STATE OF CALIFORNIA
AIR RESOURCES BOARD

MEETING OF THE

RESEARCH SCREENING COMMITTEE

June 9, 2011
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
Sacramento, California 95814
(916) 445-0753

June 9, 2011
9:00 a.m.

AGENDA

ITEM NO.: 1
DATE: June 9, 2011
Approval of Minutes of Previous Meeting

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

April 28, 2011
9:30 a.m.

MINUTES

Those in attendance via teleconference:

RSC Members in Attendance

Harold Cota
Dan Costa
Steven Japar
Charles Kolstad
Irva Hertz-Picciotto
Tracy Thatcher

Staff

Michael Benjamin
Trish Chancey
Bart Croes
Deborah Drechsler
Fereidun Feizollahi
Cynthia Garcia
Steve Hui
Nargis Jareen
Stepanie Lee from Stationary Source Division (SSD)
Dongmin Luo
Reza Mahdavi
Chandan Misra
Jim Nyarady from SSD
Linda Smith
Ralph Propper
Monica Vejar
Barbara Weller
Pat Wong
Poh-Sin Yap

The Research Screening Committee (RSC or Committee) convened the meeting at 9:33 a.m. The minutes of the January 20, 2011 and February 24, 2011 meetings were approved.

Draft Final Reports

1. "Air Pollution and Cardiovascular Disease in the California Teachers Study Cohort," California Department of Public Health, $284,652, Contract No. 06-336

   Staff informed the Committee of three comments on the report from an outside reviewer regarding: 1) whether the investigators should use only P values versus using the level of significance with point estimates and confidence intervals, 2) a justification for the investigator's selection for analysis of the individual components of PM2.5, and 3) the addition of the leading causes of death in the Teacher's cohort as compared with the general population of women. Staff requested that the Committee make a decision on comment 1, and that the information supplied by the investigator as responses to comments 2 and 3 be incorporated into the body of the report. The Committee members concurred that the investigators have appropriately used the reporting of significance testing in the draft report and that no changes were needed. A Committee member had multiple questions, mainly focused on Table 10, regarding the variables used in the analysis and in the final multivariate model. Also, the Committee member requested that staff inform the Principal Investigator (PI) of the potential bias in the results when the category "unknown" is used in Table 10. In addition, the Committee member requested a better explanation for the random effects model, asked whether the investigators can control for exposures earlier in life (i.e., prior to the start of the follow-up period), and requested a discussion on the potential change over time of menopausal status and hormonal use. Also, this Committee member requested that the investigators highlight the effects seen for the "never smoker" group in the analysis, and add a comparison of the result with NO_X and PM2.5 exposure. Finally, this Committee member requested a comprehensive discussion of the assessment used to test against the linearity of the hazard rates.

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

   The Committee approved the report.

2. "Systemic Platelet Activation in Mice Exposed to Fine Particulate Matter," University of California, Davis, $300,000, Contract No. 07-337

   Staff indicated that the Office of Environmental Health Hazard Assessment did not send any additional comments, and then gave a brief overview of the staff comments on the draft final report. None of the Committee members had any questions or comments.

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

   The Committee approved the report.

3. “Development of an Updated Base Case Ambient VOC Mixture for Assessing Atmospheric Reactivity,” University of Texas at Austin, $40,010, Contract No. 08-327

   Staff reported that some typos have been found in the final report and will be provided to Principal Investigator (PI). Two Committee members asked some clarifying questions and staff responded. One Committee member asked how the new Reactive Organic Gases mixture will be used, while another asked if the software is available to the public. Staff explained how the mixture will be used in reactivity assessment and responded that the software tool is open to the public, downloaded from Dr. Carter’s website.

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

   The Committee approved the report.

4. "Development of Updated ARB Solvent Cleaning Emissions Inventories," University of California, Riverside, $249,343, Contract No. 06-322

   Staff provided an update based on a recent re-submission of the draft final report and associated spreadsheets. The first two bullets that follow include input from a Committee member. Staff stated that the final report should explain:

   - What each spreadsheet contains and how to use them; also, each should include a descriptive title.

