STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE

RESEARCH SCREENING COMMITTEE

March 18, 2016
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

March 18, 2016
9:00 a.m.

AGENDA

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

December 11, 2015
9:00 a.m.

MINUTES

RSC Members in Attendance via teleconference

Harold Cota
J.R. DeShazo
Tim Wallington
Alan Vette
Rashid Shaikh
Yifang Zhu
Suzanne Paulson
William Eisenstein

The Research Screening Committee (RSC or Committee) convened the meeting at 9:08 a.m. The minutes of the July 8, 2015 meeting were approved.

I. New Research Project

1) "Heavy-Duty On-Road Vehicle Inspection and Maintenance Program," University of California, Riverside, $500,000, Proposal No. 2799-284

   A Committee member stated that the proposal was hard to follow and difficult to piece together, and asked for clarification on the project hypothesis. The Committee member also stated that the proposal could be improved by adding a flowchart to show how the project elements fit together. Staff responded that the project will be focused on the development of a heavy-duty vehicle Inspection and Maintenance (I/M) program, studying methods to identify high emitting vehicles such as on-board diagnostics (OBD), and thus there wasn't a hypothesis to be tested. This Committee member asked if only OBD would be used to identify high emitting vehicle, and staff responded that other methods would also be used, such as remote emissions measurements, and chassis dynamometer-testing emissions measurements. Staff stated that the contractor would be asked to add a flowchart to the project proposal to clarify how the project elements are connected.

Another Committee member commented that the proposal was clear and concise, the project team are experts in their field, the list of proposed possible I/M methods is complete, the proposed methods are technically sound, and the proposal includes a cost-benefit analysis. This Committee member had no problems with the proposal.

A third Committee member recommended the results from the study be eventually published. Staff responded that results will be published at the project conclusion.

And finally, a Committee member asked if ARB staff believed the contractor had made enough of a commitment to completing the project. Staff responded that because of previous and ongoing work with the contractor, staff has confidence that the contractor can successfully complete the project as outlined in the proposal.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

II. Draft Final Reports

1) "Very Low PM Mass Measurements," University of California, Riverside, $100,000, Contract No. 12-320

Staff addressed a question about the source of the mathematical equations contained in the final report stating that all of the equations in the final report are either taken directly from the Code of Federal Regulations (CFR) Part 1066, or the equations were derived from equations or information contained in the CFR.

The Committee asked if isokinetic emissions sampling were conducted, saying it wasn't clear from reading the report. Staff responded that isokinetic sampling was a project goal, but that they would check with the contractor. (Staff did subsequently check with the contractor, and isokinetic sampling was conducted)

The Committee also stated the final report mentions 'vehicle drift' on page 36, but it is not clear what this means. Staff responded that the vehicle emissions were observed to 'drift' over the course of the project, and this observation was discussed in the final report. (Staff did subsequently confirm that vehicle drift is discussed in the final report. The report notes that while emissions did drift over the period of months during which screening emissions testing was conducted, emissions drift did not affect the paired emissions analyses of the confirmatory testing.)

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

The Committee approved the report.

2) “Development of a New Methodology to Characterize Truck Body Types Along California Freeways,” University of California, Irvine, $350,000, Contract No. 11-316

A Committee member asked whether the data collected in this project will be available to the public. Staff stated the data can be accessed via the Truck Activity Monitoring System (TAMS, http://freight.its.uci.edu/tams) web-based user interface.

Another Committee member requested the acronyms be spelled out more frequently throughout the report.

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

The Committee approved the report.

3) “New Car Buyers' Valuation of Zero-Emission Vehicles, “University of California, Davis, $358,806, Contract No. 12-332

Staff stated the study team will complete Appendix E by including frequency counts for responses to all the survey questions. An additional appendix will include the survey questions. Illustrative screen shots of phases one, two and three of the survey’s vehicle design game will be added to this additional appendix and to the methods section of the report.

A Committee member requested the Principal Investigator clarify in the text accompanying Table 1 that the incremental values presented are not adjusted for available federal and state (California) financial incentives. Also, modify the existing table or add a new table to accompany Table 1, to include the incremental price to redesign internal combustion engine vehicles as hybrid electric vehicles, plug-in hybrid electric vehicles, battery electric vehicles and fuel cell electric vehicles for each drivetrain and body-type configuration, after taking into account the combined federal and state financial incentives offered to respondents in the survey’s design game.

The larger point for this member is the mentality of new zero-emissions vehicle (ZEV) buyers shopping for a second car to complement their existing internal combustion car is substantially different than the mentality of those considering buying a ZEV as their primary, or only, car. Buyer concerns over vehicle range may be less of a factor where the ZEV under consideration would serve as a second car. Therefore, it would be great if, given resource constraints, the study team could perform additional analysis comparing the vehicle design choices and self-reported motivations of new car buyers who design their next vehicle as their household’s primary vehicle to those who do not.

