accurate generation of data critical to meeting CARB's objectives. Together, they form a team that fits the needs of the project very well. The proposed research will inform CARB's emission inventory and SIPs to guide targeted mitigation strategies.

IV. Staff recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $1,000,000, subject to inclusion of any changes and additions specified by the Committee.

Item No.: II.4
Date: August 26, 2025
Proposal No.: 2896-317

Staff Evaluation of a Research Proposal

Title:	Assessing Long-Term Health Effects of Wildfire Smoke Exposure: Insights from an Established Birth Cohort Study
Contractor:	University of California, Davis
Subcontractor:	Purdue University
Principal Investigator:	Rebecca J. Schmidt, Ph.D.
Budget:	$700,000
Contract Term:	24 Months

For further information, please contact Dr. Barbara L. Weller at (916) 277-0971.

I. Summary

The increasing threat of more intense and frequent wildfires in California has elevated public concern about the potential health impacts of exposure to wildfire smoke, which contains record-high levels of particulate matter and air toxics such as metals. This exposure can have serious effects on vulnerable populations, like pregnant women and their developing children, who are more sensitive to environmental pollutants. While short-term health impacts have been extensively studied, the long-term health effects of wildfire smoke exposure remain largely underexplored. The proposed project builds on an existing birth cohort, the Bio-Specimen Assessment of Fire Effects (B-SAFE) Study, which provides a unique and cost-effective opportunity to address this critical knowledge gap. Led by a UCD research team, the B-SAFE cohort includes over 500 mother-child pairs who were exposed to Northern California wildfires between 2017 and 2021 during pregnancy. The UCD investigators will leverage existing data and biospecimens collected at the time of exposure and conduct follow-up surveys to collect additional health information on mothers and children 4-8 years after the wildfires. The investigators will also analyze metals in maternal and child nail samples

collected after the fires. These data will be used to assess associations between wildfire-related PM2.5 exposure during pregnancy, measured metal levels, and a range of long-term health outcomes. These outcomes include respiratory, cardiometabolic, and mental health effects in both mothers and children, as well as neurodevelopmental and behavioral impacts in children. In addition, the project will explore differences in exposure levels and health outcomes across sociodemographic and neighborhood factors to assess health disparities. The findings will improve understanding of the long-term health effects of wildfire smoke exposure and enhance CARB's ability to conduct in-depth health analyses that support the evaluation of programs aimed at reducing wildfire-related risks. The results will also strengthen CARB's public health messaging, particularly for protecting pregnant individuals and children during wildfire events.

II. Technical Summary

Objective

The overall objective is to characterize wildfire smoke exposures in the B-SAFE cohort and investigate their long-term health impacts associated with wildfire-related pollutants, including PM2.5 and heavy metals. Health outcomes of interest include respiratory, cardiometabolic, and mental health effects in mothers and children, as well as neurodevelopmental and behavioral outcomes in children. The project will also examine how these associations may vary by background factors such as race, ethnicity, maternal education, protective behaviors, neighborhood poverty, and baseline air pollution levels.

Background

California has experienced increasingly severe wildfire seasons in recent years, including the January 2025 Los Angeles fires, raising public concern about the harmful effects of wildfire smoke exposure. Wildfire smoke contains high levels of particulate matter, including combustion components that can trigger proinflammatory and oxidative stress pathways. Urban wildfires, in particular, release toxic air pollutants,

such as volatile organic compounds (VOCs) and heavy metals, due to the high-temperature combustion of building materials. The increasing intensity and frequency of wildfires, along with the unknown impacts of potential air toxics in smoke, underscore the urgent need to better understand the associated health effects on affected California communities, especially those with limited capacity and resources to cope with extreme events.

While short-term health effects of wildfire smoke exposure have been extensively studied, long-term health outcomes remain poorly understood, especially among vulnerable populations. Pregnancy is a particularly sensitive period for environmental exposures like air pollution. Studies in rhesus macaques, the closest animal model to human development, suggest that wildfire smoke may cause lasting effects on neurobehavioral and respiratory health. However, few human studies have evaluated the long-term health impacts of prenatal wildfire exposure on mothers and children.

