STATE OF CALIFORNIA

AIR RESOURCES BOARD

MEETING OF THE

RESEARCH SCREENING COMMITTEE

October 26, 2012
9:00 a.m.

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

State of California
AIR RESOURCES BOARD

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510, 5th Floor
Sacramento, California 95814
(916) 445-0753

and

Engineering IV, Building 192
Room Number: 206
Street location: Corner of California Blvd. and Highland Drive
San Luis Obispo, California 93407

October 26, 2012
9:00 a.m.

AGENDA

I. Approval of Minutes of Previous Meeting: v-vii

July 11, 2012 meeting

II. Discussion of New Research Projects:

1) "Measuring Real-World Emissions from the On-Road Heavy-Duty Truck Fleet," University of California, Berkeley, $450,000, Proposal No. 2745-275 9

2) "Evaluating the Benefits of Light Rail Transit," University of California, Irvine, $200,000, Proposal No. 2746-275 15

3) "Economic and Operational Considerations in Transitioning to a Zero or Near-Zero Emission Rail System in California," University of Illinois, $399,889, Proposal No. 2747-275 21

4) "Life Cycle Assessment and Co-Benefits of Cool Pavements," Lawrence Berkeley National Laboratory, $450,000, Proposal No. 2748-275 25

5) "Improving Detection of Particulate Matter Emissions for Certification of Advanced Clean Cars (CRC Project E-99, 'Very Low PM Measurements')," University of California, Riverside, $100,000, Proposal No. 2749-275 31

6) "Investigating Controls and Measurement Methods for Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles," Colorado State University, Fort Collins, $500,000, Proposal No. 2750-275 35

7) "Improving Chemical Mechanisms for Ozone and Secondary Organic Carbon," University of California, Davis, $450,024, Proposal No. 2751-275 41

8) "Characterizing the Climate Impacts of Brown Carbon," University of California, San Diego," $530,000, Proposal No. 2752-275 49

9) "Advanced Plug-in Electric Vehicle Travel and Charging Behavior," University of California, Davis, $650,000, Proposal No. 2753-275 57

10) "New Car Buyers' Valuation of Zero-Emission Vehicles," University of California, Davis, $250,000, Proposal No. 2744-275 63

11) "Identifying Urban Designs and Traffic Management Strategies that Reduce Air Pollution Exposure," University of California, Los Angeles, $388,001, Proposal No. 2754-275 69

III. Discussion of Draft Final Reports:

1) "Mobile Platform III: Characterizing Spatially Inhomogeneous Non-Criteria Pollutants in the Los Angeles Air Basin," University of California, Los Angeles, $290,000, Contract No. 09-357 73

2) "Measuring the Climate Impact of Residential Buildings: Greenpoint Rated Climate Calculator Version 2," University of California, Berkeley, $101,575, Contract No. 09-344 77

3) "Measurement of Diesel Solid Nanoparticle Emissions Using a Catalytic Stripper for Comparison to Europe's Particle Measurement Programme Protocol," University of California, Riverside, $170,000, Contract No. 08-302 83

4) "Are There Any Counteracting Effects that Reduce the Global Warming Benefits Attributed to Black Carbon Controls: Assessment of Cloud Drop Number Concentration Changes and its Importance in Modeling Cloud Albedo Effects on Climate," University of California, San Diego, $114,751, Contract No. 09-337 89

5) "Inverse Modeling to Verify California's Greenhouse Gas Emission Inventory," California State University, East Bay, $150,000, Contract No. 09-348 95

IV. Discussion of a Response to a Request for Proposals:

1) "Measuring Real-World Emissions from the On-Road Passenger Fleet," RFP No. 12-303

- University of Denver, Colorado
  Proposal No. 2755-275, $75,000

V. Discussion of Requests for Proposals:

1) "Technical Analysis of Vehicle Load-Reduction Potential for Advanced Clean Cars," $250,000, RFP No. 12-311

2) "Evaluating Technologies and Methods to Lower Nitrogen Oxide Emissions from Heavy-Duty Vehicles," $1,000,000, RFP No. 12-310

VI. Other Business:

1) Update on the 2012-2013 Research Solicitation

State of California
AIR RESOURCES BOARD

Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510
Sacramento, California 95814
(916) 445-0753

July 11, 2012
9:00 a.m.

MINUTES

RSC Members in Attendance Via Teleconference

Harold Cota
Steven Japar
Matthew Kahn
Charles Kolstad
Tracy Thatcher
Chung Liu

The Research Screening Committee (RSC or Committee) convened the meeting at 9:05 a.m. The minutes of the March 9, 2012 meeting were approved.

I. Discussion of a Request for Proposals (RFP)

1) "Measuring Real-World Emissions from the On-Road Passenger Car Fleet," $75,000, RFP 12-303

A Committee member suggested looking up the profiles such as smog check information and mileage for vehicles whose license plates are recorded, and examine the potential correlation between tailpipe emissions and those profiles. Staff explained that the contractor will not have access to smog check data; but ARB staff does have access and will look into that potential correlation.

A Committee member commented from past research study that sample smog check vehicles from wealthier zip codes appeared to have lower emissions than those from indigent zip codes, probably due to better maintenance. Therefore, socio-economic conditions matter to vehicle emissions. The Committee member offered to send a journal article on the subject to staff. Staff responded that other studies also corroborate that finding, and expressed interest in the journal article. The contractor will not be tasked with analysis of demographic data, but ARB staff will undertake an analysis.

A Committee member asked if the proposed budget is adequate for the proposed work that includes one sampling campaign for each of the two sampling years. Staff confirmed that the proposer of the research project felt that the budget amount was adequate, and that similar studies in the past have cost less.

A Committee member asked staff to elaborate on the idea of using high frequency data samples to investigate methods for identification of gross evaporative emitters. Staff explained that high frequency data (usually about 100 Hz) are obtained by remote sensing devices, and processed into one set of data per vehicle using one of two algorithms, dependent on the manufacturer of the devices. For vehicles with gross evaporative emissions, the processed data using the two algorithms could be different. In previous studies, only the processed data were recorded. In this proposed study, the raw, high frequency data will be recorded by the contractor, and examined by staff, to explore the possibility of identifying gross evaporative emitters.

A Committee member asked if the contractor would just collect and report the high frequency data. Staff confirmed that the contract would only collect and report the high frequency data, and that staff would make an initial analysis of the data in an effort to develop algorithms capable of detecting high evaporative emitters.

A Committee member asked whether the first sentence under Task 2 meant to say that two sampling campaigns will be performed for each of the two sampling years, or meant to say that one sampling campaign would be performed each year and provide two sampling campaigns total. Staff clarified that it is meant to say the latter. Staff will revise the scope of work to clarify that one sampling campaign will be performed for each sampling year.

A Committee member asked if the proposed sampling location (on-ramp of La Brea Boulevard to Interstate 10) is still representative in terms of the demographic profiles of the population that use this location. Staff responded that this location was chosen so that historical record could be extended, and the impact of vehicle age on emissions could be investigated. This is necessary for examining the effects of the extended warranty requirements under California's Low Emissions Vehicle (LEV II) regulation on the durability of emissions control technologies. The representativeness of the sampling location has not been studied in the past, but we will be able to get the address information for the vehicle owners from the recorded license plate numbers. Another Committee member suggested doing an analysis to see if and how the demographics have changed over time. Staff agreed to look into this question. Staff also mentioned that a dataset consisting of 3 million pieces of demographic data will become available from a South Coast Air Quality Management District study. Staff will also analyze or have a contractor analyze those data once they become available.

A Committee member questioned whether it was worthwhile to go through the request for proposal path for this project -- suggesting instead that a sole source

contract could be developed and awarded to the contractor who has conducted similar studies in the past. Another Committee member also expressed concern that having someone other than the previous contractor conduct this study would harm the continuity of the collected sampling record. Staff explained that there are multiple methods to achieve the proposed study goals and more than one group of researchers with potential capabilities to conduct the study. Therefore, a sole source contract would be very difficult to justify.

Motion: Move to accept subject to the inclusion of comments from staff and the Committee.

The Committee approved the RFP.

The meeting adjourned at 9:35 a.m.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 1
DATE: October 26, 2012
PROPOSAL NO.: 2745-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Measuring Real-World Emissions from the On-Road Heavy-Duty Truck Fleet
CONTRACTOR:	University of California, Berkeley
PRINCIPAL INVESTIGATORS:	Thomas Kirchstetter, Ph.D. Robert Harley, Ph.D.
TOTAL AMOUNT:	$450,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	66 Months

For further information, please contact Dr. John Collins at (916) 327-8097.

I. SUMMARY

The Air Resources Board (ARB or Board) Truck and Bus Regulation is leading to the introduction of exhaust aftertreatment devices to reduce emission of particulate matter (PM) to 0.01 grams per brake horsepower-hour (g/bhp-hr) and oxides of nitrogen (NO_X) to 0.2 g/bhp-hr. This would lead to the introduction of diesel particulate filters (DPF's) to control PM on a majority of California fleet by 2014 followed by gradual phase-in of model year (MY) 2010 engines, such that by 2023, all the heavy-duty diesel engines operating on California roadways will meet the MY 2010 heavy-duty engine standard. The PM and NO_X emission reductions realized by the introduction of aftertreatment devices are far greater than those associated with normal fleet turnover. However, along with the emission reduction benefits, there may be some unintended consequences of using such devices such as concomitant increase in ultrafine particle numbers, ammonia (NH_3) emissions and the nitrogen dioxide (NO_2) to NO_X emission ratio. It is therefore important to measure actual on-road emissions in order to quantity the overall effect of the regulation.

ARB-funded studies being conducted near the Port of Oakland are already demonstrating significant emission reductions occurring in the port truck fleet due to implementation of ARB's Drayage Truck Rule. The proposed research will build upon these and other sampling programs performed at the Caldecott tunnel by measuring emissions from the broader on-road truck fleet at three stages of implementation of ARB's statewide Truck and Bus Regulation: 1) 2014, when a significant fraction of the truck fleet will be equipped with DPF's; 2) 2015, when pre-1994 engines will be replaced with MY 2010 engines; and 3) 2017, when pre-1996 engines will be replaced with MY 2010 engines, and by which time a significant portion of the fleet will have MY 2010 engines or newer engines. The measurements will be performed at the Caldecott tunnel in the San Francisco bay area, where an uphill grade will ensure that the trucks operating under load have elevated exhaust temperatures to make aftertreatment systems functional (i.e., urea injection is active).

The results of this study will be used to quantify emission factor distributions, identify unintended consequences, investigate the durability and failure rates associated with the introduction of aftertreatment, and establish emissions benefits resulting from the Truck and Bus Regulation. ARB staff may perform further analysis to assess compliance of on-road fleet with the provisions of the Truck and Bus rule.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to quantify the emission rates of gas- and particle-phase pollutants from a large number of in-use, heavy-duty diesel trucks in the San Francisco bay area. This will be done over multiple years during the phase-in of different provisions of ARB's Truck and Bus Regulation. Significant decrease in PM and NO_X emissions are expected during the timeframe of this study. The magnitude of the air quality benefits will be governed in the short term by the accelerated schedule for truck retrofit/replacement, and in the long term by durability and deterioration of engines and aftertreatment devices.

Background

Diesel engine exhaust is a major source of air pollution in California and has been linked to adverse health effects as well as climate change. ARB's Truck and Bus

Regulation aims to reduce PM and NO_X emissions from on-road diesel engines through the introduction of exhaust aftertreatment devices. The rule requires that MY 1996-1999 engines must be equipped with DPFs or replaced with MY 2010 or newer engines by January 2012. As of January 2016, all heavy-duty diesel trucks must be equipped with DPFs, and all pre-1996 engines replaced with newer engines. Along with the emissions reduction benefits, the exhaust aftertreatment devices may also lead to some unintended consequences, such as concomitant increases in ultrafine particle number and NH_3 emissions, and in the NO_2 to NO_X emission ratio. Also, there is little data available currently to predict the durability and deterioration of new and retrofit aftertreatment devices. It is therefore imperative to measure in-use emissions of vehicles on the road in order to quantify the effects on emissions of truck retrofits and replacements.

Proposal Summary

Under this project, the Contractor shall:

- Assess field sampling sites prior to measurement campaigns and evaluate instrumentation. Develop quality assurance/quality control plans for various analyzers.
- Perform sampling campaigns in 2014, 2015 and 2017 at the Caldecott tunnel in San Francisco bay area. The investigator will measure at high time resolution gases and particles present in the exhaust plumes of at least 1000 individual diesel trucks in each of the three years of the study.
- At minimum, measure carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), NO_2, NH_3, nitrous oxide (N_2O), PM mass and number, black carbon (BC), and particle size distribution. NH_3 and N_2O data will be collected only during the last sampling campaign (in 2017). Particle size distribution will be collected based upon the instrumentation availability from ARB.
- Derive emission factors for individual trucks and develop histograms for individual pollutants. These results will be used to evaluate emissions trends (and therefore the benefits of Truck and Bus Regulation), any unintended consequences, and exhaust aftrertreatment durability over time.
- Provide ARB with tabulated results, including emission rates of individual trucks along with their license plates, engine model year, and aftertreatment attributes

matched in ARB's Truck and Bus Registry. ARB may use this data to assess the compliance rate of trucks with the requirements of the fleet rule.

- Provide a draft final report and a seminar at the completion of the contract.

III. STAFF COMMENTS

The proposed research affirms investigators familiarity and expertise in the area of on-road measurements and can help answer a variety of questions ARB is seeking related to quantification of emissions from retrofitted or replaced engines. The investigators have been performing on-road measurements in the San Francisco bay area since 1993. They recently sampled at the Port of Oakland in November 2009, June 2010, and November 2011 and will do another campaign in spring 2013. Dr. Kirchstetter, the principal investigator, is an Associate Adjunct Professor of Civil and Environmental Engineering at the University of California, Berkeley (UC Berkeley) and a Staff Scientist and Deputy Group Leader in the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (LBNL). He has also participated in field experiments at the Caldecott tunnel in 1993 thru 1997, 1999, 2001, 2006, and 2010. Dr. Harley, the co-principal investigator, is a Professor in the Department of Civil and Environmental Engineering at UC Berkeley and has overseen study design and data analysis for a series of field sampling projects at the Caldecott tunnel between 1994 and 2010, including work for ARB funded projects. The results from most of these sampling campaigns have already been published in peer-reviewed journals. For the proposed research, the investigators will return to Caldecott tunnel which was in the midst of 4th bore construction efforts in recent years, but should be accessible by 2014 for the first sampling campaign. Both the investigators are familiar with the geographical area of sampling and therefore have know-how of challenges related to sampling emissions from a tunnel. Additionally, both investigators have strong backgrounds in sampling techniques and collection, data processing and reporting.

Because the investigators have collected emissions data at the proposed sites, the current study will complement the previously collected data. This multi-year cumulative data will allow a robust analysis of emission factors distribution and changes resulting from the Truck and Bus Regulation. The data will also support benefits evaluation of the

diesel fleet rules, assessment of durability/deterioration of aftertreatment devices and quantifying compliance rate with the provisions of Truck and Bus Regulation.