Another Committee member thought the study and the survey were very well designed with a lot of careful empirical analysis, stating that the authors did a

good job of focusing on the implications of study findings for policy-relevant questions. The member would like to see information added to help readers understand how representative the results are, such as additional information in order to better define how well study findings represent the preferences and views of California's new car buyers. The member would like to see the following additional pieces of information:

1. What is the pool of prospective respondents to whom emails were sent to initially recruit them into the study?
2. What was the email response rate to that initial mailing?
3. Of those who responded, how many were recruited to take the survey?
4. What were the bounce and completion rates for those who started the survey?
5. Based on this additional information, what was the total response rate – from the original population emailed – to the survey?
6. Were the authors able to use any population sample rates to correct for any selection biases in the sample?
    a. If not, can you use data from other sources (such as the Caltrans California Household Travel Survey or the California New Car Dealer Association's California Auto Outlook) to determine whether the profile of the survey's new car buyers is similar to new car buyers in California?

The member would like the PI to describe the incentive offered to respondents to encourage survey participation, and add some discussion to put survey findings into the context of the existing literature. Such as are survey findings – particularly concerning government incentives and high-occupancy vehicle lane access – consistent with or divergent from what we currently know about the effects of some of these policies?

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

The Committee approved the report.

4) "Analyzing the Economic Benefits and Costs of Smart Growth Strategies," University of California, Berkeley, $330,000, Contract No. 11-326

A Committee member commented that the report was truly excellent, really informative and well-written, and the methodologies were both well-considered and very clearly presented.

The member asked researchers to address, in the discussion, certain issues with policy relevance flowing from the conclusions of this study, requesting researchers to:

1. Include in section 2.4.5.5, "Municipal Fiscal Impacts," and as appropriate in section 4.3 "Lessons for planners and policymakers," a more robust discussion of sales tax revenue.

2. In section 2.4.5.5, include a discussion of the implications of Proposition 13 for calculation of plan impacts on property tax revenues. Proposition 13's effects were not explicitly included in the report's property tax calculations. While it is difficult to know how to include them, it is worth making the point that if they were included, estimated plan benefits would be even larger than those reported.

3. Clarify, in section 3.6.5 on page 92 (and elsewhere) earlier in the report, the economic impacts ("benefit streams") reported for the different perspectives (regional, municipal, and household) are not additive.

Many of the specific plans studied were originated in the 1990s with Tax Increment Financing under redevelopment powers that no longer exist.

4. Include a discussion, in Section 4 ("Discussion") and/or Section 5 "Summary and Conclusions," of the role of tax increment financing in implementing the plans analyzed in the report, and of its implications for future smart growth policy in California.

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

The Committee approved the report.

5) "Reducing In-Home Exposure to Air Pollution," Lawrence Berkeley National Laboratory, $1,300,863, Contract No. 11-311

The Committee stated this extensive and ambitious project was well done by the researchers and the report was also well written overall. The Committee noted that the executive summary needed to be improved by adding key tables and figures. Also, the Committee mentioned that further discussion about the spatial variations of pollutant concentrations inside the home and the ozone production by the electrostatic precipitator (ESP) would be useful. In addition, the Committee suggested the researchers clarify or correct several figures. Comments from two external advisors in the California Department of Public Health and the California Energy Commission were also reported to RSC members. The advisors suggested further discussion about the differences in the performance between the filters installed on the supply ventilation and recirculating air systems. The advisors also requested clarification of some figures and additional details regarding the volatile organic compounds (VOCs) removal systems and the energy simulation software.

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

The Committee approved the report.

6) “Atmospheric Measurement and Inverse Modeling to Improve Greenhouse Gas Emission Estimates,” Lawrence Berkeley National Laboratory, $680,000, Contract No. 11-306

Two Committee members made comments on the need to improve the clarity of the draft final report, specifically the abstract and executive summary. Comments focused on the use of jargon throughout the report; a Committee member was especially critical about their use in the abstract and executive summary. Jargon terms used in technical inverse modelling manuscripts, such as “prior” and “posterior”, need to be explained in the report and especially in the abstract and executive summary. Staff will ask the Principal Investigator (PI) to explain any jargon used in the report and improve the overall clarity of the text for the benefit of a non-technical audience. A Committee member said the adjustment of the greenhouse gas emission estimates based on the CO emissions and transport needed to be better explained in the text. The PI was asked to explain the downward trend of $\Delta^{14}CO_2$ in Figure 7 top panel.

A Committee member commended the report as a very comprehensive study with a large amount of data and thorough analysis. The PI needs to clarify which tower was used for the CO emissions part of this study. Several typos were found throughout the text such as “gird” for grid, and wrong symbols for $\Delta^{14}CO_2$/ $\Delta^{13}CO_2$. Another clarification recommended was to explain the use of “mixing ratio” versus concentration. “Mixing ratio” should be used consistently throughout the text (mixing ratio in units of ppmv or ppm), figures (Figs. 4 and 5 for example), and tables. The PI should include all symbols in the glossary of terms and acronyms (p.122-123), including all symbols used in the equations. This glossary should be moved to the beginning of the report.

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

The Committee approved the report.