The B-SAFE study was developed to respond to this need by examining the mental, physical, and developmental health outcomes associated with wildfire smoke exposure. The B-SAFE cohort includes individuals who were pregnant during Northern California wildfires from 2017 to 2021 (e.g., the Camp Fire), or became pregnant within three months after the fires, and their children (totaling 544 mother-child pairs). The study also modeled daily ground-level wildfire-related PM2.5 concentrations and linked the data to geocoded residential, evacuation, and relocation addresses for cohort families. Preliminary findings from the B-SAFE study indicate wildfire exposure were linked to acute respiratory symptoms and persistent mental health challenges, such as stress and anxiety, among mothers up to a year after the wildfires. For children, early evidence suggests that prenatal exposure to wildfire PM2.5 is associated with behavioral problems, particularly among boys at age four.

Building on this existing data and promising early results, CARB proposes to fund a new project to extend the B-SAFE study and cost-effectively address critical knowledge gaps on the long-term health effects of wildfire smoke exposure in vulnerable

populations. The UCD investigator has assembled an interdisciplinary team with expertise in environmental epidemiology, neurodevelopment, climate and health, respiratory science, fire emissions and air pollution modeling, and advanced statistical methods, built upon a track record of productive collaboration.

The results of this project will generate health impact estimates for long-term outcomes associated with wildfire-related pollutants, enhancing CARB's ability to conduct health benefit analyses for its wildfire and climate programs. Furthermore, the findings will help guide CARB's public health messaging on the long-term risks of wildfire smoke exposure and support the development of effective mitigation guidance, especially for pregnant individuals and their families, during future wildfire events.

Proposal Summary

Task 1: Identify Gaps in Scientific Knowledge on Long-Term Health Effects of Wildfire Smoke Exposure

This project will evaluate the current state of knowledge on the long-term health effects of prenatal wildfire smoke exposure through a systematic literature review, with a particular focus on studies conducted in California, North America, and among vulnerable populations. Where human studies are limited, the review will incorporate evidence from non-human primate research, particularly regarding the biological mechanisms.

Key deliverables: A comprehensive report and a peer-reviewed manuscript summarizing the findings of the systematic literature review.

Task 2: Characterize Study Participants' Exposure to Wildfire Smoke Pollutants by Social Determinants of Health

The B-SAFE cohort has collected substantial data, including location histories (such as residential addresses and places of evacuation or relocation) and survey data covering participant demographics, neighborhood factors, and protective behaviors (e.g., use of air cleaners, masks, and reduced outdoor activity). In the PI's EPA-funded project,

daily wildfire air pollutant concentrations were also modeled. The current project will build on this foundation by integrating the existing data with newly collected follow-up information and measured metal exposures from biological samples to develop detailed exposure profiles linked to participants' location histories. These profiles will cover both pre- and post-natal periods. Wildfire smoke exposure will be further characterized by fire type (e.g., natural vegetation vs. wildland-urban interface burns), social determinants of health, and behavioral factors.

Key deliverables: Summary tables and visualizations showing the distributions of wildfire-associated pollutants and mitigation behaviors across fire types, participant groups, and neighborhood characteristics. A peer-reviewed manuscript will also be produced.

Task 3: Estimate Health Impact Functions for Long-Term Health Outcomes of Prenatal Wildfire Smoke Pollutants

The study will investigate associations between wildfire exposure, specifically modeled wildfire-related PM2.5 and measured metal concentrations, and long-term health effects among mothers and children, assessed 4-9 years after the wildfire events. Targeted outcomes include respiratory conditions (e.g., asthma); cardiometabolic indicators (e.g., BMI, high blood pressure, cholesterol, blood glucose, arrhythmia, myocardial infarction [adults], coronary heart disease [adults], and stroke [adults]); and mental health effects (e.g., anxiety, depression, and stress) in both mothers and children. The study will also assess neurodevelopmental and behavioral outcomes in children (e.g., autism, ADHD, and problem behaviors). Generalized linear models will be applied to assess concentration-response functions, adjusting for relevant covariates such as participant characteristics, neighborhood-level factors, and background air pollution levels. In addition, the study will conduct multiple time-point analyses to estimate health effects attributed to trimester-specific cumulative wildfire PM2.5 exposure (i.e., the sum of daily modeled estimates). A series of sensitivity and

exploratory analyses will be carried out to support and validate the assessment of long-term health effects.

Key deliverables: A summary report and a peer-reviewed manuscript presenting the results of the statistical analyses, including descriptive findings on maternal and child health outcomes and their associations with wildfire-related PM2.5 and metal exposures.