IV. STAFF RECOMMENDATION

Staff recommends that the Research Screening Committee approve this proposal for a total amount not to exceed $450,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 2
DATE: October 26, 2012
PROPOSAL NO.: 2746-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Evaluating the Benefits of Light Rail Transit
PRIME CONTRACTOR:	University of California, Irvine $150,000
SUBCONTRACTOR:	University of Southern California $50,000
PRINCIPAL INVESTIGATOR:	Douglas Houston, Ph.D.
TOTAL AMOUNT:	$200,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	28 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Senate Bill (SB) 375 requires Metropolitan Planning Organizations (MPOs) in California to develop a Sustainable Communities Strategy (SCS) that demonstrates how they will meet regional greenhouse gas reduction targets set by ARB. The introduction and expansion of light rail transit (LRT) systems and the densification of communities living around LRT stations are among the strategies being considered and pursued by regions as they work toward SB 375 goals. However, the regional travel demand forecasting models used by MPOs in their planning process are limited in their ability to accurately evaluate the impact of transit investment and transit-oriented development projects on travel demand. This research project will implement the first ever longitudinal, experimental-control, before/after evaluation of the impact of a light rail transit investment in California on travel behavior and the active transportation co-benefits for nearby residents. This project will build on an existing study that collected baseline data on travel behavior for 248 households in and near the Expo Line corridor in south Los Angeles. Due to substantial co-funding to support the second phase of data collection, this project will support a third phase of data collection, which will not only provide a rare longitudinal look at travel behavior, but will also include a significant

expansion of data collection and analysis. The results of this research can provide insight into whether and to what extent light rail transit investments can support the goals of SB 375.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to advance our understanding of the impact of light rail transit through time on the travel behavior of local residents, including travel mode, trip distance, and the physical activity co-benefits of active transportation. In the course of this evaluation, the influence (effect size) of neighborhood land uses, individual and household socio-demographics, and individual attitudes and perceptions on the relationship between LRT and travel behavior will be analyzed. This study will also examine the issue of self-selection to see if the travel impacts of new compact, transit-oriented strategies are influenced by new residents who relocate from outside the area because of their preference to live in denser, transit-accessible areas.

Background

The introduction and expansion of LRT systems and the densification of communities living around LRT stations are among the strategies being considered and pursued by regions as they work toward SB 375 goals. For instance, the Southern California Association of Governments (SCAG) region's recently adopted 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy calls for investment in public transportation and directs substantial development and densification in High-Quality Transit Areas—areas within a half mile of well-serviced transit stops. In alignment with this goal, the Los Angeles Metropolitan Transportation Authority's long-range plan commits funds to six new LRT lines over the next decade. Other California cities and regions are also considering new LRT systems or expanding existing ones as strategies to reduce vehicle demand. While these strategies are being pursued, the impact transit investment and transit-oriented development projects have on travel demand and co-benefits remains poorly understood. This study will evaluate whether or not and to what extent LRT investment in California can support the goals of SB 375 and a region's Regional Transportation Plan/Sustainable Communities Strategy.

Proposal Summary

This project will evaluate the impacts of the Expo Line light rail transit line in Los Angeles on vehicle and transit travel, as well as the physical activity co-benefits of active transport using a longitudinal, quasi-experimental study design. This study builds on data previously collected in fall 2011 before the April 2012 opening of the Expo line from 248 households living within a ½ mile (experimental group) or within ½ -2 mile distance of new Expo LRT stations. Using paper and web-based travel surveys, portable Global Positioning System (GPS) location tracking, and accelerometer activity monitoring, baseline data was collected on trips by mode, vehicle miles traveled, and minutes walking or biking for seven days. In addition, information on household income, transportation resources, individual and household demographics, and health status were collected to analyze the effect size due to these variables.

To examine potential changes in travel behavior, households from the original sample will be recruited to participate in the same data collection method in fall 2012 (Phase 2) and again in fall 2013 (Phase 3). In Phase 2, an additional sample of “new resident” households will be recruited and re-recruited in Phase 3 to assess whether their travel differs from that of long-term residents due to a preference to live in more compact, transit-oriented areas. In addition, ArcGIS will be used to develop measures of the physical and social environment. These will be used to examine what urban design factors may be associated with greater physical activity. The analysis of this data will include: 1) a comparison of self-reported trips/activities to GPS-derived trips/activities to cross-validate the study’s data collection methods and to understand factors associated with potential under-reporting of trips; 2) a cross-sectional analysis comparing the experimental group with control group and the effect size of land uses, socio-demographics, and attitudes; 3) a longitudinal, before/after analysis of factors associated with changes through time of key travel behavior outcome variables; 4) a comparison of travel behavior of new versus long-term residents; and 5) an analysis of the influence of built environment factors on physical activity levels.

This project will specifically support analysis of Phase 2 data, the collection of Phase 3 data, the processing and analysis of Phase 3 data, and the development of built and social environmental measures.

III. STAFF COMMENTS

This project incorporates comments from ARB staff in both the Research and Planning and Technical Support Divisions. In addition, several MPOs were notified of this proposed project and in some cases, provided feedback. In particular, SCAG expressed a strong interest in the results of this project.

The proposal demonstrates the research team's knowledge and experience in the subject area and provides a technically sound methodology. In addition, it details a comprehensive data collection protocol that utilizes innovative tools. The data collection will result in multiple outcome variables that will allow for analysis that can support several policy questions.

Dr. Douglas Houston, the principal investigator, and Dr. Marlon Boarnet, with the University of Southern California (USC), have significant experience in transportation and land use research. Dr. Houston has over a decade of experience focused on the environmental, health, and equity impacts of transportation systems and has several publications focused on the impacts of traffic exposure, transit access, travel behavior, and methodological considerations for using GPS as a data collection method. Dr. Boarnet is an expert in the land use transportation field, having published extensively on the role of land use and the built environment on travel behavior, including serving as a member of the authoring committee for a chapter in the National Academy of Sciences book titled, "Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use and CO_2 Emissions." Dr. Boarnet is currently working with ARB to evaluate the vehicle miles traveled impacts of transportation and land-use related policies.

This project has received co-funding from the University of California (UC) Transportation Center, the UC Sustainable Transportation Program, and the Haynes Foundation, reflecting the interest and relevance of this study. This co-funding has provided an opportunity to extensively expand the original scope of the project. The data collection will be extended another year, allowing for a rare longitudinal look at changing travel behavior. In addition, the population sample studied will be enlarged to

include a separate sample of new residents to the area, which will allow for the comparison of new residents versus long-term residents to illuminate the issue of self-selection. Another expansion from this co-funding is the development of built and social environment measures for each resident location using ArcGIS which will be used to examine how urban design factors may influence travel behavior and physical activity.

This project will help address the need to better understand the impact SCS strategies have on reducing travel demand and greenhouse gas emissions, which is vital as ARB encourages California regions to reduce greenhouse gas emissions through land use and transportation planning.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $200,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 3
DATE: October 26, 2012
PROPOSAL NO.: 2747-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Economic and Operational Considerations in Transitioning to a Zero or Near-Zero Emission Rail System in California
CONTRACTOR:	University of Illinois
PRINCIPAL INVESTIGATOR:	C. Tyler Dick, M.S., P.E.
TOTAL AMOUNT:	$399,889
CONTRACT TYPE:	Standard Agreement
CONTRACT TERM:	23 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Meeting California's long-term air quality, toxics, and climate change goals will require transitioning to a zero or near-zero emissions freight transport system, including rail operations. The objective of this research is to identify and examine the operational changes and the economic challenges and opportunities required to transition to zero or near-zero emission freight rail operations in California. Results from this project will provide technology deployment scenarios and the associated operational, economic and logistic impacts of these scenarios. The project will also identify the benefits from reduced energy costs of each deployment scenario and possible renewable energy development on railroad right-of-way. An independent project review of the draft final report and stakeholder input will provide an objective assessment of the feasibility of rail electrification to assist the State in meeting our long-term air quality, toxics, and greenhouse gas reduction goals.

II. TECHNICAL SUMMARY

Objective

The objective of this research is to identify and examine the operational changes and the economic challenges and opportunities required to transition to zero or near-zero emission freight rail operations in California.

Background

ARB is commissioning a study of operational and economic challenges and opportunities associated with transitioning to zero or near-zero emission freight rail operations in California. Meeting long-term air quality and climate change goals in California will require a zero or near-zero emission freight transportation system. This study is one part of ARB's efforts to determine how the rail transport mode can transition and evolve to meet this goal. Previous studies have taken a broad look at the potential for different locomotive technologies and alternative fuels to reach zero or near-zero emissions. This proposed research will assess the feasibility of implementing these locomotive technologies given the economics and operational requirements of freight rail transport in California.

ARB requested the University of Illinois at Urbana-Champaign's (UIUC) Rail Transportation and Engineering Center (RailTEC) to prepare a proposal for this research study. In order to respond appropriately to this opportunity and supplement RailTEC's strengths in railroad operations and economics, RailTEC will partner with a team of well-qualified experts within the university to successfully complete this study. RailTEC will be the lead on the railroad analysis and have the responsibility for overall project coordination and oversight of the management of each team. Additional faculty will be responsible for individual tasks that require their expertise in optimization and economics and geography of renewable and alternative energy.

Proposal Summary

To make progress towards meeting long-term air quality and climate change goals, this study will identify and examine the operational changes and the economic challenges and opportunities required to transition to zero or near-zero emission freight rail

operations in California. The proposed scope of this research is to assess and compare the railroad operations and economic impacts of different zero or near-zero emission locomotive technology in three steps: 1) research and develop appropriate railroad traffic and new locomotive technology deployment scenarios, 2) conduct a systems analysis of each deployment scenario to determine impacts to railway network operations, railway economics and freight logistics; and 3) examine potential benefits from reduced energy costs of each deployment scenario and possible renewable energy development on railroad right-of-way. This analysis will be limited to freight rail operations with a focus on mainline train movements, both within California and also train movements that originate, terminate, or pass through California to the extent that such movements are impacted by locomotive requirements in California. Rail traffic and locomotive movement data will be collected by working with Association of American Railroads, Burlington Northern, and Santa Fe Railway and Union Pacific to characterize the number of train movements and locomotives operating each day on California mainlines. The project team, in conjunction with ARB, will identify no more than six locomotive technology deployment scenarios for analysis. The locomotive technologies may include conventional diesel-electric locomotives meeting tighter emission standards, compressed natural gas fuel, hybrid battery locomotives with or without battery cars to extend their range, fuel cells or electrification via overhead catenary or linear synchronous motors. Various network, operations, and systems analyses will be conducted to quantify the impacts and benefits of each deployment scenario. The different locomotive deployment scenarios will be compared with recommendations described in a preliminary research report for ARB review prior to creation of the final research project report. During the course of the project, four Project Work Group Meetings will be held to obtain stakeholder feedback. To supplement the rail operations expertise of RailTEC (with local knowledge of the California freight transportation environment), a peer review of the research by an individual associated with a California academic institution with suitable expertise will be included in this project.

III. STAFF COMMENTS

Two draft iterations of this proposal were reviewed by staff in the Research Division as well as the Sustainable Freight Branch in the Stationary Source Division. Staff agreed that both drafts were thorough and technically sound. Staff was impressed with the

comprehensive analysis outlined in the proposal, and with the team of experts that has been assembled. Staff made several minor recommendations after reviewing the first draft, including: 1) adding the San Joaquin Air Basin to their analysis, in addition to the South Coast and San Francisco Bay Air Basins; 2) requesting that ARB is able to select 2-3 independent reviewers to review the draft final report. This review will be conducted under a separate contract between ARB and the reviewers chosen by ARB; and 3) allowing ARB staff to validate the data aggregation process.

ARB staff had originally recommended that the principal investigator include a subcontractor from a California institution in the project in order to foster the development of rail expertise in the state. However, this request was not able to be fulfilled due to the lack of available expertise and the limited budget allocated for the project.

The research team from the RailTEC Center at the University of Illinois was chosen to lead this project due to their unparalleled expertise in rail energy efficiency, rail capacity, railroad infrastructure, operating economics, and the development and cost-effectiveness of new rail technologies. The principal investigators, have published extensively on the topic of rail research and their expertise cannot be duplicated at any other public or private institution. The researchers leading this project also have extensive contacts in the railroad regulatory agencies across the United States and valued relationships with the rail industry.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $399,889, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 4
DATE: October 26, 2012
PROPOSAL NO.: 2748-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Life Cycle Assessment and Co-Benefits of Cool Pavements
PRIME CONTRACTOR:	Lawrence Berkeley National Laboratory, $350,000
SUBCONTRACTORS:	University of California, Davis ($50,000) PE International ($50,000)
PRINCIPAL INVESTIGATOR:	Ronnen Levinson, Ph.D.
TOTAL AMOUNT:	$650,000 (Phase 1: $450,000 from ARB, $100,000 from Caltrans; Phase 2: $100,000 from additional co-funding)
CONTRACT TYPE:	Standard Agreement
CONTRACT TERM:	36 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

The construction, use, and maintenance of California roadways and parking lots are responsible for substantial energy and resource consumption, emissions of greenhouse gases (GHG) and other air pollutants. They therefore have a strong influence on local temperatures and air quality. As California re-engineers its cities to reduce GHG emissions, air pollution, and to adapt to the temperature and air quality impacts of climate change, decision-making requires a strong understanding of the life-cycle environmental impacts of conventional and cool pavements.

To address this need, this project will conduct a life cycle assessment (LCA) of traditional cool pavements that will evaluate their lifecycle GHG emissions, and impacts on local climate and air quality. A pavement strategy guidance tool will be created to help local decision-makers as they consider adopting cool pavements in their Climate

Action Planning. Finally, outreach and partnership strategies will be pursued to ensure the results are used in policy planning.

II. TECHNICAL SUMMARY

Objective

The proposed research project seeks to advance the adoption of strategies to reduce: 1) GHG emissions; 2) air pollutant emissions; and 3) urban heat island effects of pavement systems within California. To do this, the project will: (a) review existing literature on cool pavements and pavement LCA to better understand how LCA can inform cool pavement application decisions; (b) develop a modeling tool that analyzes the GHG emissions inventories and the air quality, urban heat island, and building-energy use impacts of different pavements over a wide range of California city characteristics; (c) create a pavement strategy guidance tool that aids local officials in estimating potential local impacts of cool pavement adoption; and (d) create clear guidelines for the continual maintenance of the modeling and guidance tools.

Background

Research has identified opportunities to reduce the environmental impacts of pavements. Cool pavements, with high solar reflectance, can reduce ambient temperatures; slow the temperature-dependent formation of smog; decrease air conditioning and peak electricity demand; and induce negative radiative forcing that cools the atmosphere (Rosenfeld et al. 1998; Akbari et al. 2009). Moreover, cooler asphalt pavements may be less prone to rutting and cracking, and under certain conditions may also have lower rolling resistance due to viscoelastic energy dissipation under heavy truck loading (Lenke and Graul 1986; Pouget et al. 2012).

As California cities begin to consider cool pavements as a strategy to reduce greenhouse gases, improve air quality, and reduce urban heat islands, decision-makers require a strong understanding of the lifecycle impacts of these strategies. This helps avoid achieving isolated gains that have hidden or long-term consequences. In addition, decision makers need a stronger understanding of the potential magnitude of the climate and air quality impacts cool pavements may have in their region.

LCA offers a comprehensive approach to evaluate and improve the environmental impacts of pavements. While pavement life cycle assessment is an expanding research field, previous analyses are limited in their inclusion of use phase impacts, including heat island effects (Santero et al. 2010). In addition, many of these previous studies are project-specific and provide conclusions that are not necessarily generalizable to other situations (Santero et al. 2010). While a recent study evaluating the life cycle greenhouse gas impacts of concrete has made progress in overcoming many of these gaps, the study authors recognize the need to expand this work to other pavement types, and to expand the analysis to include multi-criteria outcomes (Santero et al. 2011).