   - How the emission factors were calculated, along with sample calculations, so that staff can verify whether these have been derived appropriately.

   - The use of Maximum Incremental Reactivity (MIR) factors to estimate the reactivity of the Volatile Organic Compounds (VOC) emissions from solvent cleaning operations.

   Motion: Move to accept subject to the inclusion of comments from staff’s update.

   The Committee approved the report.

5. "Environmental Chamber Studies of Ozone Impacts of Coatings VOCs," University of California, Riverside, $200,041, Contract No. 07-339

   A Committee member was concerned about the recommendation in the report for changes to the maximum incremental reactivity (MIR) approach, due to potential regulatory implications. Staff agreed that, although regulatory changes may be appropriate due to the findings for ethyl methyl ketoneoxime, possible changes should reflect a consideration of factors that affect all VOCs, rather than just VOCs that behave unusually. The principal investigator will be requested to modify the report’s recommendation accordingly.

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

The Committee approved the report.

6. “The Climate Change Industry in California: An Economic Analysis Assessing the Current Market and Prospects for Growth in the Global Economy,” Environmental Business International Inc., $196,211, Contract No. 07-315

   Staff updated the Committee on comments received from another commentator since the mail-out. The commentator would like to see an expanded explanation of the differences in green job numbers in this report with other recently published reports. The commentator would also like to see an expanded discussion of uncertainty associated with the estimation of green jobs in the report. One Committee member suggested that the phrase “Prospects for Growth” should be dropped from the title. Another Committee member questioned the staff suggestion that the term “climate change” should be replaced with the term “clean energy” throughout the report. After staff’s explanation of reasons for such a request, the Committee member accepted staff’s request.

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

   The Committee approved the report.

The meeting adjourned at 10:55 a.m.

ITEM NO.: 2
DATE: June 9, 2011
CONTRACT NO.: 06-324

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Collaborative Lubricating Oil Study on Emissions
CONTRACTOR:	South Coast Air Quality Management District
PRINCIPAL INVESTIGATOR:	Joe Impulliti
BUDGET:	$100,000 (funded by the California Energy Commission, other co-funding of $1,300,000)
CONTRACT TYPE:	Standard Agreement
CONTRACT TERM:	42 Months

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

I. SUMMARY

Engine lubricating oil has been implicated as a significant parent material in the formation of mobile source particulate matter (mostly PM2.5) emissions, including ultrafine PM emissions. As fuels become cleaner (especially with lower sulfur content) and emission control systems become more effective and durable, the contribution of PM emissions from the lubricant becomes increasingly significant. However, to date, much of the understanding regarding the impact of lubricating oil on PM emissions has been anecdotal and not the subject of a focused and carefully conducted research study. The Coordinating Research Council, National Renewable Energy Laboratory (NREL), the South Coast Air Quality Management District, the American Chemistry Council Product Approval Protocol Task Group, the California Energy Commission, and ARB funded a concerted effort to characterize the potential for reformulated lubricants to reduce PM emissions from mobile sources, both from new vehicles and from the much larger in-use vehicle fleet. This study helped ARB explore some currently unclear, but highly relevant issues regarding PM and OC emissions from lubricating oil. Determining the relative fractions of PM from fuel and lubricating oil proved to be very difficult. However, fresh oil results in more PM than aged oil in otherwise clean cars (i.e.,

non-oil burners), suggesting that lubricating oil formulation could influence oil-derived PM, but that does not appear to be the case for high-emitters that account for the majority of PM emissions.

II. TECHNICAL SUMMARY

Objective

This study was designed to provide a preliminary characterization of emissions from normal and oil-burning vehicles to help answer the following questions:

- To what extent does the lubricant affect PM emissions?
- What fractions of emissions are derived from fuel vs. oil combustion?
- Can tracer methods be used to determine the oil and fuel contribution to PM formation?