Task 4. Assess Disparities in the Associations of Wildfire Smoke Exposure with Health Impacts

The study will assess health disparities related to the long-term effects of wildfire smoke exposure by analyzing differences in exposure levels, health outcome rates, and access to self-protective measures during wildfire events across groups defined by social determinants of health and other factors associated with systemic racism and structural discrimination. When statistical power allows (e.g., sufficient sample size), stratified regression models will be used to assess whether specific variables (e.g., race) act as effect modifiers, that is, factors that may influence vulnerability to the health impacts of wildfire exposure.

Key deliverables: A summary report presenting stratified effect estimates by relevant participant characteristics, neighborhood-level factors, and background air pollution, examining how these factors modify the associations between wildfire-related pollutants and maternal and child health outcomes.

Task 5. Develop Accessible Outreach Materials on Key Findings and Recommendations for Vulnerable Populations

In coordination with CARB, the investigators will develop materials that highlight key findings from this study and other relevant research on downstream maternal and child health outcomes associated with prenatal exposure to wildfire-related pollutants. Drawing on insights into the effectiveness of protective behaviors, such as mask use, air purifiers, and evacuation, the study will offer recommendations for reducing health

risks among pregnant individuals and their children during wildfire events. All outreach materials will be culturally and linguistically appropriate, presented in clear, lay-friendly language, and distributed through multiple channels, including media (via press releases), online platforms (in partnership with the UCD Environmental Health Sciences Core Center, EHSCC), and local public health and community organizations.

Key deliverables: A plain-language summary and an infographic presenting key findings from the study on long-term maternal and child health effects of prenatal wildfire smoke exposure, with a focus on impacts in vulnerable populations.

Task 6. Deliver Meetings, Reports, and Data

The contractor will submit quarterly progress reports, a final report with all associated data and analysis results, and a one-page project summary to CARB. Additionally, plain-language fact sheets summarizing key scientific findings will be developed to support public outreach efforts. The contractor will hold quarterly progress meetings with CARB and stakeholders and will host a final public seminar to share key findings.

III. Staff Comments

Given the availability of longitudinal information and existing data and resources from the B-SAFE study, a cost-effective direct contract was developed in collaboration with UCD investigators. The investigators were engaged from the earliest stages, including the development of the research concept, the detailed scope of work and pre-proposal, and the full proposal and were responsive to reviewer's comments. CARB also worked closely with partner agencies, including the California Department of Public Health and the California Office of Environmental Health Hazard Assessment, to review and provide input on all phases of the proposal. Reviewers agreed that leveraging this existing, well-characterized birth cohort enhances both the cost-effectiveness and feasibility of investigating a broad range of long-term health outcomes related to wildfire smoke exposure in vulnerable populations, addressing a significant research gap. Most reviewer comments focused on the need for more detailed technical information, particularly regarding the complex exposure

assessment of wildfire-related pollutants. These concerns have been addressed and incorporated into the current version of the proposal.

Investigator Qualifications

The Principal Investigator, Rebecca J. Schmidt, Ph.D., is an Associate Professor in the Department of Public Health Sciences at UCD. Dr. Schmidt's research focuses on understanding how environmental exposures, particularly those occurring during gestation, interact with genetic susceptibility and developmental programming to influence neurodevelopmental outcomes in children. As a molecular epidemiologist, she brings a mechanistic and pathway-based perspective to epidemiologic research. With over two decades of experience, Dr. Schmidt has led numerous studies focused on prenatal and early childhood development, including the B-SAFE wildfire pregnancy cohort. She will be responsible for the scientific direction and overall execution of the proposed project, with a lead role in assessing child neurodevelopmental outcomes.

Staff believe that Dr. Schmidt's expertise in epidemiology and her leadership of the B-SAFE cohort make her exceptionally well-qualified to lead this research project.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $700,000, subject to inclusion of any changes and additions specified by the Committee.

Item No.: II.5
Date: August 26, 2025
Proposal No.: 2897-317

Staff Evaluation of a Research Proposal

Title:	Laboratory and Community Evaluation of Advanced Portable Air Cleaners and HVAC Filters for Indoor Gas Pollutants. $600,000
Contractor:	University of California, Berkeley
Subcontractors:	Tracking California Big Valley Band of Pomo Indians Central CA Env. Justice Network
Principal Investigator:	Jiayu Li, PhD
Budget:	$600,000
Contract Term:	30 Months

For further information, please contact Dr. Jeffery Williams at (916) 277-0621.