7) “Source Speciation of Central Valley GHG Emissions Using In-Situ Measurements of Volatile Organic Compounds,” University of California, Berkeley, $360,000, Contract no. 11-315

The Committee, while commending the approach and the work, thought that the report lacked clarity, particularly in the Executive Summary, Findings, and Recommendations sections and needs to follow ARB’s report format guidelines. Additional tables summarizing the results would make the conclusions more understandable. Chapter 4 needs better integration of figures and explanatory text, modifications to several very dense figures to allow the reader to understand their importance, and additional explanations on several key points such as choice of measurement height and the handling of measurement uncertainty in positive Matrix Factorization. The glossary needs to include all abbreviations (e.g. those in Table 5.5.). The Abstract and Summary need to be shortened. References should be at the end of the report, not after each section. The

Committee recommended that the report be revised and submitted to the next RSC meeting for approval.

Motion: Revise the report and bring it back to the next meeting.

The Committee tabled the report.

8) "Evaluating Mitigation Options of Nitrous Oxide Emissions in California Cropping Systems," University of California, Davis, $400,000, Contract No. 11-313

Two Committee members complimented the draft final report stating it provided a great deal of data. They suggested a few editorial changes, including adding summary tables or figures in the "Executive Summary" and "Summary and Conclusions" sections. Committee members requested adding a summary table of emission factors in the "Executive Summary" and "Summary and Conclusions" sections.

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

The Committee approved the report.

9) "Modeling the Formation and Evolution of Secondary Organic Aerosol during CalNex 2010," University of Colorado, $350,000, Contract No. 11-305

The Committee recommended a few minor editorial changes:

1. The Glossary of Terms, Abbreviations, and Symbols should be moved from page 93 to the front of the report (e.g. after the List of Tables).

2. List of Figures page vi-xi: The page numbers of the Figures should be included and the Figure Titles should be shortened (the whole caption for the figure should not be included).

3. Page 24 last paragraph, Line 6: "The equation uses ambient H_2O concentration, reactor output O_3 concentrations, flow rate, and ambient OH reactivity from collocated measurements (data from the Stevens Group, Indiana University)." Further information should be provided about this equation: either an explicit equation or additional material in an appendix that describes how OH_{exp} was estimated.

4. Page 61, line 4: "The fit in Eqn. 1…" The equation number should be changed to Eqn. 4.

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

The Committee approved the report.

10) “Probing the Intrinsic Ability of Particles to Generate Reactive Oxygen Species and the Effect of Physiologically Relevant Solutes,” $301,039, University of California, Los Angeles, Contract No. 10-314

A Committee member praised the work for being very data-rich. Also, the member stated that the final report is so detailed, with a mix of data and conclusions, that it is difficult to evaluate the findings. The information is sometimes unclear, and needs to be put into context. Another Committee member agreed that the format could be improved, noting the separate parts of the final report that were submitted. Therefore, the final report should:

1. Combine Part I and Part II;
2. Include a shorter integrated executive summary;
3. Discuss recent publications in this area;
4. Provide the basis for the composition of the simulated lung fluid used; and
5. Expand the list of abbreviations to include all abbreviations used.

Finally, a conclusion section is needed that integrates the field and lab studies, and places the data into a broader perspective. Staff agreed to work with the Principal Investigator to modify the final report accordingly.

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

The Committee approved the report. Suzanne Paulson recused herself from the discussion of this item.

The meeting adjourned at 10:59 a.m.

DISCUSSION OF A DRAFT FINAL REPORT
ITEM NO.: II.1
DATE: March 18, 2016
CONTRACT NO.: 11-308
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Emissions of Potent Greenhouse Gases from Appliance and Building Waste in Landfills
CONTRACTOR:	California Polytechnic State University, San Luis Obispo
PRINCIPAL INVESTIGATORS:	Nazli Yesiller, Ph.D. James L. Hanson, Ph.D. Jean E. Bogner, Ph.D.
CONTRACT TYPE:	Standard Agreement
TOTAL AMOUNT:	$299,826
CONTRACT TERM:	36 Months

For further information, please contact Pamela Gupta at (916) 327-0604.

I. SUMMARY

Fluorinated gases (F-gases) are high-global warming potential (high-GWP) greenhouse gases (GHG) contained in waste insulating foam, a potentially significant source of GHG emissions. Previous research estimated that up to half of the annual foam GHG emissions (5 – 7 million metric tons of carbon dioxide equivalents [$MMTCO_{2e}$]) in California occurred after the insulating foam was landfilled (half of foam GHGs are emitted from off-gassing and shredding losses prior to landfilling). The objective of the research was to measure GHG emissions from waste insulating foam in a representative California landfill, which had not been conducted prior to this research project. The Potrero Hills Landfill in Suisun City was selected as a representative California landfill. Gas samples were collected from various sites of the landfill surface that represented different cover types and ages of waste. Samples were also collected from the landfill gas extraction system before and after flare combustion. F-gas concentrations from the landfill surface varied significantly, depending upon the cover type and conditions. The F-gas emissions form the Potrero Hills Landfill were estimated

to be a maximum of 2,600 metric tons of CO_2 equivalents ($MTCO_{2e}$)/day during the wet season, decreasing to 4 $MTCO_{2e}$/day during the dry season. F-gas emissions represented 3.4 to 4.1 percent of all GHG emissions from the landfill, with methane and carbon dioxide contributing the remainder. Research findings indicate that F-gas emissions from landfills are significantly lower than previously estimated. The most significant research finding was that the landfill gas flare destruction efficiency was greater than 99.5 percent for all measured F-gases.