Two vehicles, a normal-and a high-emitter (or high-mileage), were selected for four different vehicles types and tested with the following fuel blends with both aged and fresh oil:

- Light-duty gasoline cars (non-oxygenated gasoline and 10 percent ethanol)
- Medium-duty diesel vehicles (regular diesel and 20 percent biodiesel)
- Heavy-duty natural gas vehicle
- Heavy-duty diesel vehicle

The light- and medium-duty vehicles were also evaluated at two different temperatures (20^{o}F and 72^{o}F). The Department of Engine and Emissions Research of Southwest Research Institute (SwRI), in conjunction with the Desert Research Institute (DRI), conducted the research.

Background

As new vehicles meet very stringent PM standards, the on-road PM inventory is expected to become largely influenced by PM from older vehicles. Much of the PM from the older vehicles, as well as PM from new vehicles, are derived from the lubricating oil. This is true of the ultrafine PM as well as PM in the larger sizes. The dependence of lubricant-derived PM and its toxicity on engine design, engine operation, engine maintenance, duty-cycle, fuel type, and lubricant properties needs quantification via a focused study.

Project Summary

The following provides a summary of major findings from the project:

- Unburned lube oil made up 60 to 90 percent of organic carbon (OC) emissions. This is consistent across all four vehicles and fuel types tested. This OC generally represented 20 to 50 percent of all PM emitted. [The main exceptions were the normal-emitting light-duty gasoline car where OC is less than 10 percent of PM and the heavy-duty natural gas vehicle where OC is greater than 90 percent of PM.]
- For normal-emitter light-duty gasoline and medium-duty diesel vehicles, fresh oil produced more particles (primarily soot) than aged oil. However, for high-emitters, aged oil produced more particles (primarily volatiles) than new oil. PM emission rates from the high-emitter light-duty gasoline car were 20-400 times higher than the normal-emitter.
- Use of 10 percent ethanol in normal-emitter light-duty gasoline cars resulted in higher PM emissions, particularly at 72^{o}F, compared to non-oxygenated gasoline. No trend was observed with the high-emitter.
- Both the normal-emitter and high-mileage heavy duty natural gas vehicles produced more particles (primarily volatiles from the lubricating oils) with fresh oil.
- The effect of oil age was not apparent in heavy-duty diesel vehicles, possibly because lube oil represents a small fraction of PM (around 20 percent) and thus quantifying the lube oil contribution to PM formation becomes challenging. The majority of PM emissions from both heavy-duty diesel vehicles were soot particles, indicating that the source is fuel and/or oil combustion.
- Quantification/apportionment of PM in many cases was incomplete due to limitations in analytical techniques or possibly due to low concentration of species. And none of the chemical markers were found reliable in determining engine oil consumption rates.

III. STAFF COMMENTS

This study was the first to identify the effects of lube oil and fuel types on PM and organic carbon emissions from normal- and high-emitting (or high-mileage) light-, medium- and heavy-duty vehicles. Staff from SwRI and NREL identified the physical and chemical properties of PM emissions for the matrix of vehicles type and fuels, meeting the study objectives. Determining the contribution of lubricating oil versus fuel

to PM formation for normal-emitters proved to be challenging with the current group of chemical markers, primarily due to low concentrations or confounding effects.

IV. STAFF RECOMMENDATION

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

ITEM NO.: 3
DATE: June 9, 2011
CONTRACT NO.: 07-340
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Characterization of Toxicity as a Function of Volatility of Ultrafine PM Emissions from Compressed Natural Gas Vehicles
CONTRACTOR:	West Virginia University
PRINCIPAL INVESTIGATOR:	Mridul Gautam, Ph.D.
BUDGET:	$349,996 (funded by the California Energy Commission)
CONTRACT TYPE:	Standard Agreement
CONTRACT TERM:	12 Months