I. Summary

Standard air cleaning devices and panel filters (MERV 13+) on heating, ventilation and air conditioning (HVAC) systems have been extensively studied and are well known to reduce levels of particulate matter indoors. Reduced exposure to PM has benefits for cardiovascular and respiratory health. However, there are many other pollutants such as ozone, nitrogen dioxide, VOCs, hydrogen sulfide (H_2S) from indoor sources and outdoor sources which can infiltrate indoors and cause a variety of respiratory symptoms such as reduced lung function, increased asthma attacks, and increased hospital admissions. There are several air-cleaning technologies that claim to remove these additional pollutants, such as activated carbon, chemisorbants, photocatalytic oxidation, ionization, and hybrid systems. These technologies offer potential solutions for removing indoor gaseous pollutants, but their real-world effectiveness and possible harmful byproducts are not well understood. This contract will combine controlled laboratory experiments and community-based field studies to systematically evaluate

a wide range of portable air cleaners (PACs) and HVAC filters for removing gas-phase indoor pollutants

II. Technical Summary

Objective

The primary objectives of this research study are to evaluate the effectiveness of various air cleaning filters in removing VOCs, odor-causing substances and other air pollutants such as nitrogen dioxide (NO_2) from indoor air through both controlled chamber experiments and real-world field deployments. The study aims to assess qualitatively different filtration technologies, analyze the retention capacity and longevity of carbon-based filters, and provide recommendations for selecting the most suitable air filtration solutions tailored to specific indoor air quality needs. Additionally, it seeks to determine which affordable and accessible air cleaning technologies best support residents in DAC experiencing poor indoor air quality. Finally, the research will inform the development of a guidance document outlining best practices for improving air quality in buildings that house vulnerable populations—such as schools, senior or day care centers, and hospitals—particularly those located in areas with persistent or recurring high levels of VOCs, odors, and NO_2.

Background

Indoor exposure to non-particulate pollutants like NO_2, VOCs, and odor causing substances like H_2S are a growing concern for California's public health and may present an environmental justice issue. These pollutants originate from outdoor sources (wildfire smoke, traffic emissions, oil/gas operations, landfills, geothermal and agricultural activities) as well as indoor sources (gas stoves, cleaning and personal care products, off-gassing building materials), and they pose serious health and comfort challenges. Pollution burdens can fall disproportionately on low-income and minority populations, making effective gas-phase mitigation both an environmental justice and public-health priority.

Proposal Summary

The research team will conduct a comprehensive literature review and identify candidate technologies for evaluation. They will then rigorously test 30 representative devices in a full-scale environmental test chamber (≈2700 ft³, with three independent HVAC systems) and a wind tunnel. Performance metrics will include pollutant-specific clean air delivery rates, sorbent breakthrough times, energy use, and secondary emissions (ozone, VOCs, ultrafine particles) when devices are challenged with H_2S, NO_2, and a mixture of VOCs. The top ranked devices will then be deployed to 45 homes (identified through community partners) in odor- and gas-impacted communities in Lake, Fresno, and Kern Counties. Expected outcomes include identification of the most effective technologies for each pollutant, data on filter longevity and maintenance needs, and best-practice guidance on using air cleaners in homes and other buildings. The results will directly benefit the public and the State by informing CARB's Indoor Air Quality program and mitigation efforts in impacted and vulnerable communities, by providing science-based guidance to reduce exposure to odors and harmful gases indoors.

The study will have six primary tasks:

Task 1: Literature Review

- Review of existing research, products and standards related to gas-phase air cleaning
- Summarize state of knowledge for:
    - Pollutant and odor thresholds
    - Typical indoor concentrations of H_2S, NO_2, VOCs (traffic, oil and gas operations, wildfire smoke, etc)
    - Air cleaning technologies
    - Air cleaner performance for specific pollutants

Task 2: Community Selection, Engagement & Recruitment

- Engage three impacted communities to prepare for field study
- Tracking California and University of California, Berkeley (UCB) will draft community outreach materials (flyers, surveys, plain language summaries)

- Participant recruitment, training, air cleaner deployments led by CCEJN, Big Valley Band of Pomo Indians

Task 3: Laboratory Evaluation of Air Cleaning Technologies

- Controlled experimentation in the lab to characterize the performance of selected air cleaning devices under reproducible conditions.
- Chamber testing – 2700 ft^3 to simulate a realistic room or small office environment
- Test 30 devices of five technology classes for removal of H_2S, NO_2, and VOCs.
    - Challenge mix will include subset of VOCs from wildfire smoke and petroleum related VOCs
- Wind tunnel testing - measure single-pass removal efficiency for each pollutant at the media level and to determine single pass removal efficiency.