To address these needs, this project will build upon pre-existing pavement LCA work to evaluate traditional and cool pavements across a variety of environment outcomes, including GHG emissions, and local climate and air quality impacts due to changing albedo. The resulting LCA model will be used to perform case studies evaluating the impact of different pavement technologies in different climatic and city settings and for different technology adoption scenarios. These scenarios will be used to create a pavement strategy guidance tool that can be used by city planners and decision makers as they consider strategies to reduce GHG emissions, improve air quality, reduce ambient air temperatures, and protect public health.

Proposal Summary

This project will build upon pre-existing pavement LCA work to evaluate traditional and cool pavements across a variety of environment outcomes, including GHG emissions, and local climate and air quality impacts due to changing albedo. The resulting model will allow for the creation of a pavement strategy guidance tool to help California city planners and decision makers improve the environmental performance of their pavement systems.

To do this, project staff will conduct a literature review on pavement LCA and cool pavements. This is needed to both assess the full range and boundaries of the impacts of cool pavements, and to identify LCA data sources that quantify consumption, emissions, and impacts from pavement system processes and can be used in this analysis.

Using this information, the research team, in consultation with ARB, will convene a committee comprised of city planners, pavers, and other experts to inform the selection of pavements to evaluate, and the scope and boundaries of the LCA. Once this is determined, the team will begin constructing the life-cycle inventories for various pavement systems of interest. The project will also improve upon existing pavement LCA models by evaluating the use-phase effects of changes in pavement albedo, using climate, air quality, and building energy models. These data will be combined to create a modeling tool that will be used to evaluate the environmental impacts of adopting cool pavements for a variety of different climatic and city condition scenarios in California. In addition, sensitivity analyses will be performed to evaluate which city characteristics have the most influence on the local effects of cool pavements.

The scenarios and sensitivity analyses will be used to construct a decision support tool that allows users to select their climate zone, city characteristics, pavement coverage, etc. to estimate the local impacts of different pavement type choices. Guidelines will be created to facilitate the maintenance of the modeling and guidance tools.

This project is broken into two phases. Phase 1 will conduct the literature review, perform the LCA modeling, and create a useable draft pavement strategy guidance tool. Phase 2 will refine the tool based on user feedback, enhance the documentation, and provide a plan for tool maintenance.

III. STAFF COMMENTS

The draft proposal reflects feedback from ARB staff in both the Research and the Planning and Technical Support Divisions. This project has two phases totaling $650,000. Phase 1 ($550,000) will conduct the literature review, perform the LCA modeling, and create a useable draft pavement strategy guidance tool. Phase 2 ($100,000) will refine the tool based on user feedback, enhance the documentation, and provide a plan for tool maintenance. The currently proposed contribution from ARB ($450,000) and the additional co-funding from Caltrans ($100,000) support the completion of Phase 1 ($550,000); Phase 2 is not supported by currently identified funds. ARB, in coordination with project staff, will work to identify co-funding to cover the

cost of Phase 2. If co-funding is secured, the Phase 1 reporting tasks will be omitted. However, if co-funding is not identified to fund Phase 2, the proposed Phase 1 project will conclude with a final report summarizing the Phase 1 tasks. This phased project design will facilitate the leveraging of additional co-funding while ensuring that if co-funding is not identified, there will still be a valuable, scientifically strong deliverable (guidance tool and supporting documentation) at the end of Phase 1.

This project will result in a novel, policy-relevant analysis of the life cycle GHG impacts and use-phase air quality and temperature impacts of cool pavements in different California regions. To encourage the use of the results from this scientific analysis in planning efforts, the results of the analysis will be distilled into a decision support tool that can be used by cities to estimate the potential impacts pursuing cool pavement strategies could bring. Further, the research team will partner with at least one city within California interested in considering cool pavement strategies. This partnership will not only provide valuable input into what city needs may be, informing the scope of the decision support tool, but it will also facilitate their evaluation of strategies to reduce GHG and heat island impacts.

The interdisciplinary nature of this work requires experts from diverse fields; the research team is a unique combination of expertise and experience. Dr. Ronnen Levinson and staff at the Heat Island Group at Lawrence Berkeley National Laboratory have experience evaluating the impacts of changing surface albedo on local air quality and temperature; investigating the collateral effects of cooler (lighter-colored) pavements such as increased pavement durability, illumination and their life-cycle consequences; and providing “cool community” strategies technical assistance to individuals, local governments, and other stakeholders in California. Dr. John Harvey is Professor of Civil and Environmental Engineering at UC Davis, the Director of the University of California Pavement Research Center, and the Principal Investigator for the Caltrans-sponsored Partnered Pavement Research Center. His expertise is focused on pavement materials, including their development, management, costs, and life cycle environmental impacts. Dr. Nick Santeros is a Senior Consultant at PE International and has extensive experience in life cycle assessment, including its application to pavement products. Together the research team has strong relationships with traditional and cool

pavement industrial partners. In addition, an expert committee comprised of city engineers, city planners, and other stakeholders will be convened to help guide the scope and boundaries of the LCA and to ensure the resulting decision support tool will reflect the needs and resources of the user.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $650,000, with ARB contributing $450,000 and Caltrans contribution $100,000 (to cover Phase 1), and the remaining $100,000 (Phase 2) to be supported by additional co-funding. This remains subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 5
DATE: October 26, 2012
PROPOSAL NO.: 2749-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Improving Detection of PM Emissions for Certification of Advanced Clean Cars (CRC project E-99, 'Very Low PM Measurements')
CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATORS:	Heejung Jung, Ph.D. Kent Johnson, Ph.D.
TOTAL AMOUNT:	$100,000 (ARB contribution)
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	8 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

In 2012, the ARB adopted more stringent tailpipe particulate matter (PM) emissions standards for light-duty vehicles (LDVs) as part of the Advanced Clean Cars regulations. Auto companies have expressed concerns about the repeatability of PM measurements made at the very low emissions levels called for by these new standards. The objective of this project is to study improvements to the LDV certification test procedures that would result in reduced variability for PM measurements. Possible modifications include changes to emissions sample dilution, changes to filter face velocity, and/or other modifications to the Code of Federal Regulations (CFR), Part 1066 test procedures. Results from this project are expected to include specific recommended changes to the CFR Part 1066 to reduce test-to-test variability. The successful completion of this project will aid in the timely implementation of the ARB's lower PM emissions standards.

II. TECHNICAL SUMMARY

Objective

The objective of this project is to improve the existing laboratory gravimetric certification test procedures used to demonstrate compliance with the PM emissions standards for LDVs.

Background

In January, 2012, the ARB adopted a package of regulations to reduce emissions from LDVs, including 3 mg/mile and 1 mg/mile PM certification standards. The previous PM standard was 10 mg/mile, so the new standards represent 70 and 90 percent reductions, respectively, in the PM standards. The magnitude of these reductions has raised concerns among the auto companies who are concerned about test-to-test variability at these low emissions levels, and the impact this variability may have on their ability to demonstrate compliance with the applicable PM emissions standards.

In order to address these concerns, the Coordinating Research Council (CRC) is sponsoring a research project, E-99, "Very Low PM Measurements", and invited ARB to be involved a co-funding stakeholder. The CRC, together with input from ARB, developed a Request for Proposals (RFP), and conducted a solicitation for this project.

The proposal submitted by the College of Engineering, Center for Environmental Research and Technology (CE-CERT) was selected by the CRC E-99 Panel as the most responsive proposal among the three proposals received.

The project scope has been undergoing revisions because the proposed scope of work and cost greatly exceeded the originally available funding. CRC solicitations do not disclose the available funding, but the CRC contracting process is flexible enough to permit modifications to CRC proposals and contracts to deal with such situations, including revising project scope and adding additional funding. The project will consist of the project elements and tasks listed in the proposal summary below.

Proposal Summary

The project will utilize a conventional light-duty vehicle test cell equipped with a dilution tunnel, and the test vehicle will be a late model gasoline-fueled vehicle, and the test cycles will be the Federal Test Procedure (FTP) and the US06, a high-speed test cycle.

This single vehicle will be used to study PM measurement improvements at emissions levels of both 3 mg/mile and 1 mg/mile. Confirmatory testing of test procedure improvements will be conducted for two vehicles, one at 3 mg/mile, and the second at 1 mg/mile.

The project will leverage against an ARB-funded particle measurement research project, borrowing a particle measurement instrument, as a cost savings measure.

The proposal is focused on making incremental improvements to the existing CFR Part 1066 test procedures for making LDV gravimetric PM emissions measurements. The test parameters to be studied are:

- reducing dilution
- partial flow sampling
- increasing filter face velocity
- combining PM emissions on a single filter
- filter handling

The CRC Panel members have agreed that the focus should be on modifications to existing procedures, and that the objective is not to try to redefine PM, or to try to replace gravimetric measurements with real-time PM mass measurements. Hence, the project focus is expected to be on incremental improvements to the CFR Part 1066, as outlined above. The 'filter handling' is an industry issue/concern and is related to environmental conditions and filter handling procedures at individual auto companies, and is expected to be largely be addressed outside of the scope of project E-99.

III. STAFF COMMENTS

The original three proposals received by the CRC in response to the RFP were reviewed by the CRC E-99 Panel (subcommittee) overseeing project E-99. The Panel includes ARB staff, and ARB staff will also be co-managing this project, together with a representative from the Ford Motor Company. The selection of CE-CERT was a consensus Panel decision. Subsequent to the selection, the CRC Panel has been working to develop a scope of work that is satisfactory to all stakeholders and that

matches available funding. The proposal before the Committee is the fourth iteration, and reflects comments and direction from the CRC E-99 Panel.

In order to facilitate ARB's contracting process, the proposal contains one task that is funded at $100,000. The ARB contract will be for this task, which will be part of the overall project funded by the CRC.

The principal investigators (PIs), Drs. Heejung Jung and Kent Johnson, have complementary skills and background, both heavily focused on vehicle and engine emissions testing. Dr. Jung has done considerable research on particle characterization, including projects for ARB. Dr. Johnson has been operating and managing the CE-CERT mobile emissions laboratory for a number of years and has experience measuring very low PM emissions levels. Projects managed by Dr. Johnson include projects for ARB, and other sponsors, such as the Unites States Environmental Protection Agency, and heavy-duty Engine Manufacturers Association. The PIs have delivered good performance on previous ARB research projects. Staff believes they are fully qualified to conduct this research project

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $100,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 6
DATE: October 26, 2012
PROPOSAL NO.: 2750-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Investigating Controls and Measurement Methods for Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles
PRIME CONTRACTOR:	Colorado State University, Fort Collins ($248,645)
SUBCONTRACTORS:	University of California, Berkeley ($238,405) Massachusetts Institute of Technology ($8,150) Consultants (Carnegie Mellon University) ($4,800)
PRINCIPAL INVESTIGATORS:	Allen Robinson, Ph.D. Allen Goldstein, Ph.D. Jesse Krol, Ph.D.
TOTAL AMOUNT:	$500,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Recent research indicates that light-duty gasoline vehicles (LDGVs) may be significant contributors to the organic aerosol portion of ambient Particulate Matter (PM) because of the contribution from secondary organic aerosol (SOA) formation. It has been suggested that LDGVs certified to ARB's super ultra-low emission vehicle (SULEV) standards may be equipped with emissions control systems that effectively control semi-volatile organic compounds (SVOCs) which lead to SOA formation. The objectives of this project are to: 1) investigate the control effectiveness of SULEV control technology in reducing SVOC emissions and SOA formation by testing a small fleet of in-use SULEVs, both new vehicles, as well as older, high mileage vehicles; 2) project these emissions results to a fleet-wide basis; and 3) evaluate methods for making

SVOC emissions measurements. In addition, the SVOCs control effectiveness of other fuels (E85, diesel and CNG) will also be studied. Results will inform policy makers about the effectiveness of the SULEV regulations and implementation schedule for reducing SVOC SOA-precursor emissions.

II. TECHNICAL SUMMARY

Objectives

The objectives of this project are to: 1) investigate the effectiveness of current SULEV emissions control technology in reducing directly emitted tailpipe SVOC emissions and subsequent SOA formation, and the emissions and air quality impact of SULEV technology on fleet-wide emissions, and 2) study lower cost alternatives to the current methods presently used to quantify SVOC emissions that might be used in a conventional vehicle/engine emissions test cell. These objectives will be accomplished by vehicle emissions testing, SVOCs measurements, and smog chamber experiments, followed by data analyses and reporting of results.

Background

Recent research, including vehicle testing at ARB vehicle test laboratories, has suggested that LDGV SVOC emissions may be significant contributors to ambient organic aerosol, due to SOA formation in the atmosphere. Results indicate that most vehicles, including late model year vehicles certified to ARB low emission vehicle (LEV) or ultra-low emission vehicle (ULEV) standards, do not appear to have effective SVOC emissions control technologies. That is, these LEVs and ULEVs have reduced hydrocarbon (HC) standards compared to non-LEVs, but smog chamber results do not show SOA formation reductions commensurate with reductions in the HC standards. It has been suggested that vehicles certified to ARB's SULEV standards may have control technology that is effective in reducing SVOC emissions and SOA formation. Thus, there is a need to characterize both the individual vehicle emissions, as well as the fleet-wide contribution from SULEVs.

SVOC emissions are not explicitly regulated, and hence SVOCs measurements are not typically made in the vehicle test cell. In addition, SOA formation measurements are also not generally made, so this project will include the means to measure both SVOC

emissions in the test cell, as well as SOA formation in a smog chamber. In this way, tailpipe emissions can be compared against smog chamber results.

Proposal Summary

The proposed contractor for this collaborative project would be a team of researchers led by Allen Robinson from Colorado State University (formerly with Carnegie Mellon University). The project would rely on in-kind emissions testing to be performed by ARB staff at the ARB Haagen-Smit Laboratory (HSL) in El Monte, California. This approach was successfully used during a previous three-phase project at the HSL with Dr. Robinson and researchers from Carnegie Mellon University which was funded by the United States Environmental Protection Agency (U.S. EPA) and the Coordinating Research Council (CRC).

The project focus would be vehicle emissions testing, but would also include a suite of emissions measurements targeted at SVOC emissions and SOA formation.
The project would consist of the following major tasks:

- Vehicle procurement
- Vehicle emissions testing
- SVOC emissions measurements
- Smog chamber experiments
- Data analyses and reporting

A small fleet of in-use vehicles will be procured from vehicle owners in the South Coast Air Basin (SoCAB) with an emphasis on vehicles certified to the SULEV emissions standards. Both new SULEVs, as well as higher mileage SULEVs would be procured and emissions tested over conventional test cycles such as ARB Unified Cycle (UC) and the high speed US06 cycle.

The standard suite of regulated emissions (NO_X, HC, CO, PM, CO_2) will be collected by ARB staff as part of the in-kind contribution to the project. SVOC emissions will be measured by the researchers using a variety of techniques, both using both 'traditional' sorbents and subsequent chemical analyses, as well as near-real time instruments.

The SVOCs measurements will be made by collecting emissions samples from the test cell dilution tunnel during vehicle emissions testing, and samples will also be collected for transfer (via a heated transfer line) to the transportable smog chamber for these experiments.