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

I. SUMMARY

Heavy-duty (HD) compressed natural gas (CNG) vehicles have been advanced as a means to meet stringent PM mass standards, but reductions in health impacts may not be commensurate with reductions in PM mass. Many studies have been conducted to determine the characteristics and toxicity of emissions from CNG engines for comparison with the same characteristics for conventional-fueled diesel engines and other alternative-fueled engines. In 2002, ARB initiated a pilot study to investigate emissions from CNG buses in comparison with heavy-duty diesel vehicles with diesel particle traps. The results demonstrated the benefit of CNG and diesel particle traps in significantly reducing PM emissions and other toxic pollutants. However, CNG buses exhibited relative high emissions of aldehydes and volatile organic compounds (VOCs), and posed a potential toxic risk based on mutagenicity testing. As a conclusion of this pilot CNG study, oxidation catalysts were suggested as an emissions control for CNG buses and have now been implemented statewide. As a follow-up, the current study characterized the physical, chemical, and toxicological properties of emissions from

CNG buses equipped with three-way catalysts. The CNG vehicles augment the vehicle test matrix of ongoing heavy-duty diesel vehicle (HDDV) and light-duty vehicle (LDV) studies. The three-way catalyst equipped, 2010 emissions compliant stoichiometric heavy-duty natural gas engines have proven to be a viable alternative in comparison to selective catalytic reduction (SCR) equipped heavy-duty diesel engines to meet stringent PM and NO_X standards. The work plan involved the chassis dynamometer testing of two heavy-duty CNG transit buses that are compliant with the U.S. Environmental Protection Agency (EPA) 2010 emission requirements. This study provided a comprehensive dataset of particle size distribution, criteria pollutants (CO, NO_X, total hydrocarbons [THC], PM, and CO_2), non-criteria pollutants (e.g., polycyclic aromatic hydrocarbons [PAHs], speciated gas-phase non-methane hydrocarbon [NMHC], carbonyls; metals, elemental and organic carbon (EC/OC); water soluble ions and toxicity [e.g. oxidative stress, inflammation, mutagenicity]). The relative contribution of volatile and non-volatile particle toxicity was also assessed.

II. TECHNICAL SUMMARY

Objective

The primary objective of this study is to characterize the toxicity of the volatile and non-volatile fractions of PM from advanced heavy-duty natural gas engines. The primary objective is achieved by performing a complete chemical characterization of the exhaust, which includes sampling and analysis of unregulated species in the vehicle exhaust, together with particle number and size distribution measurements of the diluted exhaust. The volatile and the non-volatile components of the PM are characterized through use of thermodenuders. The collected samples are further analyzed for oxidative stress, inflammatory markers, and mutagenicity using assays to investigate the difference in toxicity profile of the volatile and non-volatile fractions of PM.

Background

Recent emissions testing in dynamometer and on-road testing facilities have shown that particles emitted from vehicles are externally mixed; i.e., different particles of the same size can have different chemical compositions. Depending on vehicle type, age, and ambient conditions, between 70-90 percent of the particles by number (10-30 percent by mass) may consist of more volatile material (known as semi-volatile) than the other

particles, and upon heating, will partially or completely evaporate. The exposure and health implications of these findings have not yet been investigated. There are several factors that require knowledge of the relative toxicity of these non-volatile and semi-volatile particles: 1) based on particle number, people's exposure during commute is dominated by semi-volatile particles; 2) some control technologies for diesel PM, such as diesel particulate filters, effectively remove the non-volatile PM, but have a mixed impact on the semi-volatile fraction; and 3) European authorities are moving ahead with a particle number standard for diesel and some gasoline engines, considering only non-volatile particles. As California considers its own need to augment the current mass-based standards, the association between any proposed particle number-based standard and toxicity must be better understood.

ARB sponsored a study to investigate the characteristics of PM fractions, and their implications for exposure and health impacts: "*Physicochemical and toxicological assessment of the semi-volatile and non-volatile fractions of PM from heavy and light-duty vehicles operating with and without emissions control technologies*", but CNG-fueled engines were not included in the program. Because CNG engines are currently employed as a clean-burning alternative to conventional-fueled diesel engines, it is important to determine the characteristics and toxicity of emissions from CNG engines for comparison with the same characteristics for conventional-fueled diesel engines.