Task 4: Field Deployment and Community Field Study

- Deploy interventions in 15 homes in each of the three communities
- Following a randomized controlled trial design
- Monitoring will consist of 1-week baseline, 8-week intervention, and 1-week post
- Environmental data collection:
    - Continuous time-resolved measurements of NO_2, H_2S, and formaldehyde using calibrated electrochemical sensors
    - Continuous logging of temperature, relative humidity, and CO_2
    - Integrated VOC sampling using passive sorbent badges deployed for 7-day intervals at four points

Task 5: Data Analysis, Synthesis of Results, and Development of Recommendations

- Lab data analysis – Process chamber test results and rank tested technologies
- Field analysis – Evaluate efficacy of technologies
- Cost effectiveness and equity analysis
    - Guidance document incorporating results:
        - Technology ranking and best-use guide
        - Uses under specific scenarios
        - Decision flowchart for device selection

        - Community outreach materials

Task 6: Reporting and Dissemination

- Ongoing project management and the required reporting and outreach activities to ensure the project stays on track and the results are shared effectively.

Project Deliverables

- Literature review – recent publications and prior studies related to gas-phase removal. Focus on key pollutants and odorous compounds (H_2S, NO_2, VOCs). Review of performance, costs, regulations and standards.
- Organized and cleaned datasets, survey responses, etc.
- DFR – detailed report of project and results
    - One-page plain language public outreach document
- CARB technical seminar

III. Staff Comments

The proposal was reviewed by CARB staff in RD, Enforcement Division, and Office of Community Air Protection staff. Only minor comments and edits were suggested, and the investigator addressed all concerns and comments before submitting the final proposal.

Study Team

The UCB team pairs indoor air and building scientists with community partners that have previous hands-on monitoring experience in every study location. Collectively, they bring >40 years of chamber and field testing, >150 peer-reviewed papers on indoor air quality and gas-phase chemistry, and proven AB 617/tribal engagement. Dr. Jiayu Li (PI, UCB) has led field and chamber trials of portable air cleaners, wind tunnels and real-time IAQ sensors. Prof. Stefano Schiavon (Co-PI, UCB) is a top expert in indoor environmental quality, both in climatic chambers, field studies and simulations. He leads the UCB Center for the Built Environment (CBE) facility, including wind tunnels and a 2,700 ft3 multi-HVAC environmental chamber that is being used for many indoor air quality studies. The CBE is also providing $60,000 in co-funding support for this project.

Subcontractors

- Tracking California has been funded through cooperative agreements with the Centers for Disease Control and Prevention and multiple other funding sources since 2002. The diverse, multilingual staff has experience with community air monitoring projects, including the multi-county FRESSCA project, providing them with SOPs and QA tools directly transferable to this project.

- The Big Valley Band of Pomo Indians is a federally recognized tribe that operates an Environmental Protection Department (Big Valley EPA) dedicated to protecting human health, cultural resources, wildlife, water quality, and the broader ecosystem. Big Valley EPA regularly collaborates with local and state agencies as well as neighboring Tribes.

- The Central California Environmental Justice Network (CCEJN) works to eliminate environmental harms in low-income communities and communities of color across the SJV). It trains and empowers community members, especially in rural areas, through technical assistance and resources, fosters youth engagement, and serves as a regional hub for environmental activism. Acting as the lead community

partner for the FRESSCA project, CCEJN handled participant recruitment, equipment installation, survey administration, and dissemination of results.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this proposal for a total amount not to exceed $600,000, subject to inclusion of any changes and additions specified by the Committee.

Item No.: III.1
Date: August 26, 2025
Contract No.: 21RD004

Staff Evaluation of a Draft Final Report

Title:	Preterm Birth, Term Low Birth Weight, Childhood Autism, Parkinson's Disease, and Alzheimer's Disease and Air Pollution – California Studies
Prime Contractor:	University of California, Los Angeles
Subcontractor:	University Of California, Berkeley
Principal Investigator:	Beate Ritz, Ph.D., M.D.
Budget:	$998,789
Contract Term:	42 Months

For further information, please contact Dr. Arash Mohegh at (279) 208-7788.