The principal investigator (PI), Dr. Robinson, will oversee the entire project. Dr. Goldstein's team will collect filter and sorbent emissions samples and will analyze them using high resolution two-dimensional gas chromatography to quantify SVOCs. Dr. Kroll will operate a modified version of the Aerodyne Aerosol Mass Spectrometer (AMS). The goals for SVOC measurements are to: 1) comprehensively characterize SVOC emissions for the vehicles tested, and 2) determine if an alternative to sorbent sampling can be developed, such as utilizing an instrument inlet to a conventional flame ionization detector that is set up for sampling of SVOC emissions.

The smog chamber experiments will quantify SOA formation within the chamber over a period of about three hours. Drs. Lipsy and Presto will conduct the smog chamber experiments. Results will both provide data about SULEV performance in controlling SVOCs emissions and subsequent SOA formation, and also data that can be used for future emissions and chemical transport modeling.

Data analyses will be performed for each task (CVS testing, SVOCs measurements, and smog chamber experiments), and the results will be summarized in the final report.

III. STAFF COMMENTS

The proposal was developed in collaboration with ARB’s Research Division staff and has been reviewed by staff from ARB's Research, Mobile Source Operating, Monitoring and Laboratory, Planning and Technical Support Divisions, and the U.S. EPA. The project proposal will form the basis for the project emissions test plan that will be prepared collaboratively with the researchers and ARB prior to beginning emissions testing.

The PI, Dr. Allen Robinson, has an extensive background in combustion source emissions sampling, emissions inventory development, smog chamber experiments, and chemical mass transport modeling. Dr. Robinson was part of the Carnegie Mellon

University research team developing the 'volatility basis set' (VBS) emissions measurements and air quality modeling approach, and this collaboration is continuing now that Dr. Robinson is at Colorado State University. Dr. Robinson recently successfully led his team conducting a three-phase vehicle emissions sampling campaign at ARB emissions test laboratories in southern California, and hence he is considered to be very well qualified to conduct this research project.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $500,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 7
DATE: October 26, 2012
PROPOSAL NO.: 2751-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Improving Chemical Mechanisms for Ozone and Secondary Organic Carbon
PRIME CONTRACTOR:	University of California, Davis, $370,024
SUBCONTRACTOR:	California Institute of Technology, $80,000
PRINCIPAL INVESTIGATOR:	Professor Anthony Wexler
TOTAL AMOUNT:	$450,024
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

I. SUMMARY

Despite improvements in urban air quality in recent years, unacceptable levels of ground-level ozone (O_3) and atmospheric particulate matter (PM) continue to be a persistent problem in both urban and rural areas of California. To meet National Ambient Air Quality Standards, State and local agencies must develop State Implementation Plans and adopt additional regulations to control emissions of these pollutants and their precursors. It is therefore necessary to understand the physical and chemical processes that form these pollutants under various atmospheric conditions. Photochemical air quality models are the primary tool for determining the limiting precursors for various secondary pollutants in California air sheds. Chemical mechanisms are an integral part of these photochemical air quality models and must represent the state-of-the-science understanding of how O_3 and other secondary pollutants are formed and their relationships to the primary pollutants emitted from different sources. This project will comprehensively update chemical mechanisms for predicting the formation of secondary organic carbon, assess the reactivity of volatile organic compounds (VOC) in California's airsheds related to O_3 formation, and evaluate

impacts of nitrogen pentoxide (N_2O_5) on secondary aerosol formation. The results will provide ARB with improved and more up-to-date mechanisms for gas-phase and secondary particulate matter PM prediction that underlie ARB's air quality planning effort.

II. TECHNICAL SUMMARY

Objective

The primary objectives of this project are to extend the Statewide Air Pollution Research Center (SAPRC) chemical mechanism to allow for prediction of secondary organic aerosol, and assess the reactivity of volatile organic compounds in California's airsheds. Additionally, the latest understanding of N_2O_5 formation and heterogeneous reactivity and its impacts on secondary PM will be incorporated into SAPRC.

Background

Chemical mechanisms are an integral part of the photochemical air quality models and must represent the state-of-the-science understanding of how O_3 and other secondary pollutants are formed and their relationships to the primary pollutants emitted from different source categories. Photochemical air quality models are also routinely used in California to assess the effectiveness of air pollution control strategies to achieve the National Ambient Air Quality Standards (NAAQS) for both O_3 and particulate matter (PM2.5 and PM10). Therefore, it is critical that the SAPRC chemical mechanisms used in ARB's photochemical air quality models are based on the best science and updated periodically.

SAPRC mechanisms have been developed and updated several times under ARB's sponsorship. Recently, SAPRC chemical mechanisms were modified to improve model prediction for secondary organic aerosol (SOA) formation. Well-controlled environmental chamber experiments were conducted that provided needed input to develop a chemical mechanism to predict SOA formation from aromatic compounds, which represent an important class of SOA precursors for which existing models perform poorly. The aromatic mechanism was evaluated by conducting model simulations, and the model simulated most of the data without overall bias. This represents significant progress toward the eventual development of a chemical model to

predict SOA formation due to anthropogenic emissions. Such a model is essential to developing cost-effective control strategies for PM2.5. However, continued development and evaluation is needed before "PM-SAPRC" could be used for scientific and regulatory modeling applications.

ARB's regulatory photochemical air quality modeling program, which provides the technical basis for both O_3 and PM State Implementation Plans, routinely uses state-of-the-science models that contain the latest SAPRC chemical mechanism. Further improvements to this chemical mechanism will allow ARB's regulatory efforts to be based on the most credible emissions control strategies.

Proposal Summary

This project is a collaboration between the University of California at Davis (UC Davis) and the California Institute of Technology (Caltech) to extend SAPRC to allow for prediction of SOA through the incorpo ration of a sequential oxidation model into the reaction scheme. In addition, air quality meteorological scenarios will be updated and combined with recent volatile organic compound (VOC) surrogate updates to provide a framework for reactivity modeling assessments. Furthermore, the latest understanding of nitrogen pentoxide (N_2O_5) formation and heterogeneous reactivity will be incorporated into SAPRC to evaluate its impacts on SOA and inorganic aerosol. The goals of this project will be accomplished through the completion of the following tasks.

- Task 1: SAPRC Secondary Organic Aerosol Development

Investigators at UC Davis and Lawrence Berkeley National Laboratory recently published a Statistical Oxidation Model (SOM) that provides a computationally-tractable framework for predicting the formation of low volatility organic compounds that result from multi-generation oxidation. Currently, the SOM exists as a stand-alone framework for SOA simulation; for use in air quality models it is necessary that it be merged with existing chemical mechanisms, in this case SAPRC, to allow for simultaneous simulation of gas-phase criteria pollutant and inorganic particulate matter concentrations. Modifications to the aerosol operator in these models will also be needed to deal with gas-to-particle conversion of the condensable organic species

predicted by SAPRC+SOM in a similar way that condensable inorganic species such as nitric acid are handled.

Therefore, as part of Task 1, SAPRC and SOM will be combined into one photochemical modeling framework (SAPRC-14). UC Davis investigators will use an existing library of results from smog chamber experiments in the development of the SOA component of SAPRC-14, as well as results from new experiments that will be incorporated into the model as they become available. Another part of SOA SAPRC-14 development involves the identification of biogenic and anthropogenic VOCs that lead to SOA: new smog chamber experiments will be performed at Caltech that will help to fill data gaps in these reaction pathways.

- Task 2: Update the modeling scenarios used in reactivity assessment

The reactivity of a VOC is defined as the additional O_3 that forms per unit of VOC when a small amount of the VOC is added to a base case photochemical system. One important application of the SAPRC chemical mechanism is to estimate O_3-forming potential (reactivity) of individual VOCs. The original VOC surrogate concentrations and emissions/meteorological scenarios were compiled based on 1980's data from 39 urban cities across the US. Under contract to ARB, the composition of the VOC surrogate for the Los Angeles region was recently updated, based on measured ambient concentrations from the Photochemical Assessment Monitoring Stations (PAMS) and calculated emission rates from national and state inventories. Several steps must be completed to construct updated scenarios for VOC reactivity scales that reflect modern conditions.

During Task 2, changes to VOC surrogate concentrations representative of the United States (U.S.) will be projected based on changes in the Los Angeles region, and new meteorological scenarios will be developed to represent modern conditions in regions across the U.S. Furthermore, updated meteorological and emissions scenarios will be combined with updated VOC surrogate concentrations to assess VOC reactivity in urban regions across the U.S., and reactivity estimates for key VOCs derived from box model simulations will be compared to reactivity estimates derived from multi-day 3-D airshed model simulations in California airsheds.

- Task 3: Evaluate organic nitrate and N_2O_5 chemical mechanisms and assess their impact on secondary aerosol formation

Atmospheric nitrogen plays a critical role in O_3 production and it contributes to particulate nitrate formation. Studies show that N_2O_5 chemistry can strongly impact particulate nitrate formation in the San Joaquin Valley and the South Coast Air Basin, especially during cooler fall and winter months when daytime oxidant concentrations are reduced. During Task 3, the SAPRC chemical mechanisms used in airshed model will be updated with recent N_2O_5 data obtained from laboratory and field studies. These updates will include information about interactions between the nitrogen chemistry and carbon chemistry influencing SOA formation. Additionally, modeling simulations for typical summer and winter smog situations in major air basins (e.g., South Coast and San Joaquin Valley) will be conducted to investigate the impact of updated N_2O_5 chemistry and vertical mixing representations on secondary pollutants such as organic nitrate and aerosol.

Final deliverables will include a version of SAPRC that integrates the code and concepts of the SOM, giving SAPRC a framework for including SOA-forming reactions along with identification of key uncertainties in SAPRC-SOM, and a detailed description of SAPRC-SOM. At the conclusion of the project, a draft final report and text files of all relevant data used in this study will be submitted to the ARB. Journal article preparation will start as soon as results emerge, with manuscripts submitted to peer-reviewed journals.

III. STAFF COMMENTS

Staff from ARB's Planning and Technical Support and Research Divisions, and experts from the South Coast Air Quality Management District and United States Environmental Agency (U.S. EPA) reviewed two pre-proposals received in response to the ARB's July 2012 solicitation for research approaches from the University of California and California State University. The UC Davis team was invited to submit a full technical proposal to ARB. An early version of the UC Davis full proposal was reviewed by the same review team. The UC Davis proposal includes a section on "Review Comments and Responses" that addresses reviewers' comments, point-by-point. The reviewers

generally recognized the quality of the proposed research effort and the practical importance of the results. The level and quality of effort are sufficient as proposed; the investigators have proposed enough labor to ensure successful completion of this study.

Dr. Wexler will serve as the principal investigator coordinating and synthesizing the effort of other task leaders, and will work on conceptual design of integration between the traditional SAPRC mechanism and the new SOM. Dr. Wexler was one of the early developers of the fundamentals underlying modeling of aerosol dynamics in the atmosphere. The resulting CMAQ-UCD model is used by the U.S. EPA for research purposes. His current work related to this project is supported by the Department of Energy's Atmospheric Systems Research program. This project represents a collaboration of Dr. Wexler with Dr. Cappa and Dr. Kleeman (both UC Davis), and Dr. Seinfeld (Caltech).

Dr. Seinfeld is one of the pioneers in air pollution modeling and measurement. Related to this project, he is currently measuring SOA yields in an environmentally-controlled smog chamber at Caltech, under funding from the National Science Foundation (NSF) and the Department of Energy's Atmospheric Systems Research program. Data from this chamber will be employed to help parameterize the SOM for this project. Dr. Kleeman has successfully completed several research projects for ARB; one focal point of his research was the incorporation of the Caltech Atmospheric Chemistry Mechanism into photochemical models with source apportionment techniques to allow for the source apportionment of known SOA. Dr. Cappa is the co-originator and developer of the SOM work. He is currently leading a project funded by the NSF to investigate SOA phase and volatility. He is also leading projects funded by the NSF, the Department of Energy's Atmospheric Systems Research program, U.S. EPA and National Oceanic and Atmospheric Administration to develop quantitative linkages between particle composition (including organic components) and optical properties.

The results of this project will provide an improved and more up-to-date chemical mechanism that will enable air quality modelers to obtain improved predictions of SOA formation and its influence on ambient conditions in California. Further improvements to

this chemical mechanism will allow ARB's regulatory efforts to be based on the most credible emissions control strategies. The results will also advance our understanding of the processes by which chemistry involving N_2O_5 could have important consequences for the chemical production of secondary PM. Additionally, assessment of the reactivity of volatile organic compounds on O_3 and secondary PM formation would be useful for a number of O_3 and PM control strategies.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $450,024, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 8
DATE: October 26, 2012
PROPOSAL NO.: 2752-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Characterizing the Climate Impacts of Brown Carbon
PRIME CONTRACTOR:	University of California, San Diego, $270,268
SUBCONTRACTORS:	University of California, Davis, $176,482 Stanford University, $43,250 Carnegie Mellon University, $40,000
PRINCIPAL INVESTIGATOR:	Lynn Russell, Ph.D.
TOTAL AMOUNT:	$530,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

I. SUMMARY

Black carbon (BC) (the dark soot produced from combustion) absorbs light and gives off heat, and is now recognized as a significant contributor to global warming. Light-absorbing organic carbon that is not black, called brown carbon (BrC), was recently discovered to also be a potentially large contributor to global warming. The combustion sources that contribute to BrC in the atmosphere are not well characterized, and recent studies suggest that there may be multiple pathways for its formation. To help characterize and differentiate sources of BrC from BC, the proposed research will apply advanced instrumentation that will provide unprecedented chemical and optical characterization of BrC sources and investigate its formation pathways. These results will be used to separate and characterize BrC, and quantify its importance in regional and global modeling climate forcing. This project will improve our understanding of the fundamental processes that govern BrC formation and its evolution in the atmosphere,

and help us determine the potential climate benefit of mitigating sources of BrC emissions in California.

II. TECHNICAL SUMMARY

Objective

This research project will identify and characterize the contribution of BrC to climate forcing in California by: 1) providing the state-of-the-art real-time measurement techniques at two California locations that determine the chemical concentrations and optical properties of burning activities; 2) quantifying the BrC organic components and the multi-wavelength absorption from burning emissions and from atmospheric formation of secondary components; and 3) examining the globally and regionally-averaged climate response of BrC.

Background

Airborne particulate matter (PM) varies in its composition and plays a significant role in human health impacts and the climate system. Among different types of PM, carbonaceous PM, containing organic (OC) and BC is especially important because of its abundance in the atmosphere, and its health effects, which are the focus of increasing interest. With respect to climate impact, BC is the principal absorber of visible solar radiation in the atmosphere, whereas OC is often described as light-reflecting. Recent studies show that certain OC fractions can also absorb solar radiation efficiently, although they differ from typical BC; these fractions are referred to as “brown carbon.”

Although BrC is pervasive in the atmosphere, neither its sources nor the extent to which BrC contributes to direct aerosol climate forcing are well understood. A California-specific study suggests that there may be multiple pathways for the formation of BrC, and it may account for as much as 20 percent of the solar radiation absorbed by the earth’s atmosphere. While BrC absorbs less energy per unit mass than BC, some source types (such as open biomass burning) can emit substantially more BrC than BC, such that the total quantity of BrC may lead to more warming than BC. Thus, the role of BrC is important for determining the potential climate benefit of mitigating sources with high OC emissions.