II. TECHNICAL SUMMARY

Objective

The primary objective of this project was to determine the magnitude and types of greenhouse gas emissions from landfilled insulating foam from disposed appliances and demolished buildings. In order to accomplish the primary objective, the following supporting objectives were to: 1) develop a waste flow analysis of each stage of foam waste (from recycling to landfilling); 2) determine GHG emissions from each stage of foam waste prior to landfilling; 3) determine maximum potential GHG emissions from landfilled foam; 4) determine actual emissions of foam GHGs from landfills measuring surface flux emissions, and landfill gas collection and combustion system emissions; 5) determine destruction efficiency of foam GHGs captured by landfill gas collection systems; 6) determine reductions of waste foam GHGs within landfill, through biological attenuation or capture/combustion; and 7) scale emissions and reductions results statewide.

A secondary objective was for ARB to apply the research findings to validate the assumptions on GHG emissions from waste insulating foam that are used in the Cap and Trade Compliance Offset Protocol for Ozone-Depleting Substance (ODS) Destruction. The ODS Protocol heavily discounts reduction benefits from destroying the GHGs recovered from waste insulating foam. Unlike some previous research, the Destruction Protocol's working assumption is that after waste foam is landfilled, only negligible emissions of the GHGs within the foam are released to the atmosphere; with the vast majority of G-gases degraded within the landfill, presumably from bio-attenuation by microbial or landfill gas recovery management.

Background

Waste insulating foam from refrigerator-freezers and building insulation that has been landfilled is assumed to be a potentially significant source of GHGs because the insulation contains foam expansion agents of fluorinated gases (F-gases), consisting of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs), which have high-GWPs ranging from 700 to 4750. An ARB-funded study completed in 2010 on insulating foam GHG emissions in California confirmed the significant potential of GHG emissions from landfilled foam, up to half of the total foam GHG emissions estimated at 5 – 7 million metric tons of carbon dioxide equivalents ($MMTCO_{2e}$) annually (ARB contract 07-312 with Caleb Management Services). However, actual emission measurements from landfills were not part of the scope of work in the Caleb research, which broadly assumed that all GHGs within landfilled foam were eventually emitted into the atmosphere. The Cal Poly San Luis Obispo research was intended as a follow-up study to determine GHG emissions from F-gases in landfills.

Project Summary

The Potrero Hills Landfill in Suisun City (Solano County) was selected as a representative municipal solid waste landfill that also accepts construction waste and recycled metal shredder waste (commonly called auto fluff), both expected to contain large amounts of waste insulating foam. Static flux chambers for collecting F-gas emissions samples were placed at seven separate locations of the landfill surface representing the varying cover types and waste ages, including daily cover, extended daily cover, interim cover, and final cover. Sampling using four static flux chambers occurred at each of the seven collection sites, and each site was sampled eight times between February and August 2014, with testing conducted in both wet and dry seasons to capture the main climatic conditions in California. Twenty gas samples were obtained at each test location in a given season. Overall, a total of 280 gas samples were obtained. All sample locations were in areas of the landfill that contained previously installed gas extraction systems designed to collect landfill gas (primarily methane) and transport the gas to a high-temperature flare, where the gas is combusted. The flare operates as a temperature of approximately 930 °C (1,705 °F).

Six gas samples were collected from the landfill gas extraction system before combustion, and three samples were collected after flare combustion.

The gas samples obtained in the field tests were analyzed at Rowland-Blake Laboratory at the University of California, Irvine. Original research plans called for the analysis of only the four main F-gases used as foam expansion agents. However, the laboratory was able to analyze, at no added cost, the most common 12 F-gases used as refrigerants, solvents, propellants, and foam expansion agents. Therefore, the research constitutes an expanded and more comprehensive study of F-gas emissions from a municipal solid waste landfill. The F-gases tested were: CFC-11, CFC-12, CFC-113, CFC-114, HCFC-21, HCFC-22, HCFC-141b, HCFC-142b, HCFC-151a, HFC-134a, HFC-152a, and HFC-245fa.

Measured concentrations of sampled F-gases varied greatly by up to seven orders of magnitude. F-gas emissions were greater from the most recent landfill cover, and decreased with the age of the landfill cover. F-gas emissions were greater during the wet season than the dry season. Overall, F-gas emissions flux decreased with decreasing hydraulic conductivity and increasing cover thickness. The F-gas emissions from the Potrero Hills Landfill were estimated to be a maximum of 2,600 metric tons of CO_2 equivalents ($MTCO_{2e}$)/day during the wet season, decreasing to 4 $MTCO_{2e}$/day during the dry season. F-gas emissions represented 3.4 to 4.1 percent of all GHG emissions from the landfill, with methane and carbon dioxide contributing the remainder.

The most significant research finding was that the landfill gas flare destruction efficiency was greater than 99.5 percent for all measured F-gases. Given that a standard landfill gas collection system is assumed to have a minimum 75 percent capture rate of landfill gas (U.S. EPA, AP-42 emission factors), we can conclude that the vast majority of F-gases in landfilled insulating foam are thermally destroyed rather than emitted from landfills.