I. Summary

CARB currently quantifies twelve adverse health outcomes associated with reductions in fine particulate matter emissions resulting from its programs and regulations. However, scientific evidence supports the existence of additional particulate matter-related outcomes and impacts of other criteria pollutants such as ozone, as well as adverse effects of air toxics, including both cancer and non-cancer effects. Thus, in April 2020, CARB adopted Board Resolution 20-13 directing staff to expand their methodologies to include additional air pollutants and health endpoints. The project modeled daily air pollution surfaces at 100-m spatial resolution for fine particulate matter, ozone, and nitrogen dioxide, as well as for six air toxics (benzene, 1,3-butadiene, chromium, lead, nickel, and zinc) in California from 1990 to 2019. The researchers used the air pollution surfaces to investigate relationships between pollutant exposures and PTB, term low birth weight (TLBW), autism spectrum disorder

(ASD), and Alzheimer's and Parkinson's disease (AD and PD, respectively) as well as the corresponding economic savings in healthcare expenditures. The researchers disseminated their findings through media engagements to raise awareness about the health impacts of air pollution and will inform CARB's efforts to expand its analysis of health benefits associated with its current and future programs and regulations.

Regulatory/Policy Implications

This study developed California-specific quantitative estimates of associations between exposure to criteria air pollutants/air toxics and health endpoints 1) at high spatial resolution, 2) for broader sets of air toxics as well as health outcomes, and 3) with stratifications by race and socio-economic status. CARB will directly use these associations in health impact assessments of air pollution control programs, providing a more nuanced and comprehensive quantification of the benefits of CARB's emission reduction plans on public health, especially in vulnerable communities, relative to current methods. The study also identified gaps in demographic and exposure data for evaluation in future work.

II. Technical Summary

Objective

The aim of this study is to provide California-specific data for air pollution-related health outcomes beyond the endpoints currently quantified by CARB. The researchers developed daily 100-m spatial resolution surface air pollution concentrations throughout California from 1990 to 2019 using land-use regression modeling. The modeled pollutants are fine particulate matter ($PM_{2.5}$), NO_2, ozone (O_3), and six air toxics (benzene, 1,3-butadiene, chromium, lead, nickel, and zinc). Then, the researchers: 1) identified dose-response curves, stratified by race and socio-economic status where data is sufficient, for PTB, TLBW, ASD, and AD and PD, and 2) estimated the corresponding direct and indirect health care costs. Finally, the study supported

public outreach to raise awareness among affected community members about adverse health impacts of air pollution exposures.

Background

Recent reviews of peer-reviewed health studies, such as the U.S. EPA's recent Integrated Science Assessments for particulate matter and ozone, have identified numerous adverse health outcomes associated with air pollution exposures. CARB currently quantifies twelve $PM_{2.5}$-related health endpoints, including premature death from cardiopulmonary disease, hospital admissions from heart- and lung- related causes, and emergency room visits for asthma. Existing studies have demonstrated air pollution-related impacts for adverse birth outcomes (ABO) such as low birth weight, neurodevelopmental disorders such as autism, and neurodegenerative diseases such as AD and PD. However, available evidence is insufficient to determine California-specific associations between air pollutants and these adverse health effects.

Project Summary

Task 1: Systematic Literature Review

The researchers performed a systematic literature review to assess the impact of air pollutants on ABO, ASD, PD, and Alzheimer's Disease/Alzheimer's Disease and Related Dementia (AD/ADRD). The review included both California-focused and global peer-reviewed literature.

The process defined strict inclusion criteria for study populations, air pollutant exposures ($PM_{2.5}$, NO_2, O_3, air toxics), and specific health outcomes. A three-phase search strategy targeted existing reviews, recent individual studies, and California-specific research. After applying the selection criteria, the review included 43 systematic and 28 qualitative reviews for BO; 20 systematic and 29 qualitative reviews for ASD; 4 systematic and 11 qualitative reviews for PD; 13 systematic and 27 qualitative reviews for AD/ADRD. The review noted positive associations between exposures to $PM_{2.5}$, NO_2, and O_3 during the entire pregnancy and BO, but associations

between exposures in specific trimesters of pregnancy and BO are mixed. The researchers concluded that existing results are generally inconsistent about associations between air toxics and BO due to issues like exposure misclassification from census tract level assessments, highlighting the need for analysis at a higher spatial resolution.