Project Summary

Two 2010-compliant CNG buses equipped with three-way catalyst were tested using a portable chassis dynamometer under steady state cruise, Urban Dynamometer Driving Schedule (UDDS) and idle operations. Both criteria and non-criteria pollutants have been measured and analyzed. The non-volatile and semi-volatile PM samples were collected using four thermodenuders in parallel for chemical and toxicological analysis. Additional analysis of the ammonia emissions was also performed. Work at the wheel was measured in this study (axle horsepower hours, or ahp-hr), so the results could be presented in a work-specific format which provides an approximate comparison with emissions standards. However, it should be noted the work estimated from the chassis dynamometer at wheel would be lower than the work calculated from an engine dynamometer.

The following provides a summary of major findings from the project:

- The PM emitted from the two 2010-compliant CNG buses is 0.4 ± 0.01 mg/ahp-hr during cruise cycle and 0.7 ± 0.3 mg/ahp-hr during UDDS cycle, compared to the PM emission standard of 10 mg/brake horsepower hours (bhp-hr).
- NO_X emitted from the two 2010-compliant CNG buses is 0.1 ± 0.04 g/ahp-hr during cruise cycle and 0.2 ± 0.1 g/ahp-hr during UDDS cycle, compared to the NO_X emission standard of 0.2 g/bhp-hr.
- NMHC was completely removed by the catalyst as indicated by the very small difference between THC and methane emissions.
- Even though both buses are 2010-compliant, the catalytic activity is different, resulting in different emissions of the gaseous pollutants, such as NO_X, CO, and HC between the two vehicles.
- Organic carbon (OC) dominated the PM compounds.
- BTEX was significantly reduced by the three-way catalyst to below detection limit values.
- Total PAH emission was in the same order of magnitude during both cruise and UDDS cycles, 7.4 ± 0.6 μg/mile for Bus 1 and 5.3 ± 0.01 μg/mile for Bus 2. Naphthalene is the dominant PAH species.
- Production of ammonia is a catalytic process and is closely related with the air-fuel ratio and exhaust temperature.

III. STAFF COMMENTS

This project conducted testing and provides a dataset to characterize the physiochemical and toxicological properties of emissions from heavy-duty CNG vehicles fitted with advanced after-treatment controls. This data will contribute to assessment of the health impacts of technologies used to meet the latest heavy-duty emission standards, and will contribute to evaluation of potential new emission regulations based on characteristics other than PM mass.

There is still some important data not yet available due to the work schedule and work load of the analytical labs. These data include metals and reactive oxygen species (ROS) toxicity analysis by University of Wisconsin-Madison, carbonyl species by ARB, toxicity analysis by UCLA, and mutagenicity analysis by UC Davis. These analyses are being performed by ARB or under contract directly for ARB (not a subcontract to West Virginia University [WVU]). The delays are not under the control of WVU, and staff considers the contractual obligations of WVU to be complete. Once the missing data are received by ARB, staff will prepare an addendum to the report that will include the currently missing data.

ARB staff will also conduct a comparison of the results from this study with ARB's earlier CNG bus studies, Phase II HDDV and LDV studies, and other up-to-date emissions characterization studies (e.g. the Advanced Collaborative Emissions Study, [ACES]). Once put in this context, the benefit of the three-way catalyst will be better understood.

IV. STAFF RECOMMENDATION

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

ITEM NO.: 4
DATE: June 9, 2011
CONTRACT NO.: 06-329
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Flux Measurements of Biogenic Precursors to Ozone and Particulate Matter in the Central Valley
CONTRACTOR:	University of California, Berkeley
PRINCIPAL INVESTIGATORS:	Allen H. Goldstein, Ph.D., and John Karlik, D. Env.
BUDGET:	$400,003
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	47.5 Months