III. STAFF COMMENTS

Various ARB staffers in the Research, and Transportation and Toxics Divisions were asked to review the draft report. Additionally, members of the project's technical

advisory committee were asked to review the draft report. The technical advisory committee is comprised of 22 landfill, waste management, or emissions experts from government (U.S. EPA, California Department of Toxic Substances [DTSC], and CalRecycle), industry (waste management companies, landfill operators, and recyclers), academia, and consulting.

Initial comments noted that while the sampling and analysis were thorough, the results and conclusions section of the report should be expanded and clarified. Subsequently, the results and conclusions were revised by the Principal Investigators. The literature review of previous research on F-gas emissions from waste insulating foam is very comprehensive and should be used as the benchmark on the subject.

Due to the data limitations of sampling just one landfill, the investigators were careful not to extrapolate the findings from the landfill into state-wide estimates. However, placing the estimated emissions into a statewide perspective can be a helpful policy tool. Given that F-gases in the sample landfill represented just 3.4 to 4.1 percent of all the landfill GHG emissions, ARB staff estimated that if the research findings were extrapolated to all landfills in the state, the weighted range of statewide foam GHG emissions from landfills would be between 0.3 $MMTCO_{2e}$ to 0.4 $MMTCO_{2e}$ annually, significantly less than the previously calculated theoretical emissions of half of all foam GHG emissions annually 5 – 7 $MMTCO_2E$ in California.

Research findings also validate foam GHG emissions assumptions used in the Cap and Trade Compliance Offset Protocol for ODS Destruction. After foam has been landfilled, we expect a few F-gas emissions. Perhaps more important from a policy point of view, we can confidently predict that total GHG emissions from the foam sector are expected to decrease by 90 percent or more in the next several decades, due to the following two factors:

1) The standard foam expansion agent CFC-11, with a 100-year GWP of 4750, was prohibited beginning January 1995, and replaced with HCFCs and HFCs with GWPs between 700 and 1430.

2) Beginning January 1, 2020, U.S. EPA regulations will prohibit the use of high-GWP F-gas foam expansion agents in the new manufacture of insulating foam. Although GWP limits are not specifically cited in the regulations, all foam expansion agents with a 100-year GWP greater than 150 have been prohibited in future production.

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.: II.2
DATE: March 18, 2016
CONTRACT NO.: 11-325
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage
CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR:	Frank Mitloehner, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$400,000
CONTRACT TERM:	36 months

For further information, please contact Dongmin Luo at (916) 322-4357.

I. SUMMARY

Dairy silage (dairy feed fermented for presentation) has been identified as a significant source of volatile organic compounds (VOCs) and nitrogen oxides (NO_X), both of which are ozone precursors, and thus may contribute to the extreme ozone nonattainment of the San Joaquin Valley (SJV) where 80 percent of California's 1700 dairy farms are located. This project monitored VOC and NO_X emissions throughout different phases of silage management at dairies, evaluated the mitigation potential of several silage management practices on VOCs recommended by the San Joaquin Valley Air Pollution Control District (SJVAPCD), and developed and validated a new VOC model simulating silage emissions from California dairies. The study indicated that storage of silage in Ag-Bag (a plastic bag manufactured exclusively for silage storage) rather than in conventional piles, removing silage from storage pile (defacing) by lateral- rather than perpendicular- cutting or using raking, and adding water to the feed material (also known as total mixed ration or TMR) resulted in lower emissions of VOCs. Storage of silage in Ag-Bag, however, did not lower NO_X emissions compared to conventional piles. Adding microbial and chemical additives to silage even enhanced VOC emissions, except for potassium sorbate fortified at 0.1 percent (wet silage). A new

VOC emission model was developed in this project and incorporated into a whole-farm modeling approach, which was used in evaluating the effect of different mitigation practices on VOC emissions. The simulation results indicated that most of the VOC emissions from silage would occur during feeding rather than the storage phase, and thus mitigation efforts should focus on feed lanes, not the exposed face of silage piles, at dairies. The significance of this conclusion, however, would benefit from further field verification.

II. TECHNICAL SUMMARY

Objective

The purpose of this project was to identify and quantify mitigation options that reduce silage emissions from California dairies. Specific objectives were to measure and compare VOC and other gaseous emissions from all phases of different silage management practices; and to improve and perform modeling of whole farm emissions from California dairies. Key variables characterizing the physical conditions of silage, such as bulk density and moisture content, were also measured to evaluate their effects on emissions and provide validation data for modeling.

Background

Extreme nonattainment of the ozone standard is a major concern for air quality in the SJV. Attention has been drawn to emissions of ozone precursors from dairy operations in the area. Experimental evidence suggests that silage (fermented animal feed) on dairies is a significant source of both VOC and NO_X emissions, which may lead to the formation of ozone. In addition to the ozone contribution, silage emissions also represent an economical loss of feed value. To reduce VOC emissions from silage, SJVAPCD adopted Rule 4570 in 2006, which is comprised of various mitigation measures related to silage production and management, including the use of silage additives (i.e., preservatives), compaction of silage pile, limiting silage open pile face and pile size, etc. Research, however, was lacking on the effectiveness of these prescribed control strategies.