BrC emissions released from residential, agricultural, and wildfire burning activities are highly seasonal or episodic, and thus poorly characterized as fraction of particulate matter 2.5 (PM2.5) in California. Because their emissions are highest in the winter months when air quality is worst in the San Joaquin Valley and Sierra foothill communities, quantifying their role in the atmosphere is essential both to improving local air quality and to understanding climate impact. In addition, secondary organic aerosols (SOA) formed from urban emissions provide another source of BrC. For example, aqueous oxidation during fog episodes in the South Coast Air Basin produces light-absorbing organic compounds.

Climate modeling and monitoring research has mainly focused on the atmospheric concentrations of BC and OC and their estimated effects on global warming. Since BrC potentially is an important contributor to atmospheric warming, estimates of the warming effect purely based upon BC and OC alone are insufficient. BrC should be incorporated into climate models, and its impact on net forcing needs to be estimated. This research study will help to identify sources of BrC and quantify its relative contribution to the absorption of solar radiation by PM. This will allow for improved assessment of the potential climate benefit of reduction of specific PM sources with high OC emissions that are determined to be large contributors to BrC.

Proposal Summary

The goal of this project will be accomplished through the completion of the following three tasks, which cover observational data and observationally-constrained climate model assessment.

- Task 1: Characterize and differentiate sources of BrC from BC

The proposed research will include measurements at two California sites (to be selected in consultation with ARB staff to leverage other studies and facilities) that investigate at least two types of BrC (e.g. residential burning and urban SOA). Ambient organic aerosol will be chemically characterized and source-associated using complementary techniques: mass fragments by real time Aerosol Mass Spectrometry (AMS) and rapid single-ultrafine-particle mass spectrometer (RSMS), and functional groups off-line by

Fourier Transform Infrared (FTIR) spectroscopy. Similarly, complementary multi-wavelength optical measurements will be made by real time cavity ring-down (aerosol extinction spectrometer) and a photo-acoustic spectrometer. Cloud condensation nuclei (CCN) are the subset of aerosols that serve as seeds for cloud formation and are the key to understanding the aerosol indirect effect and hydrological cycle. Hence, CCN measurements will serve to characterize the role of water uptake on the BrC particles. In addition, size-resolved number and mass distributions by differential mobility analysis (DMA) and optical particle sizing (OPS) scattering measurements will be included. Several measurement techniques will be continuous during field studies.

- Task 2: Quantify chemical and optical characteristics of BrC sources and examine the formation of secondary BrC

The goal of Task 2 is to use statistical analysis methods to separate and characterize the BrC component of organic aerosol. Part of this task will be accomplished by comprehensive field sampling methods described in Task 1. FTIR will be used to characterize the chemical characteristics of the fine particle organic carbon and to associate different organic chemical signatures with tracers for specific sources. AMS can provide detailed size and time resolution to better quantify multiple sources and diurnal changes. These techniques would allow not only for quantitative characterization of the BrC organic composition, but also identification of source categories and quantitative source contributions through the use of elemental tracers and positive matrix factorization (PMF). Investigators will also compare these chemical signatures for burning and urban smog with the multi-wavelength optical measurements, and evaluate the characteristic spectral absorption of both urban fog-smog and wintertime burning activities.

Source-Oriented Sampling (SOS) is a technique originally developed by University of California, Davis (UC Davis) scientists based on a system that conditionally samples particles from the atmosphere depending on the sources or source combinations that predominate at the sampling site at a given time. Using SOS for high-biomass events (in addition to regular timed samples for diurnal patterns), investigators will also carry out PMF-analysis of the source-specific FTIR spectra, i.e. Source-Oriented-Sampling-

enhanced (SOS) PMF. This new approach combines the FTIR PMF approach with SOS technique to obtain improved separation and chemical characterization of BrC organic mass from other organic emissions. This enhanced separation will be essential for apportioning BrC among its primary and secondary sources.

- Task 3: Assess net contribution of BrC to California climate

The investigators will compare the BrC concentrations and properties evaluated in Tasks 1 and 2 to the concentrations and properties of biomass burning and other BrC sources included in regional and global climate models. This task consists of four parts: Weather Research and Forecasting model with chemistry (WRF-Chem) regional simulations, GATOR-GCMOM global and nested regional simulations, GISS-TOMAS global simulations, and chemically and optically-constrained climate forcing estimates. Gas, Aerosol, Transport, Radiation, General Circulation, Mesoscale, and Ocean Model (GATOR-GCMOM) is a one-way-nested (feeding information from coarser to finer domains) global-regional climate model that simulates climate, weather, and air pollution on all scales. GISS-TOMAS model is a combination of the Goddard Institute for Space Studies (GISS) general circulation model and the Two-Moment Aerosol Sectional microphysics algorithms. These multiple methods for assessing the BrC climate forcing are essential to constrain both the regional and global BrC impacts (with WRF-Chem and GATOR-GCMOM), the specific indirect effects that contribute to them (with GISS-TOMAS), and the uncertainty compared to observational constraints (with AERONET).

Projected twenty-year global simulations with and without BrC will be performed to examine the globally and regionally-averaged climate response of BrC. Two one-year simulations nested from the globe to California will also be run, one with and one without all BrC. The purpose of the simulations is to examine the spatial distribution, optical properties, radiative properties, and human exposure effects of BrC. Results from global climate modeling simulations will be compared with the 2013 BrC measurements gathered as part of the project. A sensitivity model test simulation will be run subsequently, based on the initial comparison with data, to test whether modifying

the emission rate of BrC improves the comparison with data and/or affects the climate response.

At the conclusion of the project, a draft final report and text files of all relevant data used in this study and suitable for data archiving will be submitted to ARB. The draft final report will include a comprehensive summary and discussion of all of the topics and issues addressed in this research project. Journal article preparation will be taken up as soon as results emerge, with manuscript(s) submitted to professional journals.

III. STAFF COMMENTS

Staff from ARB's Planning & Technical Support and Research Divisions, experts from Harvard University, and the United States Environmental Protection Agency (U.S. EPA) reviewed 5 pre-proposals received in response to ARB's solicitation from University of California and California State University in July 2012. The review committee selected the University of California, San Diego (UC San Diego) pre-proposal since it more closely addressed all of the topics as expressed in the solicitation. The UC San Diego team was invited to submit a full technical proposal to ARB. An earlier version of the UC San Diego full proposal was reviewed by the same review team. The reviewers generally recognized the quality of the proposed research effort and the practical importance of the results. U.S. EPA experts stated that the assembled team has extensive experience and resources (including instrumentation and models) to apply to the project and the results will be well worth the resources. Overall, the level and quality of effort is adequate; the investigators have proposed enough labor to ensure successful completion of this study.

Due to the range of sources and chemical complexity of BrC, a series of advanced measurements are needed to characterize their chemical and radiative properties and their sources in order to improve net climate forcing estimates. Dr. Russell will serve as the principal investigator coordinating and synthesizing the effort of other task leaders. This project represents a collaboration of Dr. Russell (UC San Diego) with Dr. Wexler and Dr. Cappa (UC Davis), Dr. Roberts (UC San Diego), Dr. Ramanathan (UC San Diego), Dr. Adams (Carnegie Mellon University), and Dr. Jacobson (Stanford Univeristy). In addition, Dr. Hawkins will collaborate in these measurements at no cost

using support from her existing Harvey Mudd College funds and undergraduate students.

The state-of-the-art real-time measurement techniques proposed in this research project are uniquely suited to the objectives of this project, and the research team has the necessary/comprehensive instrumentation and data analysis expertise, as documented by their peer-reviewed publication record on this topic. The advanced instrumentation used for these measurements will provide unprecedented chemical and optical characterization of BrC. The quantitative analysis of these results will separate and characterize BrC, providing important quantification of particle properties for modeling climate forcing.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $530,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 9
DATE: October 26, 2012
PROPOSAL NO.: 2753-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Advanced Plug-in Electric Vehicle Travel and Charging Behavior
CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATORS:	Thomas Turrentine, Ph.D. Michael Nicholas, Ph.D.
TOTAL AMOUNT:	$650,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	44 Months

For further information, please contact Mr. Fereidun Feizollahi at (916) 323-1509.

I. SUMMARY

Plug-in electric vehicles (PEV) are anticipated to become an increasing share of new light-duty vehicle sales; however their environmental benefits will vary depending on consumer usage and charging behavior. This project's objective is to collect and analyze in-use vehicle data from a variety of vehicle types in a household context to improve estimates of emission profiles and consumer benefits. This will result in a comprehensive and highly resolved dataset of vehicle and recharging/refueling parameters that allows for characterization of the current state of PEV household travel. This information can help regulators and policymakers to adjust treatment of PEVs in regulatory or incentive programs, appropriately plan for possible grid impacts from PEV charging, and evaluate the benefits of public infrastructure investments. Lastly, this research can also continue to improve our understanding of how general vehicle operations and travel behavior may affect emissions.

II. TECHNICAL SUMMARY

Objective

The objective of this research project is to collect and analyze in-use vehicle data from households that own PEVs. A wide array of data will be collected from all vehicles within the households – both PEV and non-PEV – in order to improve emissions estimates at the vehicle, household, and fleet levels. The data will also be used to inform potential demand on the electrical grid as well as the need for potential future supporting infrastructure.

Background

During ARB's January 2012 board meeting, the Board resolved to study consumers' actual usage of plug-in electric vehicles and report back to the Board by 2016. Consumer usage and charging habits of PEV owners remain ambiguous due to limited data availability and the diversity of PEV attributes. However, these behaviors will have significant implications for statewide emissions, energy consumption, and electrical grid management based on the total miles these vehicles travel using off-board electricity sources (eVMT). As PEVs are expected to become an increasing share of the light-duty fleet, understanding these behaviors will be important for appropriately projecting fleet emissions and estimating consumer impacts as well as efficiently planning future resources. The California Public Utilities Commission recognizes the potential impact of PEVs on the grid and has issued a ruling to investor-owned utilities to consult with ARB on this proposed research to identify possible opportunities to collaborate on their Load Research Plan.

Proposal Summary

This proposed research will enhance ARB's understanding of PEV-owning households' travel and charging behavior. The primary data collection method will be through instrumentation with a customized data logging device that captures vehicle location, operations, and charging data transmitted to a server via a cellular network. Approximately 115 households will be recruited to participate, owning an estimated 300 PEV and non-PEV vehicles total. Data will be collected from all vehicles within the household for twelve months, with the entire data collection period spanning over two

years. Collecting data over two years has the benefit of eliminating seasonal effects as well as providing insights into how households adapt their travel patterns and vehicle trip assignments as they become more familiar with their PEVs or as public charging infrastructure expands. The data will be highly resolved – many parameters collected at a frequency as high as one-second intervals – which will provide opportunities for future studies to improve understanding of travel behavior in general and further refine emissions estimates.

The in-use vehicle data will be supplemented with two surveys of the participating households. As part of the recruitment effort, the first survey will be administered to all eligible households to gather data on household characteristics, charger availability, important destinations, and expectations about their PEVs. The results of this survey will be used to select households along the various dimensions of interest: PEV technology type, access to workplace charging, geographic diversity, and annual miles traveled, etc. The exit survey will be conducted at the conclusion of the household's data collection period to provide context for interpreting the vehicle data and capture relevant changes to the household (e.g. change in workplace location or household structure) and reflections on their experiences with the vehicle and charging infrastructure.

Given the large volume of data generated from this project, the data will be processed using database software and geographic information systems (GIS) to describe the current state of PEV household vehicle use dynamics and charging, the interaction between charging infrastructure and eVMT, and inform policymakers on strategies for increasing eVMT and the need for additional public charging infrastructure.

III. STAFF COMMENTS

A true comparison of the emissions benefits of PEV technology types requires a comprehensive dataset of a household's travel behavior, not just a PEV in isolation. There is presently no complete dataset available on actual consumer usage and charging of PEVs in a household context. This research project will fill this gap and is extensive enough to provide a complete picture of household travel behavior and allow for a robust and systematic evaluation of the different technologies. The data collection

effort can also be leveraged to collect other useful vehicle operations data at minimal marginal cost to be used for future analyses on evaporative emissions, on-board diagnostic systems, or in-use fuel consumption relative to different driving conditions.

A prior draft of this proposal was distributed for review to ARB staff in the Research and Mobile Source Control Divisions; the California Environmental Agency; United States Environmental Protection Agency; the California Energy Commission; the California Public Utilities Commission; South Coast and Bay Area Air Quality Management Districts; Oak Ridge National Laboratory; and the United States Department of Energy. Among the comments received, reviewers were generally positive about the need for this research project and the qualifications of the research team.

The comments received were mostly requests for clarification or further elaboration on the research tasks. One reviewer questioned whether hydrogen fuel cell vehicles could be included in the sample; another questioned the generalizability of these existing PEV-owning households to future market participants; a third requested more detailed discussion on the data deliverables. Reviewers also commented on the prioritization for the currently optional tasks that could be completed should additional funding become available. Reactions were mixed for the inclusion of a full-time project manager to handle the logistical aspects of this research. However, there was general support for the inclusion of interviews or other qualitative research of participating households as well as the addition of other vehicle types to be sampled and the requisite recruitment efforts. Some of these comments have been addressed in the submitted version of the proposal, though staff recommends further discussion on the issues of generalizability of results and elaboration on how each of the data deliverables listed in Table 2 (of the submitted proposal dated September 18, 2012) will be collected, inferred, calculated, or otherwise generated. Any additional comments received from other reviewers will be presented to the committee at their meeting.

Staff continues to seek funding partners to expand the sample size of the study, which could be used to augment the samples of the three PEV technologies and allow for further stratification of the data, e.g. Leaf owners within PG&E territory, and/or allow for the inclusion of future vehicle types, e.g. Ford CMAX Plug-in Hybrid (PHEV20) or BMW

BEVx. A larger sample size would strengthen the justification for a full-time project manager that is currently proposed but unfunded. Staff will update the committee at their meeting on any commitments for co-funding.

This research team has been investigating consumer behavior related to alternative fuel vehicles for decades and currently serves as the State's research center on plug-in hybrid and electric vehicles. They have led previous vehicle instrumentation research projects and demonstrated the ability to receive and process large volumes of data. In addition, they have conducted extensive research on charging infrastructure that will complement the interpretation of the vehicle and survey data. Additionally, they may be able to leverage existing partnerships with industry and other government agencies to enhance the quality of the final deliverables.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $650,000, subject to changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 10
DATE: October 26, 2012
PROPOSAL NO.: 2744-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	New Car Buyers' Valuation of Zero-Emission Vehicles
CONTRACTOR:	University of California, Davis, $250,000
PRINCIPAL INVESTIGATORS:	Kenneth Kurani, Ph.D. Thomas Turrentine, Ph.D
TOTAL AMOUNT:	$250,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	18 Months

For further information, please contact Mr. Fereidun Feizollahi at (916) 323-1509.

I. SUMMARY

New advanced light-duty vehicle technologies and designs, including those that reduce criteria pollutant and greenhouse gas emissions (GHG), continually evolve in response to consumer preferences and other market conditions. Total on-road fleet emissions and compliance with vehicle standards will therefore depend on consumers' willingness to purchase and use these advanced light-duty vehicles. This project's objective is to conduct a statewide survey and household interviews about California buyers of new vehicles to understand consumer attitudes, barriers, and motivators toward purchasing zero, near-zero, and low-emission vehicles. The project will produce a statistically robust representation of California's new car buying population to identify the factors that influence new-vehicle purchase decisions and the areas where additional policies, incentives, or outreach could be implemented to facilitate greater adoption rates of cleaner cars.