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

I. SUMMARY

Biogenic volatile organic carbon (BVOC) emissions inventories are critical elements in federally required state implementation plans for ozone and particulate matter (PM). ARB's computer model for estimating BVOC emissions requires plant species composition and dominance, canopy area, leaf area index, leaf mass density, and taxonomic emission factors to produce BVOC emission inventories. This study focused on improving current emission factors for agricultural crops as these are a potentially significant source of emissions in the San Joaquin Valley (Valley) during the ozone season. Specifically, the project collected biogenic emissions data for previously unmeasured chemical species emitted by the most common crops in the Valley using a combination of enclosure and canopy eddy covariance flux measurements. In addition to validating and extending our current assumptions about agricultural biogenic emissions, this study was unique in that it included a full year of measurements in an orange orchard. This longitudinal study captured a number of different activities such as fertilizing, harvesting, and pruning which result in increased biogenic emissions. Results of this project will be incorporated into ARB's current biogenic emissions inventory model that will be used in future State Implementation Plans.

II. TECHNICAL SUMMARY

Objective

This study is designed to enhance current emission factors for agricultural crops with the objective of validating and improving assumptions in ARB's biogenic emissions inventory modeling.

Background

Although progress has been made over the past thirty years, the San Joaquin Valley (Valley) is still not in attainment with federal and state air quality standards for ozone and particulate matter (PM). To develop effective control strategies, having an accurate estimate of ozone and PM precursor emissions from all sources, including biogenic emissions from plants, is critical. As one of the most productive agricultural areas in the United States, crops in the Valley represent a potentially significant source of biogenic volatile organic compounds (BVOCs) that need to be accounted for in air quality modeling and future State Implementation Plans (SIPs).

Biogenic emissions inventories are developed using computer models that rely on a wide range of inputs including the number and species of plants in a given area, their biomass, and their species-specfic emission factors. In addition, an understanding of how biogenic emissions vary as a function of environmental conditions such as light and temperature, as well as human activities, such as harvesting or pruning, is needed.

The primary source of emission factor input data for ARB's biogenic emissions inventory model is the Winer and Benjamin taxonomic method, which is based on studies in southern California, and more recent work at the Blodgett Forest Research (BFR) station east of Sacramento. Since it is logistically impractical to measure emissions from all 6,000 plant species in California, the taxonomic method was developed to assign emission factors to unmeasured plant species using the limited database of data for measured plant species.

This study expands the current limited database of emission factors for agricultural crops by measuring emissions for the most common crops found in the Valley. This project builds upon previous emission factor studies of agricultural crops by expanding

the suite of chemical species measured to include some of the short-lived monoterpenes and oxygenated species. In addition, by measuring emissions in an orange orchard in the Valley for an entire year, this study captured the effect of different activities such as plant flowering, fertilizing, harvesting, and pruning on emissions.

Project Summary

Using the taxonomic relationships, known emissions behavior of plants, the acreage of their plantings within the San Joaquin Valley, and information from a literature search, after consultation with ARB staff, the PI selected target crops (25 species). Among these were orange (Citrus sinensis 'Washington Navel'), lemon (Citrus limon 'Meyer'), mandarin (Citrus reticulata 'W. Murcott' and 'Clementine'), almond (Prunus dulcis 'Nonpareil'), grape (Vitis vinifera 'Crimson Seedless' and 'Pinot Noir'), pistachio (Pistacia vera 'Kerman'), tomato (Lycopersicon esculentum 'Mortage Lifter'), carrot (Daucus carota 'Bolero Nantes' and 'Red Label'), cherry (Prunus avium 'Bing'), Japanese plum (Prunus salicina 'Satsuma'), olive (Olea europea 'Manzanillo'), and pomegranate (Punica granatum 'Wonderful'). For each plant species, there were 2 to 8 individual plants. Crop potted plants of these cultivars were enclosed in branch/entire plant enclosure systems of the type that has provided a significant fraction of existing emission factors. They were subjected to appropriate light and other conditions that mimicked those in agricultural fields. Photosynthetic active radiation (PAR) and other measurements accompanied chemical measurements with gas chromatography mass spectrometry with flame ionization detection (GC/MS-FID), as well as proton transfer reaction mass spectrometry (PTR-MS). Mono and sesqui terpenes, methanol, acetone, acetaldehyde, isoprene, isoprene-ozone oxidation products, methyl butenol, and many other intermediate compounds of terpene ozone oxidation were measured. GC/MS-FID provides a measure of totality of biogenic emissions while PTR-MS provides a measure of the constituent components. Eight thousand chromatograms were collected and analyzed for these plant species.