This project monitored VOC and NO_X emissions from all phases of silage management at dairy farms, performed controlled experiments and modeling to evaluate silage emissions as well as emissions from whole dairy farms under different management

scenarios, and quantified the mitigation potential of the control measures outlined in Rule 4570. In addition, ammonia (NH_3) and nitrous oxide (N_2O) were measured to provide a more complete assessment of silage emissions.

Proposal Summary

This project included four major tasks: 1) to evaluate effects of five microbial and chemical additives on VOC emissions from silage; 2) to compare emissions of VOCs and NO_X from different silage storage types (conventional piles vs. Ag-Bag) and silage defacing methods (lateral- or perpendicular-cutting or raking; 3) to quantify emissions of VOCs and NO_X from TMR receiving different water additions; and 4) to develop and perform modeling of VOC emissions from silage management as well as from whole dairy farms. In addition, NH_3, a particulate matter (PM) precursor, and N_2O, a potent greenhouse gas, were also monitored in task 2 to provide a more complete assessment of silage emissions.

Evaluation of silage additives was carried out in 19-L buckets as incubators over 170 days and emissions of five most important VOCs (methanol, ethanol, 1-propanol, methyl acetate, and ethyl acetate) were measured using headspace gas chromatography. Out of the five additives tested, only potassium sorbate applied at the rate of 0.1 percent (wet silage) inhibited VOC emissions. It reduced the total ozone-forming potential (TOFP) by 55 percent compared to the control with no additives. All microbial additives and the lower dose of potassium sorbate (0.009 percent wet silage) increased TOFP by 115-205 percent.

The silage emissions of VOCs, NO_X, N_2O, and NH_3 from different defacing techniques, storage types, and TMR treatments were measured at dairy farms using flux chambers and wind tunnels connected to gas analyzers in a mobile lab equipped with automatic sampling and data acquisition system. Lateral defacing resulted in the lowest emissions of VOCs (TOFP 15 O_3 g/day/m^2), NO_X (1.6 mg/day/m^2), and N_2O (0.04 mg/day/m^2) compared to perpendicular defacing (TOFP 25 O_3 g/day/m^2, NO_x 3.8 mg/day/m^2, and N_2O 1.2 mg/day/m^2) and raking (TOFP 25 O_3 g/day/m^2, NO_x 2.0 mg/day/m^2, and N_2O 2.1 mg/day/m^2), except for NH_3 (0.8 mg/day/m^2) which was higher than raking (0.2 mg/day/m^2), but lower than perpendicular defacing (1.1 mg/day/m^2). Storage of

silage in Ag-Bag reduced the VOC emissions by almost 90 percent, but increased NO_X, N_2O, and NH_3, compared to a conventional pile which had a lower density and a larger exposure area.

Effects of adding water to TMR varied also, depending on the gas. Adding water at 5 percent and 10 percent reduced VOCs and NO_x by 34-38 percent and 11-28 percent, respectively, but increased NH_3 by 15 percent during a 24-hour period. Overall, from the perspective of ozone control, reduction of VOCs and NO_X emissions in the feed lanes, which represent the greatest exposure of silage surface area, is possible by inclusion of water in the TMR.

A new VOC emission model was developed and incorporated into an existing whole farm model by solving the mass transfer equation of convention-dispersion-diffusion numerically. The new model predicted ethanol emissions relatively well, but under-predicted methanol emissions. Simulation of VOC emissions from a representative dairy farm in California using the new whole farm model indicated that more than 88 percent of VOC emissions (as TOFP) from silage would occur during feeding rather than the storage phase. Therefore, mitigation efforts should target feed lanes, rather than the exposed face of silage piles, which is the focus of the current Rule 4570.

III. STAFF COMMENTS

The project was delayed due to a health-related incident in the early stage of the study. The draft final report submitted to the RSC was reviewed by ARB staff, and shared with the California Department of Food and Agriculture, California Energy Commission, and California Department of Resources Recycling and Recovery. The report is currently under review by a large group of stakeholders including SJVAPCD and industry groups. The Principle Investigator calculated and added the total ozone forming potentials for VOC emissions throughout the report, elaborated the model description, and added Figures 22 to 26 comparing results of measured and predicted VOCs by the old and new models, in response to staff comments. The project drew several important conclusions, most importantly, that the bulk of silage emissions on dairy farms would occur in the feed lanes, rather than from silage storage piles, which are the focus of the

current Rule 4570. The significance of this conclusion, however, would benefit from further field verification.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve 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.: II.3
DATE: March 18, 2016
CONTRACT NO.: 11-312
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Effects of Complete Streets on Travel Behavior and Exposure to Vehicular Emissions
CONTRACTOR:	University of California, Los Angeles
PRINCIPAL INVESTIGATOR:	Yifang Zhu, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$250,000
CONTRACT TERM:	36 months

For further information, please contact Dr. Barbara Weller at (916) 324-4816.