II. TECHNICAL SUMMARY

Objective

The main objective of this research is to collect information on the decision-making process and influencing factors on new light-duty vehicle buyers in California, with a particular focus on the barriers and motivations for purchase of near-zero and zero-emission vehicles (ZEVs). The results of the research project will inform policy makers about the potential areas where policies, incentives, or outreach might be effective to remove significant barriers or enhance motivations for the adoption of near-or pure-ZEVs.

Background

California must meet stringent climate stabilization and air quality targets. Advanced light-duty vehicle technologies can contribute to achieving these goals and recent amendments to the light-duty vehicle emission program call for lower fleet average rates of criteria pollutants and GHGs as well as an increasing zero (tailpipe) emission vehicle (ZEV) requirement. Manufacturers' compliance with these regulations and total emissions from the on-road light-duty fleet will depend in part on at least some consumers being willing to purchase new vehicles with lower emission profiles than are currently offered, including near- or pure-ZEVs. These ZEV-type vehicles include plug-in hybrid vehicles (e.g. Chevy Volt), range extended battery electric vehicles, full battery electric vehicles (e.g. Nissan Leaf), and hydrogen fuel cell vehicles (e.g. Honda Clarity). The production and sale of ZEVs is of special interest because these vehicles fulfill ZEV requirements while simultaneously lowering a manufacturer's fleet average emissions and can make a significant contribution to emission reductions from the transportation sector.

Proposal Summary

The proposed research will enhance ARB's understanding of purchasers of new light-duty vehicles in California to facilitate greater adoption of ZEV technologies. The primary data collection method will be a statewide on-line survey, with supplemental data collected through household in-person interviews. 1,700 households representative of the new car buying population in California will be surveyed; only households with recent history of a new vehicle purchase will be eligible to participate.

The researchers will develop a written survey to collect information related to the purchase process, factors and considerations influencing their ultimate purchase decision, social and environmental attitudes, consumer awareness and knowledge about ZEVs as well as basic household characteristics. The survey will be developed in a manner to allow for longitudinal analysis; both worded to maximize the number of questions to be included in potential future surveys if funding is available and as consistent as possible with prior, related surveys that would allow for additional historical data points to be included. From the survey respondents, roughly 40 volunteers representing populations of special interest, such as actual purchasers of ZEVs or purchasers of larger vehicle types that are unlikely to be offered as ZEVs in the near-term, will be interviewed in-person to provide additional details on or supplemental information to their survey responses, and richer context for their purchase decisions.

The research results will be presented in three main forms. For the survey, descriptive statistics on the responses will first be compiled, e.g. frequencies, distributions, and other summary statistics. Afterwards, multivariate analyses will be performed to correlate purchase decisions to personal, households, or contextual measures such as attitudes or socioeconomics. Lastly, interview transcripts will be analyzed and summarized to identify themes and compare the different market segments. Additionally, evaluating the combined results will help isolate any prevalent real or perceived barriers and motivators for ZEV purchases.

III. STAFF COMMENTS

Although past research has evaluated general consumer vehicle purchasing behavior or even consumer acceptance of ZEVs, those efforts occurred at a time when actual availability of ZEVs in dealer showrooms was more limited, the technology less mature, and fuel prices lower and less volatile. Today and in the next few years, the landscape will be changing rather rapidly with greater availability of ZEVs and supporting infrastructure. This research project will provide an up-to-date picture of the current state of the new vehicle market specific to California and the consumers within this market, with a particular focus on where policy interventions may facilitate the removal of barriers or enhance motivations for consumer purchases of ZEVs. Additionally, due to the technology-neutral nature of the ZEV requirements, it is important to obtain a

comparable measure of consumer awareness and attitudes for the full array of potential vehicle offerings.

A previous draft of this proposal was discussed by the Research Screening Committee at its May meeting. Committee members commented on the need to improve the connection between this research and the regulatory objectives; additional details related to pilot-testing of the instruments, the research questions addressed by the analytic plan, and the coding scheme for the interviews; and finally, the possibility of increasing the household interviews. The submitted proposal addresses these comments by providing a revised description of the project objectives that strengthens the regulatory justification for this research and additional discussion of the data processing and analysis. Augmenting the household interviews is not possible within the current budget, so the proposal remains at 40, though a cost estimate for doubling the interviews is provided should additional funding become available.

The updated draft proposal was also distributed to staff at ARB, the California Energy Commission, and the United States Environmental Protection Agency. Reviewers were generally positive about the need for the research and the qualifications of the research team. The main comment focused on providing a better explanation for which topics are more appropriate for exploration through the survey and which are better-suited for interviews. Another comment related to the timing of the interviews and whether conducting the interviews before the survey would be more illuminating than as follow-ups to the survey. A third comment requested clarification that hydrogen fuel cell vehicles would be included in the survey, at least as part of the awareness and attitudes sections. Other comments were clarifying or editorial in nature.

Lastly, the South Coast Air Quality Management District expressed interest in co-funding this project to provide additional detail for their air basin. Given that South Coast represents the largest new vehicle market within the state as well as the air quality improvements required in the air basin, these more detailed regional results would provide further insights into multiple policies related to market potential, incentives and infrastructure. Any co-funding would be used to recruit additional respondents in the South Coast region, analyze the regional results, and provide a

comparison between the regional and statewide results. Staff will update the committee at their meeting on any commitments for co-funding.

This research team has been investigating consumer behavior related to alternative fuel vehicles for decades and the principle investigators are recognized experts in the field. They are also involved in complementary research projects, such as household interviews of Nissan Leaf owners in the San Diego region, which will provide them with additional perspective for interpreting the results of the statewide survey and interviews. Additionally, they may be able to leverage existing partnerships with industry and other government agencies to enhance the quality of the final deliverables.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $250,000, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT
ITEM NO.: 11
DATE: October 26, 2012
PROPOSAL NO.: 2754-275

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Identifying Urban Designs and Traffic Management Strategies that Reduce Air Pollution Exposure
PRIME CONTRACTOR:	University of California, Los Angeles, $260,541
SUBCONTRACTOR:	University of California, Riverside, $127,460
PRINCIPAL INVESTIGATOR:	Suzanne E. Paulson, Ph.D.
TOTAL AMOUNT:	$388,001
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

For further information, please contact Elizabeth Scheehle at (916) 324-0621.

I. SUMMARY

While California has made tremendous progress in reducing vehicular emissions, evidence of the dangers of near-roadway pollutant exposure is growing; highlighting the need to ensure that implementation of Senate Bill (SB) 375 is consistent with ARB's criteria and toxic pollution exposure reduction policy goals. The objective of this study is to characterize pollution levels at various transit stop environments in southern California, with a focus on features in the built environment, such as building setback and height. This will be accomplished through pollution measurements, meteorological measurements, and modeling. The results of this project will be a rich data set characterizing transit stop environments and a predictive model for a complex urban landscape. This information may provide transportation and urban planning decision makers with the tools they can use to guide everyday decisions that impact exposures in these environments.

II. TECHNICAL SUMMARY

Objective

The objectives of this proposal are three-fold: 1) to characterize how spatial distribution of air pollutants in transit stop environments varies with local emission sources and the built environment; 2) develop a general model that can predict the dispersion of air pollutants in different transit environments; and 3) evaluate how this model can be used as decision-support tools for planners and policy makers.

Background

A large number of studies have used epidemiology to assess the association of a wide range of adverse health outcomes associated with exposure to pollution from vehicle fleets. Vehicle emissions are rapidly diluted away from roadways; however, existing networks of air quality monitors cannot fully characterize pollutant concentrations near roadways. Several recent studies have shown that because many pollutants are so highly elevated around roadways compared to areas at even moderate distances from roadways, a large fraction of an individual's exposure to many pollutants can be attributed to relatively short time periods spent on and near roadways.

Proposal Summary

The focus of the proposed study are features of transit stop environments that may both play a major role in determining pedestrian air pollution exposure and could be modified through local planning and transportation decisions. These meta-features include: 1) traffic volume, composition, and traffic calming strategies; 2) building heights around the arterial; and 3) building set-backs from the arterial. The result will be a set of tools and guidelines that transportation and urban planning decision makers can use to guide everyday decisions that impact the exposure of pedestrians in transit oriented developments.

The approach will be to combine real time measurements, statistical analysis of real-time data and its relation to the morphology of the built environment and traffic management strategies, and development of a sophisticated model using this data. The model will be based partly on the Operational Street Pollution Model (OSPM), a model widely used in Europe to characterize air pollution dispersion in street canyons.

III. STAFF COMMENTS

This proposal is timely and relevant as it addresses an important gap analyzing the potential for unintentional effects due to implementation of SB 375. However, staff feels that both the measurement and model development plans are ambitious. The core of staff concerns is the application of OSPM to complex urban environments that exist in southern California (compared to the street canyons of Europe). In addition, the results of the proposal appear to rely heavily on modeling results. However, a successful measurement campaign (while as proposed is ambitious) that includes health relevant measurements will, in itself, be able to provide important information on air pollution in transit stop environments and can provide valuable input to model development. The results of this project will be able to provide useful information on best practices for citing and building transit stops to minimize exposure in these microenvironments.

The Principal Investigator, Professor Suzanne Paulson, has more than a decade of research experience in atmospheric science and has recently published a manuscript on characterizing meteorological conditions in the South Coast using CART (classification and regression tree) analysis under current contract, 09-357, "Characterizing Spatially Inhomogenous Non-Criteria Pollutants in the Los Angeles Air Basin." She has extensive experience with mobile sampling and mobile platform data analysis, with several published manuscripts over the last 3 years. Her co-PI, Professor Venktram, at the University of California, Riverside, has extensive experience in model development with several peer-reviewed manuscripts. Professor Paulson has also lead previous ARB funded studies with success.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed $388,001 subject to any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: 1
DATE: October 26, 2012
CONTRACT NO.: 09-357
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Mobile Platform III: Characterizing Spatially Inhomogeneous Non-Criteria Pollutants in the Los Angeles Air Basin
CONTRACTOR:	University of California, Los Angeles
PRINCIPAL INVESTIGATOR:	Suzanne E. Paulson, Ph.D.
TOTAL AMOUNT:	$290,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	18 months

For further information, please contact Elizabeth Scheehle at (916) 324-0621.

I. SUMMARY

Highly localized vehicle emission impacts due to sharp concentration gradients near roadways are a concern for people who live or spend time in these environments. These impacts are magnified by atmospheric conditions present during the early morning hours (pre-sunrise (PSR)). Previous results suggest broad areas of elevated pollutant levels around major roadways may be common during pre-sunrise hours, however, this hypothesis needed to be tested. The objective of this project was to expand these important pre-sunrise results by measuring early morning pollution gradients in a wider variety of geographic locations and to characterize air pollution and exposure in low-income and/or minority neighborhoods that are adversely impacted by sources (e.g. freeways, busy arterial roads). The results showed pre-sunrise impacts occurred throughout various locations in the South Coast Air Basin (SoCAB), with pollution gradients extending greater than 2 km downwind of major freeways. In addition, significant differences in pollution levels were seen between different communities in SoCAB that could be attributed to sources such as freeways and

airports. These results have important exposure implications as 50 percent of SoCAB population lives within 1.5 km of freeways.

II. TECHNICAL SUMMARY

Objective

The objective of this study is to generalize previous pre-sunrise results to several locations in Southern California, and to characterize air pollution and exposure in low-income and/or minority neighborhoods that are adversely impacted by sources (e.g. freeways, busy arterial roads).

Background

Highly localized vehicle emission impacts due to sharp concentration gradients near roadways have been of growing concern in recent years and have important exposure and health implications for those spending time in close proximity to major roadways. In a preceding study[1] by the current investigators, a wide impact area of elevated pollutant concentrations on the downwind (up to ~2000 m) and upwind (up to ~600 m) sides of a freeway was measured during the PSR hours. This impact area was much larger than earlier measurements during daytime, particularly on the downwind side, where pollutant concentrations dropped slowly, remaining at about 40 percent of their freeway edge values 1200 m downwind. The measurements were made during meteorological conditions typical of the PSR period, characterized by weak winds and a radiation inversion. The results suggested broad areas of elevated pollutants around major roadways may be common in the early morning hours; however this hypothesis needed to be tested. There are also concerns regarding the proximity of roadways with high traffic densities to primarily minority and low-income neighborhoods. Although Southern California has met Federal Air Quality Standards for carbon monoxide (CO) and nitrogen oxide (NO_X) on a regional basis, concentrations of these pollutants are more elevated along heavily traveled roadways.

[1]Hu, S., Fruin, S., Kozawa, K., Mara, S., Paulson, S.E., Winer, A.M. 2009. A wide area of air pollution impact downwind of a freeway during pre-sunrise hours. Atmospheric Environment 43, 2541-2549.

Project Summary

Researchers at the University of California, Los Angeles used the mobile platform, developed by ARB, to measure ultrafine particles (UFP), particulate matter (PM) 2.5 mass, black carbon, oxides of nitrogen (NO, NO_2, NO_X), carbon dioxide (CO_2), carbon monoxide (CO), and particle bound poly aromatic hydrocarbons (PAHs) in different locations in the South Coast Basin. These locations include West Los Angeles, downtown Los Angeles/Boyle Heights, and Claremont. Measurements were conducted during PSR hours to characterize and quantitatively describe freeway plumes. Measurements were also taken during the day to investigate differences in pollution levels in these different communities. Some of the major results include:

- The PSR (or nocturnal) extension of freeway plumes far downwind (> 2 km) compared to daytime plume length (<300 m) is a general phenomenon in SoCAB.
- Daytime UFP concentrations were found to be significantly different from each other in SoCAB communities. UFP levels ranged between 3.3×10^4 and 1.1×10^4 particles cm^{-3}. These differences were attributed to the density of heavily traveled roadways in these communities.
- A freeway closure event (so called "Carmageddon") in 2011 resulted in a 20 to 70 percent decrease (depending on location) in traffic flows in West Los Angeles. Reductions of around 70 percent were observed for both UFP and PM2.5 during this event.

III. STAFF COMMENTS

This report contains a comprehensive and quantitative characterization of PSR freeway plumes in various locations throughout SoCAB. The study was also designed to compare pollution across communities over time. These comparisons provide important information on localized pollutant trends over many years and may be used to potentially assess future rule benefits.

There are limitations to any measurement campaign and those should be acknowledged. First, the sample size used to quantify freeway plume dispersion is based on only 5 days of data. Staff recommends adding a short section on future work which could include additional sampling as a scope of future work to validate the current data set. Second, the utilization of classification and regression tree (CART) analysis to

characterize meteorological conditions was an excellent first step to compare pollution across communities over time. However, staff is concerned that the regional meteorological data used in the CART analysis may not necessarily reflect highly localized meteorological conditions which will affect near-road pollutant concentrations. These limitations need to be acknowledged in the report. However, the results provide an important contribution to the existing literature on near-roadway measurements, including the quantification of early morning freeway plumes and development of a predictive model to explain such observations.