All crops measured are low isoprene emitters, their basal emission factors (BEF) 0.2 percent to 2 percent of high isoprene emitting plants. Aside from peach and orange plants, most other species had low mono-terpene emissions; aside from pima cotton and orange plants, most other species had low oxygenated mono-terpene emissions.

For sesquiterpenes, orange plants alone had emissions of significance where many other plant emissions were below the limits of detection. Flowering episodes significantly increased orange plant emissions. The oranges were chosen as the plant for the field study because they are one of the most common as well as highest emitting agricultural crops in the Valley.

While measurements of BVOC in a plant enclosure can provide emission factors, eddy covariance measurements are necessary to determine actual fluxes. Based on information from the screening phase, in phase II the PI took a flux measurement platform to an orange orchard near Visalia California and began above canopy eddy covariance flux measurement data on BVOC emissions, leaf mass, leaf area index, ozone, and micro meteorological data relevant to BEIGIS simulations at two sites. Instruments included PTR-MS, fast and slow ozone sensors, and probes for specific data such as relative humidity. Measurements included those for VOC, ozone, CO2 and meteorology (such as wind speed), wind direction, relative humidity, PAR, and temperature. The measurement platform remained in effect for one full year to study spring flowering and summer heat stress effects. During flowering, emissions increased as expected from the greenhouse measurements. High emissions of β-myrcene, sabinene, Δ-limonene, and γ-terpinene chemical species were observed during flowering, limonene and para-cymene during the summer. This study captured emissions associated with flowering, pruning, harvesting, and fertilizer application that are currently not accounted for in ARB's biogenic emissions inventory model. Through gas chromatography flame ionization detection data analysis, the PI suggested additional chemical species are emitted that are currently unaccounted for in ARB's biogenic emissions inventory models. These species and the flowering, and other management episodes may be important in ozone and secondary organic aerosol formation.

III. STAFF COMMENTS

This study has improved and expanded the emission factors for agricultural crops commonly found in California by measuring chemical species previously not accounted for. This will be invaluable for ARB modeling staff as they will be able to use measured

rather than assumed emission factors for the future SIP modeling of the San Joaquin Valley and other agricultural areas in California.

IV. STAFF RECOMMENDATIONS

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

ITEM NO.: 5
DATE: June 9, 2011
CONTRACT NO.: 06-332
Link to Report

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE:	Spatiotemporal Analysis of Air Pollution and Mortality in California Based on the American Cancer Society Cohort
CONTRACTOR:	University of California, Berkeley
PRINCIPAL INVESTIGATOR:	Michael Jerrett, Ph.D.
BUDGET:	**$**749,974 (co-funded by South Coast Air Quality Management District)
CONTRACT TYPE:	Interagency Agreement
CONTRACT TERM:	36 Months

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

I. SUMMARY

The portion of the nationwide American Cancer Society (ACS) cohort living in California (76,000 individuals with over 20,000 deaths for an 18-year follow-up ending in 2000) was used to investigate the statewide health risk associated with exposure to particulate matter (PM) and gaseous air pollution on all-cause and cause-specific deaths. The investigators used twenty individual-level variables to control for confounding of the air pollution-death association from lifestyle, dietary, demographic, occupational, and educational influences, and variables to control for neighborhood-level confounding (e.g., poverty, unemployment). Using multiple statewide models for PM less than or equal to 2.5 µm (PM2.5), the investigators found significantly elevated risks for death due to cardiovascular disease (CVD), with the largest risk for death due to ischemic heart disease (IHD). PM2.5 was also associated with all-cause deaths statewide, but only when using the land use regression (LUR) model for exposure and controlling for residence in the largest urban areas. The other pollutants investigated – nitrogen dioxide (NO_2), PM less

than or equal to 10 μm (PM10), PM10 sulfates, and ozone – all showed consistent associations with CVD and IHD that are similar in size to those observed for PM2.5, although the exposure estimates for these pollutants are correlated with each other and with PM2.5.