I. SUMMARY

With the growing interest in smart growth, climate change mitigation, and social equity, an increasing number of communities have adopted complete street policies to make streets accessible for all users-drivers, transit users, pedestrians, bicyclists, seniors, children, and people with disabilities. Complete streets are planned to reduce vehicle miles traveled (VMT) and associated emissions by enhancing active travel and decreasing dependence on passenger vehicles. However, there is limited data on the actual impacts of complete street on changes in travel behavior and on street users' exposure to air pollutants. This project aimed to provide information in these areas by employing two study designs comparing complete streets to incomplete streets. A neighborhood survey and road side intercept surveys were also conducted to assess travel behavior change and street users' perceptions. Air pollutant exposure data were collected for both study designs. Overall, the study found that complete streets had likely exerted favorable impacts on some, but not all, of the tested parameters. The ultrafine (UFP) and fine particle (PM2.5) concentrations on the complete streets were 1300 particles/cm^3 and 0.3 µg/m^3 lower than those on the incomplete streets, respectively. Motorized vehicle flow was reduced by 16 percent after the conversion to a

complete street. There were limited changes in travel behavior in residents living within a walkable distance to a complete street conversion; however, street users believed that the complete streets provided more shade, were more interesting, easier to cross, and made the pedestrians feel safer. The location and function of the complete street had the greatest impact on the traffic flow, street usage, and on-road air quality on the street. Overall, the data suggest that complete streets located in densely populated downtown business settings may have more positive impacts than those in other land use contexts. This study provided ARB with an initial analysis on the impact of complete streets on travel behavior and street users' exposure.

II. TECHNICAL SUMMARY

Objective

This project aims to answer how complete streets impact travel behavior and street users' exposure to vehicular emissions. Individual travel behaviors (e.g. the frequency and mode choice of travelers) and exposure to PM2.5 and UFP among drivers, cyclists, and pedestrians were studied before and after two complete street retrofit projects (i.e., Ocean Park Boulevard and Michigan Avenue in Santa Monica, California). Road-side intercept survey data and air pollutant exposure data were also collected on twin-streets, each comprised of a complete street and a parallel incomplete street.

Background

Complete streets are designed to decrease VMT and support multiple forms of transportation, not just motor vehicles through behavioral change. However, there is little evidence on how complete streets result in travel behavior changes or how these changes may be impacted by the location and usage of the land around the complete streets. This study aimed to address these research areas and help to fill the knowledge gap on the impact of complete street designs on travel behavioral response and on personal exposure to traffic-related air pollutants.

Project Summary

This project examined how complete streets impact travel behavior and street user's exposure using two study designs, a before-after study and a difference-in-difference (DID) study. Fine and ultrafine exposure data were collected for both study designs. For the before-after study, individual travel behavior (e.g. the frequency and mode choice of

travelers) data were collected by a neighborhood survey before and after two complete street retrofit projects (Ocean Park Boulevard and Michigan Avenue in Santa Monica, California). A DID study was conducted in which six pairs of streets, one complete and a parallel incomplete street were selected to represent the diversity in road type (i.e., arterial vs. local streets) and land uses (e.g., downtown business districts, urban mixed-use areas, and suburban residential areas). Measurements from October 2013 to March 2015 were conducted for 4 days on these six pairs of twin-streets. Traffic, pedestrian, and cyclist flow were measured and road-side intercept surveys were conducted to assess street users' perception on the streets.

Overall, this study found that the complete streets had likely exerted favorable impacts on some, but not all, of the tested parameters. The before-after study on Ocean Park Boulevard found that the UFP concentrations decreased significantly after the complete street retrofit; but PM2.5 did not decease and no significant change was seen in motorized vehicle flow. However, it was observed that the motorized vehicle flow was reduced by 16 percent and the on-road UFP and PM2.5 dropped when comparing the weekends before- and after-retrofit at the Michigan Avenue project. The DID study showed that, on average, the UFP and PM2.5 concentrations on the complete streets were 1300 particles/cm^3 and 0.3 µg/ m^3 lower than those on the incomplete streets, respectively. Intercept survey results also revealed that the street users believed that the complete streets provided increased ease of use and safety, although the before-after travel behavior results found limited travel behavior changes of residents living nearby. Overall, the data suggested that complete streets located at densely populated downtown business settings may have more positive impacts than those in other land use contexts. This investigation provided ARB with an initial analysis on the impact of complete streets on travel behavior and street users' exposure to air pollution, and the extent to which such impacts may differ across different land use/road types.

III. STAFF COMMENTS

A number of staff in the Research Division and two outside reviewers from Caltrans and South Coast Air Quality District reviewed and commented on the first draft of the final report. Overall comments suggested adding more description and discussion of the results of the study in the context of existing relevant literature. The final version of the draft report was modified based on staff comments.

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.: II.4
DATE: March 18, 2016
CONTRACT NO.: 11-315
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Source Speciation of Central Valley Greenhouse Gas Emissions using In-Situ Measurements of Volatile Organic Compounds
CONTRACTOR:	University of California, Berkeley
PRINCIPAL INVESTIGATORS:	Allen Goldstein, Ph.D. Marc Fischer, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	$360,000
CONTRACT TERM:	48 months