Staff is awaiting comments from other client Divisions, particularly for chapters of the report regarding quantification and modeling of the PSR freeway plumes.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: 2
DATE: October 26, 2012
CONTRACT NO.: 09-344
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Measuring the Climate Impact of Residential Buildings: GreenPoint Rated Climate Calculator Version 2
PRIME CONTRACTOR:	University of California, Berkeley, $56,575
SUBCONTRACTOR:	StopWaste.org, $45,000
PRINCIPAL INVESTIGATOR:	Daniel M. Kammen, Ph.D.
TOTAL AMOUNT:	$101,575
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	32 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Residential buildings generate a significant source of greenhouse gas (GHG) emissions. Green buildings are recognized as a strategy to reduce GHG emissions, but further research was needed to better quantify GHG reductions. The objectives of this study were to review, validate, and enhance existing methods used to estimate GHG reductions of green homes, expand the capacity of the GreenPoint Rated (GPR) Climate Calculator, and conduct field testing and stakeholder input to develop Version 2 of the GPR Climate Calculator. Version 2 of the Calculator is more accurate in estimating the GHG emission reduction potential of green homes. Results of the study can help to inform the body of knowledge to better estimate the GHG reduction potential of green homes compared to conventional homes regardless of occupant behavior.

This information may give greater confidence in estimating the GHG reduction potential of green homes to meet the 2020 climate goals of Assembly Bill 32 and longer term 2050 climate goals.

II. TECHNICAL SUMMARY

Objective

The objectives of this research projects were to: 1) review, validate, and enhance existing GHG calculation methods in the Calculator; 2) expand the capacity of the Calculator; and 3) conduct field testing and stakeholder input to develop Version 2 of the Calculator.

Background

An estimated 1.2 million new homes will be added to the California housing stock by 2020[1]. There is a lot of interest for local governments to use the GPR Climate Calculator outputs in the climate action planning and implementation process. More than 70 local governments have adopted green building ordinances. Over 45 cities and counties, including 5 out of the 10 most populated jurisdictions in the state, have mandated the GPR program for all new home construction. More than 30 jurisdictions have also required GPR certification for retrofits to existing homes. Cities and counties will be able to use Version 2 of the climate calculator to quantify GHG reductions for both new construction and existing home retrofits. The University of California, Berkeley (UC Berkeley) was selected as the researchers for this project based on their experience to develop a household carbon footprint calculator under a separate contract with ARB as part of the CoolCalifornia.org effort. The household Climate Calculator estimates a life-cycle carbon footprint based on occupant behavior. UC Berkeley's extensive research experience with lifecycle analysis and GHG emission quantification methods made them uniquely qualified to review, validate, enhance and expand the methods included in the GPR Climate Calculator. StopWaste.org was selected as the subcontractor due to their experience with developing Version 1 of the GPR Climate Calculator. They also provided in-kind funding of $25,000 to the project. StopWaste.org worked closely with Build It Green based on their unique position administering the GPR program and close working relationship with GreenPoint Raters that certify compliance with the program.

[1] California Energy Commission, "Revised California Energy Demand Forecast 2012-2022," February 2012.

Methods

Review, Validate and Enhance Existing Methods

The research team compared the assumptions in each GHG calculation method with recent research studies and approaches used in other tools. The research team validated several of the existing methods and provided suggested changes to revise other methods including updates to the assumptions. For all of the energy and water related measures, they developed a simple regression model to better represent the correlation between occupancy and the number of bedrooms in a typical home. The updated regression model represents a more realistic view of expected occupancy in homes. Additionally, the research team updated the energy related calculation methods to be more consistent with the Title 24 Energy Efficiency Building Standards Code (Part 6) and the Home Energy Rating System (HERS) II rating system to account for time dependent valuation (TDV) and utility specific emission factors. The water measures were updated to account for 10 different hydrological zones in California. The research team developed a new method to quantify construction and demolition (C&D) waste recycling based on a combination of the United States Environmental Protection Agency's Waste Reduction Model (WARM) and ARB emission factors. They presented the research findings and proposals to update various methods during energy, water, and materials at stakeholder meetings.

Expand Capacity of the Climate Calculator

A list of additional measures was developed as a starting point to expand the capacity of the Climate Calculator. The research team prioritized additional measures based on expected GHG reduction potential, feasibility of collecting third-party verified data, technical data available to estimate impacts, likelihood of adoption rates, cost effectiveness, and applicability across the multiple GPR programs. The proposed methods were also presented during the stakeholder meetings.

Conduct Field Testing and Stakeholder Input

As part of the stakeholder input, the research team coordinated three focused meetings on energy, water, materials to solicit feedback from technical experts on suggested changes and additional GHG calculation methods to include in Version 2 of the GPR Climate Calculator. During these meetings, technical experts provided

recommendations for further revisions. The research team finalized the suggestions to enhance the methods and expand the capacity of the GPR Climate Calculator. StopWaste.org updated the GPR Climate Calculator with the recommended changes.

StopWaste.org worked with seven GreenPoint Raters to evaluate the feasibility of gathering data from green homes pursuing certification. Each rater was assigned two projects for a total of 14 projects in the sample. GreenPoint Raters used a combination of site visits and review of existing documentation to complete the proposed calculations for Version 2 of the Calculator. They also provided written comments on the barriers and usefulness of the revised calculation methods.

Results

A total of five methods in the existing Version 1 Calculator were validated with no changes. Eight of the existing methods were updated based on more current data. An additional three methods were added to the GPR Climate Calculator to estimate embodied emissions of material used in home construction. Overall results indicate that Version 2 is more accurate in estimating the GHG emission reduction potential of green homes. Due to the limited sample size of 14 projects, the research team was not able to make a general comparison of the GHG reduction potential of a green home certified by Version 2 compared to the same home certified by Version 1. However, the research team did recognize trends with the GHG reduction estimates for the individual calculation methods. Energy related GHG reduction estimates decreased in cooler climate zones and increased in warmer climate zones. Appliance related GHG reduction estimates increased for smaller homes and decreased for larger homes. Water related GHG reduction estimates decreased in Southern California homes and increased in Northern California homes. Materials related GHG reduction estimates for recycling construction and demolition materials significantly decrease due to the updated assumption that a minimum of 50 percent of these materials are recycled.

Conclusions

Overall, the updated Version 2 of the GPR Climate Calculator provides a more accurate and robust accounting for estimating the GHG reductions of green homes. Some of the updated measures resulted in increased GHG reductions and in other cases, the GHG

reductions decreased. There is a need for further coordination of stakeholder input to continue to update GHG calculation methods using stakeholder technical expertise and best available current research. An expanded research study to develop Version 3 of the GPR Climate Calculator would be useful to refine the GHG reductions of green homes and continue to inform climate policy at the state level. Further study is also needed to inform updates to building codes to resolve discrepancies between the standards and the best practices outlined in current GHG research studies. Results of an expanded study would give greater confidence in the GHG reduction estimates of green homes to meet both the 2020 and 2050 climate goals.

III. STAFF COMMENTS

ARB staff reviewed and commented on the draft of the final report. Staff from the California Energy Commission and several key experts also reviewed the report and provided suggested changes related to the energy, water, and materials portions of the report. Staff provided a number of comments to the investigator, which mainly focused on suggestions to expand the content and more thoroughly describe each section of the report to more closely match the research final report format guidelines.

One of the main conditions to funding this research study was that a public version of the GPR Climate Calculator be made available free of charge to any interested party. The research team updated the excel spreadsheet, and developed a Version 2 of the GPR Climate Calculator. Build It Green is developing a new homeowner education section of its website: www.greenpointrated.com where the updated Version 2 of the GPR Climate Calculator will be housed. While the public version has not yet been finalized, Build It Green's web programmer will program the Calculator interface and UC Berkeley will complete the back-end calculations. Stop Waste.org has secured additional funding to complete an online public version of the GPR Climate Calculator.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: 3
DATE: October 26, 2012
CONTRACT NO.: 08-302
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Measurement of Diesel Solid Nanoparticle Emissions Using a Catalytic Stripper for Comparison to Europe's Particle Measurement Programme Protocol
CONTRACTOR:	University of California, Riverside
PRINCIPAL INVESTIGATORS:	Heejung Jung, Ph.D. Thomas D. Durbin, Ph.D.
TOTAL AMOUNT:	$170,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	42 Months

For further information, you may contact Dr. John Collins at (916) 327-8097.

I. SUMMARY

Europe's Particle Measurement Programme (PMP) protocol prescribes regulatory specifications for sampling particle emissions from both gasoline (direct-injection) and diesel vehicles having very low PM mass emissions. A number of studies have demonstrated that the PMP protocol yields robust and repeatable measurements of solid particles larger than 23 nanometers (nm) in diameter. Volatiles and particles smaller than 23 nm are excluded from the PMP measurement. However, when using the PMP approach to measure solid particles, ARB and other investigators have observed high number concentrations of apparently solid sub-23 nm particles downstream of the PMP sampling system. ARB recently evaluated instruments implementing the PMP protocol and found a significant number of solid sub-23 nm particles in several ARB in-house investigations and in a University of California, Riverside (UC Riverside) study entitled, "Evaluation of the Proposed New European Methodology for Determination of Particle Number Emissions and Its Potential in California for In-use Screening," (contract 05-320).

The current study further investigated sub-23 nm diesel particle penetration and formation in laboratory and vehicle exhaust experiments using a PMP compliant particle measurement system and an alternative catalytic stripper (CS) system. The results provide evidence that the majority of sub-23 nm particles found downstream of the PMP systems are artifact particles formed by chemical reaction and/or re-nucleation of volatile compounds. The artifact particles are mainly present below 10 nm.

II. TECHNICAL SUMMARY

Objective

The goal of this study was to investigate the penetration and formation of solid particles during laboratory and diesel exhaust measurements using both a PMP system and an alternative Catalytic Stripper (CS) system. The specific objectives of this project include:

- Assembly and characterization of an alternative PMP system based on the use of a catalytic stripper for treatment of the aerosol sample;
- Side-by-side comparisons of the CS system and the PMP system to investigate the nature of sub-23nm particles;
- Determination of the physical nature, abundance, and size of particles observed after the PMP volatile particle remover for aerosol samples from three sources: laboratory simulation, vehicle exhaust on a chassis dynamometer, and vehicle exhaust during on-road real-world traffic.

Background

The PMP protocol specifies a measurement method for regulating diesel particle emissions by non-gravimetric means in Europe. The protocol specifies a method to measure solid particles larger than 23 nm, and eliminates any contribution from nucleation mode particles. Solid particles are defined by the PMP protocol as particles that can survive after passing through a volatile particle remover that includes an evaporation tube (ET) that has a wall temperature of 300–400°C. Sub-23 nm particles are excluded by using a condensation particle counter (CPC) with a 50 percent cut point of 23 nm. However, the exclusion of sub-23 nm particles raises some issues because a number of studies have found non-volatile sub-23 nm particles downstream of the PMP system. But measurement of solid particles less than 23 nm is complex because

nucleation can occur downstream of the PMP evaporation tube. Therefore, it is important to investigate whether these sub-23 nm particles observed downstream of the PMP system are truly solid or volatile, and if they are solid, whether they come from the exhaust or are artifacts of the measurement system.

An alternative system commonly used by researchers to remove volatile particles from a sample stream is a catalytic stripper. In contrast to the PMP system using ET, the CS system removes all volatile hydrocarbon components and sulfur components by catalytic reactions at an elevated temperature. Therefore, re-nucleation will not occur downstream of the CS system. Until recently, no studies have been conducted to compare the PMP system with a CS system in terms of volatile particle removal efficiency or artifact formation.

Project Summary

A PMP compliant particle measurement system, the AVL Particle Counter (APC) Advanced, and an alternative system for removing volatile particles, the CS system, were evaluated and compared using laboratory-generated model volatile particles, and using dilute exhaust from a DPF-equipped heavy-duty diesel vehicle operated on a heavy-duty chassis dynamometer and operated in real-world traffic.

The controlled laboratory experiments provided important information needed to understand and evaluate the formation and volatility of the sub-23 nm particles observed downstream of the APC system when sampling vehicle exhaust. The laboratory tests were conducted with pure sulfuric acid aerosols, pure tetracosane aerosols, and then with mixed sulfuric acid / tetracosane aerosols. To investigate the characteristics of the remaining particles observed downstream of the APC system, the CS system was added downstream of the APC system (APC-CS). No particles were seen downstream of the APC-CS when aerosol was composed of pure sulfuric acid or pure tetracosane, which indicates that particles observed downstream of the APC were composed of volatile material. However, when using the aerosol mixture, a number of particles were found downstream of the APC-CS. The particles included non-volatile particles that were formed in the APC system through chemical reaction of volatile species.

Over the steady state cycle tested on the chassis dynamometer, particles downstream of the APC system were almost all between 3 and 10 nm. Number concentrations of the 3 to 10 nm particles downstream of the APC system were significantly higher than the total number concentration in the dilution tunnel, demonstrating that those particles were mostly artifacts formed by chemical reaction and/or re-nucleation of volatile compounds in the APC system.

To evaluate the presence of sub-23 nm particles over transient cycles, the vehicle was operated on the road under real-world driving conditions and on a chassis dynamometer over the Urban Dynamometer Driving Schedule (UDDS) cycle. For both the on-road real-world traffic and the UDDS tests, real-time PM emission results showed the presence of re-nucleated sub-23 nm particles between 3 and 10 nm downstream of the PMP system, consistent with the results from the laboratory and the steady state cruise chassis dynamometer tests.

To summarize, the investigators found sub-23 nm particles downstream of a PMP compliant particle measurement system. The particles included both solid and volatile particles. And it appears that these particles are artifact particles formed in the measurement system by chemical reaction and/or re-nucleation of volatile compounds.

III. STAFF COMMENTS

Staff reviewed this report and provided comments to the investigators. The investigators were responsive to comments, and staff is satisfied with the quality of work performed and the quality of the draft final report. Although Europe has established standards for solid particulate measurement using the PMP protocol, the potential impact of sub-23 nm particles remains a concern. A number of studies have shown that not all sub-23 nm or nucleation mode particles are volatile. Some studies have found solid particles in the nucleation mode from diesel exhaust. This study provided a direct comparison of sub-23 nm particles measured using a European PMP compliant particle measurement instrument, the APC system, and an alternative CS system for removing volatile particles. The comparison was made using laboratory, chassis-dynamometer and on-road real-world traffic tests. The investigators found that nearly all of the diesel

sub-23 nm particles were artifact particles between 3 and 10 nm formed by chemical reaction and/or re-nucleation of volatile compounds. Staff believes that this project has led to much better understanding of the sub-23 nm particles observed in diesel emissions. Results and updates on this study have been presented at several conferences, and the final results are expected to be published in a peer reviewed journal.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: 4
DATE: October 26, 2012
CONTRACT NO.: 09-337
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Are There Any Counteracting Effects that Reduce the Global Warming Benefits Attributed to Black Carbon Controls: Assessment of Cloud Drop Number Concentration Changes and its Importance in Modeling Cloud Albedo Effects on Climate?
CONTRACTOR:	University of California, San Diego
PRINCIPAL INVESTIGATOR:	Lynn Russell, Ph.D.
TOTAL AMOUNT:	$114,751
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	30 months

For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

I. SUMMARY

Black carbon (BC) is a major component of atmospheric particles that is generally emitted by combustion sources such as automobile exhaust and biomass burning. BC is the main light-absorbing component of atmospheric particles and has been tied to regional climate change by its contribution to global warming and the suppression of precipitation. BC particles could also indirectly cause changes in the absorption or reflection of solar radiation through changes in the properties and behavior of clouds. These so-called BC indirect effects are thought to have a net cooling effect on the atmosphere. In contrast to the direct BC effect, the net climate forcing due to these indirect cloud feedbacks is highly uncertain. This report provides an assessment of the relative importance of the indirect effect of BC forcing on California's climate, based on observations, data analyses, and modeling studies. The results suggest that for regions like the California sites studied in this report, where BC mitigation targets primarily fossil fuel sources, the cloud albedo effect of BC particles may partially offset the climate

benefits of direct forcing reduction. The result of this study has immediate value for understanding the pathways by which BC could be of importance in California's climate change, and will help inform ARB's policy making on developing BC emission control strategies.