Task 2: Obtaining and Coding Health Outcomes Information

In this task, the researchers acquired and prepared health outcomes data for analysis. UCLA fulfilled all Institutional Review Board requirements, obtaining necessary approvals for new study protocols and UCB investigator authorization. Key data acquisitions included 1990–2019 birth outcome and ASD data from the California Department of Public Health's Vital Statistics Applications System, and Dr. Ritz's birth record–Department of Developmental Services (DDS) dataset was updated through 2022. UCLA also integrated population-based data from Dr. Ritz's Parkinson's Environment and Genes (PEG) and Sacramento Area Latino Study on Aging (SALSA) studies, which provide lifetime residential and occupational histories, alongside detailed cognitive assessments. The researchers obtained air pollution surface data from UCB and assigned exposures to both the birth record dataset and the PEG and SALSA cohorts. Finally, for economic analyses, the researchers sourced birth outcome and ASD rates from the California birth registry and DDS, respectively, and obtained PD and AD rates from published literature to ensure generalizability.

Task 3: Development of High-Resolution Air Pollution Models

This task involved developing high-resolution (100 m) daily land use regression (LUR) models for NO_2, $PM_{2.5}$, and O_3 across California (1989-2021). These machine learning models integrated diverse data sources, including traffic, land use, and meteorological conditions, achieving strong performance (adjusted R^2 values of 84% for NO_2, 65% for $PM_{2.5}$, and 92% for O_3). Longitudinal analysis showed consistent declines in NO_2 concentrations due to regulations, and $PM_{2.5}$ also decreased over time. O_3 concentrations, however, showed no significant annual trend.

Additionally, high-resolution annual air toxics models developed for benzene, 1,3-butadiene, chromium, nickel, lead, and zinc exhibited moderate to strong predictive performance (adjusted R^2 0.59-0.90). Benzene, 1,3-butadiene, and lead concentrations declined due to regulations, while zinc levels increased, likely driven by urbanization, increasing traffic, and agricultural and forest management practices. Land use and meteorological factors, which vary drastically across California, significantly influenced pollutant distributions and trends.

Task 4: Modeling Concentration-Response Functions for Health Outcomes

This task comprehensively examined air pollution's health impacts on ABO, ASD, PD, and ADRD in California. For ABO, while $PM_{2.5}$ and NO_2 associations with PTB and TLBW declined over time, brake/tire-wear air toxics like nickel and zinc showed increased association with PTB in 2013-2021, especially among Black and Hispanic mothers and low socio-economic status populations.

For ASD, prenatal $PM_{2.5}$ and NO_2 exposure linked to increased risk, though effect sizes declined. Benzene and nickel showed strong, persistent associations with ASD across the study period, with variations by race/ethnicity, socio-economic status, and region. In PD, traffic-related air toxics, particularly nickel (odds ratio: 2.61-3.87) and benzene/1,3-butadiene, were strongly associated with risk. Lead and chromium also showed associations, reinforcing pollution's contribution to PD. For ADRD, NO_2 and $PM_{2.5}$ are positively associated with dementia/CIND (cognitive impaired without dementia) incidence ($PM_{2.5}$ increased hazard by ~50%, NO_2 by ~20%). Among air toxics, 1,3-butadiene showed a positive association with dementia/CIND.

Key findings:

- Overall positive association between PTB and $PM_{2.5}$ (odds ratio: 1.032, 95% CI: 1.030, 1.035), with higher estimated associations in 1998-2012 relative to close to null in 2013-2021 for White, Hispanic, and Black mothers; the reduction in

association over the study 1998-2021 may be attributable to decrease in $PM_{2.5}$ exposure levels.

    - Equally elevated associations across area-level SES neighborhoods.

    - Increased association for zinc with PTB from 2006-2012 to 2013-2021 only among Black and Hispanic mothers and low-SES neighborhoods, indicating that these communities are specifically experiencing increased impacts of exposure to non-tailpipe sources of $PM_{2.5}$ in recent years.

- Small positive associations for TLBW with $PM_{2.5}$, NO_2, and O_3 for babies born between 1990-2021 across all area-level SES neighborhoods, with the association in Asian/Pacific Islander mothers being close to null.

- An increase in one interquartile range (IQR) exposure to $PM_{2.5}$ (IQR=3.53 µg/m3) during the entire pregnancy increases the chance of ASD by 10%.

- Long-term (10-year) increased exposure to $PM_{2.5}$ (IQR=1.82 µg/m3) increases the risk of PD by 14%.