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

I. SUMMARY

To guide development of greenhouse gases (GHGs) reduction strategies, California has developed state-wide GHGs emission inventories (EI). ARB has supported research to improve our GHGs EI, developing regional and source specific information for some GHGs. For example, ARB has supported methane and nitrous oxide (N_2O) research programs, including measurements at towers and inverse modeling. In this project, proton transfer mass spectrometry (PTR-MS) was used to continuously measure a suite of volatile organic compounds (VOCs) at 5 elevations on a tall tower in Walnut Grove from summer 2012 through early fall 2013. The VOC data and continuous carbon dioxide (CO_2), methane (CH_4), and carbon monoxide (CO) measurements were analyzed to develop source apportionments for CH_4 and N_2O. Their results confirm that dairies and livestock are the largest regional sources contributing to CH_4 emissions, accounting for 55 – 90 percent of total emissions over different seasons. N_2O agriculture emissions accounted for about 80 – 90 percent of the observed enhancements during fertilizer use in the spring and summer but declined to about 20 percent of the observed enhancements in late fall season when crops are harvested. In

contrast, N_2O emissions from the dairy and livestock source were relatively constant across seasons, accounting for more than 80 percent of the total enhancements in fall and winter, and less when agricultural emissions were larger. Likely because of the rural location, the contribution of motor vehicles and hydrocarbon extraction emissions was not significant in the regional inventory observed at Walnut Grove. This is a significant difference from the state-wide GHG EI which includes urban emissions. For GHG sources which have significant seasonal or process variation in emissions, the findings highlight the importance of multi-month measurements to validate the inventory.

II. TECHNICAL SUMMARY

Objective

This project funded one year of VOC tracer measurements to constrain estimates of GHG emissions from multiple sources, particularly agricultural-related sources with varying emission rates. Specific objectives included:

1) Continuous high-accuracy concentration measurements for a suite of VOCs over one full year at five elevations from 10 to 525 meters above ground level at the Walnut Grove tall tower site coordinated with continuous CO_2, CH_4, CO, 222-Rn, and N_2O measurements.
2) Analysis of concentration time series of VOC tracers and GHGs to attempt to distinguish individual source category contributions to the regional GHG emissions.
3) Combining the measured data in an already existing inverse modeling analysis framework (developed for data collected at the Walnut Grove tower) to ascribe regional emission estimates to specific source sectors.

Background

The Climate Change Solutions Act of 2006 (AB 32) requires ARB to develop an emissions inventory of greenhouse gases (GHGs: CO_2, CH_4, N_2O) for California. In addition to a global baseline concentration for many GHGs, specific GHGs are emitted from multiple anthropogenic sources. To aid in identifying the contribution from specific source categories, measurements of additional chemicals which can serve as tracers for those specific source categories is a standard EI improvement technique. This project established the first continuous measurements of VOCs as GHG source tracer concentrations in the Central Valley of California.

ARB has funded and maintained the Walnut Grove Tower (WGT) measurement program, as well as other ambient monitoring programs aimed at constraining GHG emissions, for more than a decade. The WGT allows collection of gaseous data at five elevations above ground level (525 m, 394 m, 262 m, 131 m, and 10 m) with hourly resolution. The Principal Investigator (PI) performed VOC tracer analysis in Bakersfield during CALNEX 2010 and with some aircraft flights during the California Airborne Biogenic VOC Emission Research in Natural Ecosystem Transects (CABERNET) campaign.

Project Summary

This goal of this project was to obtain temporally resolved source-apportioned estimates of CH_4 and N_2O enhancements from the Walnut Grove Tower (WTG), which is located 30 miles south of the Sacramento. The PI conducted a pilot project in summer of 2011 and demonstrated that PTR-MS could be successfully deployed for continuous automated VOC measurements switching between multiple inlet heights at the Walnut Grove tower. Following the pilot study, the PTR-MS was further optimized. Continuous measurements of CO_2, CH_4, N_2O, CO, and ~20 VOC masses were collected at WTG from summer 2012 through early fall 2013. All measurements were processed to yield 60-minute average time resolution concentrations for each measurement height.

The positive matrix factorization (PMF) source apportionment model was applied to the combined GHG-VOC data suite. Knowledge of VOC source markers was used to identify the likely and relative GHG source contributions to each PMF source factor. Some agricultural sources of GHGs have significant seasonal variation in emissions and the PIs used seasonality to apply PMF on distinct time periods to evaluate the temporal dependence of the contributing GHG sources. A subset of the measured GHG and VOC data was selected for the inverse modeling. By comparing mixing ratios for samples from different levels of the tower, the PI defined the well-mixed criteria for each season.

III. STAFF COMMENTS

At the December 11, 2015 meeting, the Committee commented on an earlier version of this draft report and asked that the report be revised and returned for Committee review. The Committee's comments included: lack of compliance with ARB's draft report format, the abstract and executive summary needed condensation, incomplete glossary, additional tables and references, re-packaging figures in Chapter 4 specifically to improve readability, description of the choice of measurement heights to reflect available data, improvements to Chapter 5 in terms of re-packaging of figures and refinement of summaries and conclusions, and other more specific items. Research Division staff provided the PI with a detailed list of suggested edits.

The revised draft report has incorporated most of technical comments provided. Where the PIs did not accept staff comments, appropriate technical explanations have been provided. The revised report is significantly improved and staff believes the authors addressed the committee's comments. Staff has tracked a number of needed grammatical and typographical edits.

This project was the first use of speciated VOCs as tracers for sources of GHGs. It demonstrated the use of a source apportionment methodology, commonly used for criteria pollutants, can also provide valuable insights to improve GHGs inventories.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve 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.