II. TECHNICAL SUMMARY

Objective

The objectives of the study were: 1) to assess effects from exposure to PM and gaseous air pollution on all-cause and cause-specific mortality in California, based on the ACS cohort; 2) to investigate the impacts on mortality related to proximity to traffic and different particle constituents, and intraurban exposure gradients; and 3) to determine whether critical time windows in exposure exist in the relationship between air pollution and mortality in California.

Background

Epidemiologic studies conducted over several decades have provided evidence suggesting that long-term exposure to elevated levels of PM in ambient air is associated with increased death rates. Two major U.S. cohort studies, the Harvard Six Cities study and the ACS study came under intense scrutiny in 1997 when the results were used by the U.S. Environmental Protection Agency to support new National Ambient Air Quality Standards for PM2.5. A reanalysis of the ACS cohort added ten years of data, which increased the follow-up time to more than sixteen years and tripled the number of deaths, and used new PM2.5 exposure data. The results of this reanalysis indicated a nationwide increased risk of about six percent in premature death for all-causes for each 10 μg/m3 increase in PM2.5. For this contract, the California portion of the ACS cohort was used to estimate the relative health risk for all-cause and cause-specific death in California associated with PM and its constituents and with gaseous air pollution.

Report Summary

The investigators examined the contributions of time, duration, air pollution sources, and level of exposure to death associated with air pollution in California by using the ACS cohort and different statewide exposure models. This study used different statewide exposure models that ranged from basic models such as Inverse Distance

Weighting (IWD), to more sophisticated ones such as the integrated LUR model with the Bayesian Maximum Entropy Kriging model. Also, for the first time, members of the ACS cohort had their home addresses geocoded, so that air pollutant exposure levels could be assigned to their residences. This allowed for the more accurate use of exposure and health models. In all, the analysis included 76,000 individuals with over 20,000 deaths for an 18-year follow-up ending in 2000. The investigators used twenty individual-level variables to control for confounding of the air pollution-death association from lifestyle, dietary, demographic, occupational, and educational influences, and variables to control for neighborhood-level confounding (e.g., poverty, unemployment).

With all the statewide exposure models of PM2.5, the investigators found significantly elevated relative risks for CVD, with the largest being observed for death due to IHD. The investigators also found significant associations between PM2.5 and all-cause death, but only when using the LUR model for exposure and controlling for residence in the largest urban areas. The investigators determined that their primary finding for PM2.5 of elevated risks for CVD and IHD were insensitive to the different exposure or health models used, although there was a trend toward larger risks in more refined exposure models. In addition, the investigators found significantly elevated statewide risk for CVD and IHD associated with exposure to NO_2, PM10, PM10 sulfate, and ozone, although the exposure estimates for these pollutants are correlated with each other and with PM2.5. The NO_2 LUR estimate had significant associations with all-cause, CVD, IHD, and lung cancer deaths. Exposure estimates based on roadway proximity had elevated, but insignificant risks, suggesting weaker effects than with the NO_2 model, probably due to increased exposure measurement error. The investigators found a significantly elevated risk for death from all-causes in association with PM2.5 exposure in Los Angeles where the monitoring network is capable of detecting intra-urban variations in PM2.5. The risk found in Los Angeles was consistent with that found in an earlier analysis of the Los Angeles ACS cohort by the same principal investigator.

In conclusion, the results from this project found consistent and robust effects of PM2.5 and the other highly correlated pollutants on deaths from CVD and IHD. The

investigators also found significant associations between PM2.5 and all-cause death, although these findings were sensitive to model specification. The statewide risks are comparable to those seen in the most recent national ACS study. These results were also consistent with past ACS analyses and with findings from other national and international studies.

III. STAFF COMMENTS

The report should include more detailed narratives of the exposure models and the critical time windows analysis. The report also needs to include the mathematical details of the models used and analyses conducted.

IV. STAFF RECOMMENDATION

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