- Risk of AD/CIND increased by 49% for an increase to one IQR exposure to $PM_{2.5}$ (1.05 µg/m3) in the short- (1-year) and long-terms (10-year).

- The association for air toxics, as well as the results of the racial stratification, were not statistically significant for all the endpoints. Here are some of the highlighted exceptions:

    - 55% increased risk for ASD for one IQR increased exposure to benzene (0.44 ppb) during pregnancy. This increased risk is estimated to be 91% for the Hispanic population.

    - 164%, 64%, and 57% increase in PD for one IQR increased long-term (10 years) exposure to nickel, benzene, and 1,3-butadiene, respectively.

Task 5: Analysis of Economic Burden of Disease

This task quantified direct (medical expenses, special education services, transportation to hospitals) and indirect (loss of productivity) economic impacts from reduced air pollution for ABO, ASD, PD, and AD in California across three decades. For ABO, $PM_{2.5}$ reductions yielded significant cost savings in earlier decades (e.g., PTB savings of $9.54 billion, 1990-2000), but showed increased costs in 2010-2020 (e.g., PTB loss of $10.65 billion) because of increases in estimated $PM_{2.5}$ exposures. NO_2 consistently generated cost savings for both PTB and TLBW across all periods.

For ASD, $PM_{2.5}$ exposure consistently led to cost savings, increasing from $0.57 billion (1990-2000) to $8.11 billion (2010-2018), with NO_2 showing even greater savings, peaking at $30.27 billion (2010-2018). In PD, $PM_{2.5}$ reductions generated significant savings early on (e.g., $22.78 billion, 2000-2010) but led to a $16.01 billion increased costs in 2010-2020 because of increases in estimated $PM_{2.5}$ exposures, while NO_2 consistently produced large savings, reaching $62.08 billion (2010-2020). For AD, $PM_{2.5}$ was associated with trillions in savings in earlier decades (e.g., $38.68 trillion, 2000-2010), but a $26.51 trillion loss in 2010-2020. NO_2 consistently resulted in substantial cost savings for AD, reaching $9.60 trillion by 2010-2020. Overall, these findings indicate high economic savings from continued implementation of emission-control strategies including stricter vehicle emission standards, but some economic benefits are reversed in recent years due to increased $PM_{2.5}$ emissions from wildfires.

Task 6: Outreach and Community Engagement

This task focused on translating research into public engagement and policy impact through various outreach efforts. The team actively participated in media engagements, presented at scientific conferences, published journal manuscripts, and delivered community lectures. These activities aimed to raise awareness about air pollution's health impacts and highlight regulatory policy roles, and to encourage discourse on environmental health risks. Through interviews with major news outlets, presentations at international scientific conferences, and community initiatives, the

team helped bridge the gap between research and public understanding. Furthermore, other institutions are utilizing the developed air pollution surfaces for collaborative research, demonstrating the broader impact and utility of the project's findings.

III. Staff Comments

Dr. Ritz and Dr. Su submitted the draft report titled "Preterm Birth, Childhood Autism, Parkinson's and Alzheimer's Disease and Air Pollution."

The draft is well written and reflects the achievements made by the project in estimating the exposure to fine particulate matter, ozone, nitrogen dioxide, and six air toxics. The draft presents the results of the health data analysis and lists all the investigated dose-response functions, stratified by race and socio-economic status. The report includes the economic analysis based on direct and indirect costs as well as the recorded incidences of each outcome. Researchers' outreach efforts are listed in the report and include publications, media outreach, and presentations for schools in overburdened areas.

The report does not cover certain components of Task 6 included in the agreement (STD 213) with CARB, including: 1) lay-friendly summaries and fact sheets in English and Spanish of scientific literature on air pollution and health effects, 2) recruitment of community members and health professionals with compensation to review outreach materials, and 3) engagement with the American Academy of Pediatrics Climate Change and Health Task Force, the UCLA Center for Autism Research and Treatment group, and the Bakersfield Parkinson’s Support Group on outreach events. Researchers are still reviewing comments about the economic valuation of Alzheimer's Disease. Minor revisions can further improve the draft, including harmonizing references and adding units to some tables and figures, and the researchers are addressing them.

IV. Staff Recommendation

Staff recommends the RSC recommend that CARB approve this DFR contingent upon completion of remaining outreach efforts in Task 6, and subject to inclusion of any additional changes specified by the Committee.