II. TECHNICAL SUMMARY

Objective

The main objective of this study was to assess the importance of the indirect effect of BC (whereby an increase in BC particles causes an increase in droplet concentration and a decrease in droplet size for fixed liquid water content) on radiative forcing of the Earth's atmosphere. Climate models used in this study are constrained and initialized by field measurements selected to represent atmospheric particles found in different ambient conditions in California.

Background

Atmospheric particles play an important role in the global climate system through modifications of the global radiation budget: directly, by scattering and absorption of radiation; and indirectly, by the modification of cloud properties. For example, atmospheric particles serve as cloud condensation and ice nuclei, thereby modifying the microphysics, the radiative properties, and the lifetime of clouds. The indirect effect of particles is usually split into two effects: the first indirect effect, whereby an increase in particles causes an increase in droplet concentration and a decrease in droplet size for fixed liquid water content, and the second indirect effect, whereby the reduction in cloud droplet size affects the precipitation efficiency, tending to increase the liquid water content, the cloud lifetime, and the cloud thickness.

Recently, the issue of BC has moved to the science and policy mainstream given the global focus on climate change. According to a recent assessment, BC is the second largest contributor to global warming with an estimated radiative forcing of 0.9 W/m^2, next to 1.6 W/m^2 for carbon dioxide. Atmospheric BC also reduces regional rainfall and changes the spatial distribution of precipitation, further impacting regional climate. Reducing BC emissions therefore has been proposed as a control strategy to offset short-term climate changes. While BC has been found to contribute to the warming of

the atmosphere due to direct solar absorption, BC particles also impact the climate in a series of feedbacks through their complex interaction with clouds. BC particles internally mixed with or coated by hygroscopic species (i.e., compounds that absorb water vapor from air) serve as efficient cloud condensation nuclei for both warm and mixed-phase clouds. Perturbations to the BC concentration can therefore change the cloud droplet number concentration and droplet size, which in turn influence both the cloud optical properties and cloud lifetime. These two indirect effects are thought to have a net cooling effect on the atmosphere.

Net climate forcing for BC is actually the sum of direct forcing (direct absorption of solar radiation), snow/ice albedo forcing (forcing that results from the darkening of snow and ice), and indirect forcing (a range of forcing effects resulting from impacts on clouds, including changes in cloud lifetime, reflectivity, and composition). These different kinds of climate forcing involve different mechanisms of action and can have offsetting climate effects. Since the effects can counteract one another, it is important to consider all types of forcing when estimating the net climate impact of BC. However, due to lack of data, most studies of BC have focused on direct radiative forcing only. A more limited number of studies have estimated the indirect climate effects. This research project provides an assessment of the relative importance of indirect BC climate effects at California regional level by developing a balanced approach between observations, data analyses, and modeling studies.

Project Summary

The overall research objective of this work was accomplished by the completion of four major tasks:

- Task 1: Analysis of available measurements and identification of BC chemical case studies constrained by field measurements

In order to characterize aerosol-cloud interactions in California, five field campaigns were identified that represent a variety of ambient conditions with the most complete available chemical and physical measurements of externally mixed particles; the sites are classified as: clean marine (Trinidad Head), polluted urban (Riverside and Sacramento), polluted marine (Long Beach), and biomass burning dominated (La Jolla). Aerosol Time of Flight Mass Spectrometry (ATOFMS) has been used to identify

BC-containing particles from carbon fragments in a variety of locations (sampling sites listed above) in California, providing a rich data set for model comparison. For this study, ATOFMS identification of BC-containing particle number measurements was used to initialize the aerosol-cloud interaction parcel model to evaluate the impact of BC-containing aerosols on clouds in California. Routine monitoring measurements were used to constrain and compare the total elemental carbon (EC) mass concentrations as determined from the field studies and climate models as a check on the total aerosol mass. With respect to EC and BC terminology, estimates of BC and EC are made with a variety of instrumentation and measurement techniques.

In order to determine the ambient aerosol distributions, the investigators have also obtained co-located Scanning Mobility Particle Sizer (SMPS), Optical Particle Counter (OPC), and Aerodynamic Particle Sizer (APS) measurements of the particle number and size distributions from the same five sites. They have obtained density measurements of the chemical particle types identified by the ATOFMS from literature based on laboratory studies. Finally, they have synthesized these three sets of measurements (ATOFMS, APS, and SMPC/OPC) to describe the aerosol particles to initialize their physical (size and mass) and chemical (both internal and external mixing states) properties in the aerosol model for each site.

- Task 2: Scenario and sensitivity model runs and analysis of results

The investigators used a chemically detailed microphysical parcel model (observationally constrained by initial measured aerosol concentrations from five California sites) to provide simulated cloud drop number (CDN) concentrations. Two General Circulation Models (GCMs) with explicit aerosol-cloud interactions were applied to evaluate the indirect effects of BC on CDN concentrations. The parcel model simulates a simple cloud layer that was consistent with typical stratocumulus observations common in California, while incorporating accurate kinetic activation of cloud droplets. The impact of reducing BC is determined by repeating parcel model simulations for 50 percent and 90 percent reduction in BC compared with the base (measured) case, the results of which are also compared with GCM results. The results indicate that the total cloud droplet number agrees with the GCMs within a factor of 10-20 percent, which is acceptable given the variability between the three models.

- Tasks 3 and 4: Evaluation of uncertainty and significance of model results and sensitivity studies

Finally, the investigators completed a number of sensitivity studies to describe a variety of observed ambient conditions by altering the updraft velocity, allowing for adiabatic cooling, changing the air entrainment rate, and conserving the total available water vapor. The particle number size distributions agree well for the three model types, though BC particles in the parcel model are smaller than the GCMs possibly because the locations and seasons of the field campaigns did not represent all of the particle sources included in the GCMs. The results also indicate that in the polluted California environment, BC particles contribute between 14 percent and 18 percent of the total cloud droplets. The parcel model predicted that BC mitigation reduces the droplet population in clouds by 5 to 9 percent for 50 percent BC mitigation, and 11 to 17 percent for 90 percent BC mitigation resulting in the formation of fewer, larger cloud droplets that correspond to a lower cloud albedo. This trend qualitatively agrees with the GCM calculations.

The implications of this comparison are that in addition to total number concentration, the internal mixing state of the BC is also a significant factor in determining the net impact on clouds. For regions like California, where BC mitigation targets primarily fossil fuel sources, the cloud albedo effect of BC particles may partially offset the climate benefits of direct forcing reduction. It was concluded that the reduction in CDN in California due to the decrease in activated BC particles supports the possibility that the cloud albedo effect of BC particles may partially offset the direct forcing reduction. The report recommends that a complete understanding of the climate impacts of BC mitigation in California and the rest of the world (including processes such as the impact on sea ice and land glaciers) requires further work to reduce the uncertainty associated with indirect BC effects.

III. STAFF COMMENTS

An earlier version of the report was reviewed by staff from ARB's Planning and Technical Support and Research Divisions and the current version has incorporated staff comments to improve its clarity. The final report accurately describes the completed work and its implications, and identifies future research needs. The

reviewers' comments generally recognized the quality of the research effort and the practical importance of the results. The investigators also prepared a "Response to Comments" file that addresses comments made by ARB staff. In addition to preparing this draft final report, the investigators published the results of their work in the Journal of Geophysical Research. The University of San Diego's response document and the published paper were sent to the RSC members along with the draft final report.

The report contains new results on the importance of the first indirect effect of BC on radiative forcing in California. Several models were investigated, each by different climate scientists from Stanford University and Carnegie Mellon University, and results from all three modeling studies agree qualitatively – decreases in BC emissions result in decreases in cloud droplet number concentrations. The problem that the authors attempt to address is very complex, and the conclusions which they draw are reasonable. While this study cannot provide a definitive conclusion on the impact of mitigating fossil fuel BC (especially since semi-direct climate feedbacks have not been considered), it is an important first step in resolving the large uncertainties associated with aerosol forcing in the current literature.

A complete understanding of the climate impacts of BC mitigation in California and the rest of the world (including processes such as the impact on sea ice and land glaciers) requires further work to reduce the uncertainty associated with indirect effects. While the scope of this work was limited to determining the impact of BC on cloud droplet number and size, future work is needed to estimate the actual forcing impact through radiative transfer calculations.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: 5
DATE: October 26, 2012
CONTRACT NO.: 09-348
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Inverse Modeling to Verify California's Greenhouse Gas Emission Inventory
CONTRACTOR:	California State University, East-Bay
PRINCIPAL INVESTIGATOR:	Marc L. Fischer, Ph.D.
TOTAL AMOUNT:	$150,000
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	30 months

For further information, please contact Elizabeth Scheehle at (916) 324-0621.

I. SUMMARY

The California Global Warming Solutions Act of 2006 (AB 32) requires ARB to develop a statewide greenhouse gas (GHG) emissions inventory. This study uses ambient methane (CH_4) measurements and inverse modeling to estimate emissions and provide a comparison to the ARB-developed inventory. The inverse model relies on maps of CH_4 source locations and emission estimates to accurately estimate emissions. This study uses two different maps, one based on California-specific data and the other that uses a generalized approach (EDGAR 4.2). Utilizing these different maps, along with ambient measurements, the analyses yields annually averaged CH_4 emissions that are 1.5±0.1 and 2.5±0.3 times larger than the ARB estimated CH_4 emissions based on the California-specific CH_4 and the generalized CH_4 emission maps, respectively. These results suggest that CH_4 emissions could account for approximately 8 percent to 16 percent of the State's total GHG emissions (whereas ARB currently estimates about 6 percent). However, as can be seen from the large range of emission estimates, the modeling approach has large uncertainties derived from the different emission maps. The other part of the uncertainties lie in the inability of the model to accurately resolve the Southern California area and additional tower measurements in the South Coast Air

Basin (SoCAB) are recommended. Additional work is also needed to identify and reduce the remaining model uncertainties.

II. TECHNICAL SUMMARY

Objective

The objective of this project was to use ARB's tower-based ambient measurements along with inverse modeling to estimate emissions and provide a comparison to the ARB-developed CH_4 inventory, which is based on bottom-up (activity based) methods.

Background

Recent studies have revealed significant differences in top-down ambient air measurement based emission estimates and bottom-up inventory type estimates for non-CO_2 GHG. This study was designed to develop a modeling framework to provide more detailed and spatially resolved top-down estimates for comparison to ARB's GHG estimates. The modeling is based on ambient measurements using ARB's newly established GHG research network of towers, which currently focuses on methane since it can be accurately measured and has fewer confounding natural sources. This study provides information that can help pinpoint areas of uncertainty for the GHG inventory.

Project Summary

This project developed an inverse modeling framework and used it to estimate regional CH_4 emissions using ambient CH_4 concentrations measured at a network of towers. Two CH_4 emission maps were used as inputs to the inverse modeling: 1) based on a seasonally varying "California-specific" emissions map, calibrated to state-wide by CH_4 emission totals; and 2) the EDGAR4.2 CH_4 emission map, which is based on generalized approaches and data. The model used ambient measurements from ARB's elevated towers throughout the state and inputs on wind patterns and land coverage of each tower from the Weather Research and Forecast and Stochastic Time-Inverted Lagrangian Transport models. Uncertainties due to wind velocity and boundary layer mixing depth are also evaluated.

The analyses yields annually averaged CH_4 emissions that are 1.5 and 2.5 times larger than the ARB estimated CH_4 emissions based on the California-specific CH_4 and the generalized (EDGAR 4.2) CH_4 emission maps, respectively. These results suggest that CH_4 emissions could account for approximately 8 percent to 16 percent of the State's total anthropogenic GHG emissions (whereas ARB currently estimates about 6 percent) or between 43 and 85 MMT CO_2eq per year. The relatively large range of total emissions reflects the current limitation to uniquely resolve urban versus rural CH_4 emissions, particularly from Southern California and more measurements are necessary in this area to overcome this uncertainty.

The model also provided regional CH_4 emissions estimates by source. The results are best characterized for central California, where most of the towers reside. Additionally, central California meteorology is easier to model. This source level analysis suggests that livestock and landfills are the predominant CH_4 emissions sources though, as with the regional analysis, significant differences are observed between the results obtained with the California-specific and the EDGAR4.2 CH_4 emission maps. The current inability of the modeling to adequately address Southern California and distinguish between urban and rural emissions is likely influencing the source level conclusions.

The differences in both the state and regional level assessments points to the importance of the input emission maps to achieving accurate results. Effort must be spent to ensure accuracy of source strength and distribution.

In summary, the study showed that atmospheric CH_4 measurements can be used to estimate CH_4 emissions at regional scales using the inverse modeling approach, and that California's inventory may be underestimating CH_4 emissions in the state, though considerable uncertainty remains. Additionally, the importance of the input inventory becomes readily apparent, suggesting that investing in gridded state inventories for inverse modeling and doing additional runs as the inventory is improved spatially and methodologically is important.

Recommendations for work to reduce uncertainties include:

- Additional tower measurements and a validated atmospheric transport model for SoCAB. The current tower network is effective in estimating CH_4 emissions from the central valley, likely comprising a majority of the California total, but does not strongly constrain emissions from southern California.
- Additional measurements of source specific tracers (e.g., volatile organic compounds [VOC] speciation) will help apportion emissions to different sources of CH_4.
- Uncertainty in the inverse model estimates of CH_4 emissions are dominated by uncertainty in meteorological modeling of trace gas transport. Additional work is needed to identify the source of these errors and reduce them.

III. STAFF COMMENTS

This project has shown that the inverse modeling framework, in combination with high accuracy GHG measurement data, can be used to evaluate and improve emissions inventories. As a result of this study, inverse modeling of a suite of major GHG is being undertaken in a follow-on contract. The project also led to the addition of at least one more ARB tower in the Los Angeles (LA) area. The LA area modeling will be further improved by ARB's collaboration with Caltech, the Jet Propulsion Laboratory, National Institute of Standards and Technology, Lawrence Berkeley National Laboratory, and UC San Diego to develop an integrated, high density GHG measurement network in LA, aimed at understanding CH_4 and CO_2 emissions in the LA region. Finally, a VOC speciation study is currently underway to further study source attributions at the Walnut Grove tower.

Two minor tasks originally scoped in this project were not conducted. First, due to the lack of high accuracy carbon monoxide (CO) data from the GHG measurement network, inverse modeling of CO to evaluate the precision of the model itself could not be carried out. Secondly, one of the tasks was to train ARB staff on the inverse modeling

framework but due to changes in ARB staffing, no appropriate person was identified so this task was not conducted. The allocated budget for both tasks was applied to conduct more modeling for one additional month each season to minimize uncertainties.

Overall, ARB staff considers the draft final report to be of high quality. Several clarifying comments and edits were sent to the principle investigator. Additionally, ARB staff asked that additional conclusions and recommendations be considered and included in the report in order for ARB to improve the network in a way to improve the modeling results and address emission inventory concerns. Despite the request for detailed recommendations, ARB staff thinks the report is complete and provides the agency with valuable information on regional methane emissions.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.