REVISED May 23, 2003

Modeling Workgroup
Mobile Sources Technical Review Subcommittee
Clean Air Act Advisory Committee

Minutes of the Workgroup's Meeting on February 11, 2003
Alexandria, Virginia

Introduction and Opening Remarks

John Koupal (EPA, co-chair) called the meeting to order at approximately 1:00 p.m., and Workgroup members introduced themselves. A meeting agenda and two handouts (MOVES Update for FACA Modeling Workgroup; Comments on MOVES Reports) were distributed prior to the meeting.

Handout: MOVES Update

Implementation Plan and Publication Status

Mr. Koupal described the implementation timetable for the MOVES (Multi-scale mOtor Vehicles & Equipment Emission System) modeling system. An internal version of MOVES (planned for September 2003) will be used for validation, to benchmark against fuel consumption estimates. The initial release (planned for December 2003) will focus on the policy evaluation components of the model, including well-to-pump emission estimation instead of the 1990-2002 inventory numbers, and the scope will be initially limited to inventories for calendar year 1999 and forward. Data will be linked to the TRENDS and NEI (National Emission Inventory) processes. A full on-road release will replace the MOBILE6 model in Fall 2005. Prior to that, MOVES will be limited to on-road greenhouse gases (GHG, such as CO_2, CH_4, N_2O).
Mr. Koupal acknowledged that this represents a change in the scope from that of the planning documentation and the November 2002 mobile source models workshop. The off-road release, planned for 2006, will replace the NONROAD model.

The EPA is ready to evaluate comments received from stakeholders on the MOVES Draft Design and Implementation Plan that was published in October 2002. An independent third party (Southwest Research Institute, contractor) chose a peer review panel, and comments from the panel on the design and implementation plan are expected within the next few weeks. The EPA is going to wait to evaluate stakeholder comments until the peer review panel comments are in as well. The panel should remain in place at least through the first iteration of the model (that is, on-road GHG).

For the emission analysis plan for GHG, distributed by electronic mail in December 2002, the stakeholder comment period is still open (extended to March 3, 2003). Comments on the emission analysis plan may be submitted by electronic mail to newgen@epa.gov. Several

background reports have been posted to the MOVES website, http://www.epa.gov/otaq/ngm.htm. The peer review panel will also review the emission analysis plan. Tom Darlington (AIR) asked whether the peer review panel will review stakeholder documents. Mr. Koupal replied that the panel will only be reviewing EPA documents, which keeps the panel independent of the stakeholder process. He added that the CRC (Coordinating Research Council, Inc.) will be pursuing additional review of the MOVES emission analysis plan and the background documents. Gene Tierney (EPA/OTAQ) commented that peer review feedback is not "the final word" and that EPA will take into account other sources that provide input, such as stakeholder comments.

Emission Data Gathering

Mr. Koupal said Eastern Research Group (ERG) is continuing to add data to the Mobile Source Observation Database (MSOD), which is going to be the central repository of the in-use emission data used by MOVES. Bob Slott (consultant) noted that the list of data sources does not mention remote sensing data. Mr. Koupal responded that the initial release is specific to GHG, for which there is no remote sensing data. Remote sensing data will be considered when the model expands to criteria pollutants.

Mr. Koupal expressed thanks to organizations that are providing additional data. For example, the addition of more than 10 years of in-use heavy-duty chassis test results from West Virginia University will greatly improve the data base.

Fleet and Activity Data

Mr. Koupal mentioned several sources of data used to characterize the fleet and vehicle activity for MOVES. Mr. Slott commented that a lot of the registration data sets (such as Polk's) may include vehicles that are no longer in use and asked whether there will be cross-checking to reduce duplication. That is, if a vehicle is moved to a different state, its information could reside in more than one data base. Tom Wenzel (Lawrence Berkeley National Laboratory) responded that the Polk data base only includes currently registered vehicles.

Mr. Koupal noted that while Ward's Automotive Yearbook has data on both vehicle characteristics and sales, he is not sure how to link those data. A caller cautioned that it is important to differentiate between calendar year and model year. David Lax (API) recommended the Automotive News Market Data Book as an additional source of data. Behshad Norowzi (North Carolina DOT) suggested extracting vehicle age distribution directly from registration data, from year to year, to estimate new vehicle sales.

Earlier, the EPA planned to update vehicle activity information every calendar year for MOVES. Mr. Koupal noted that the current plan is to fall back to an approach like that used in the TRENDS work, to update fleet and activity information only every 3 years, using vehicle data

sources such as Ward's sales to fill in between years. MOBILE6 uses a similar approach, with backcasting and forecasting based only on 1996 data.

Mr. Slott recommended using compliance and other information to correct registration-derived data. Sandeep Kishan (ERG) added that other information might include remote sensing and EZPass data.

Vehicle-Specific Power

Mr. Koupal discussed the use of vehicle-specific power (VSP) in MOVES. An approach developed by North Carolina State University that MOVES proposes to use categorizes vehicles among 14 bins. This binning strategy fundamentally replaces the speed correction that has been used in the MOBILE models over the years. However, the binning strategy shows a bias based on the average speed of the cycle, for fuel mode but more clearly for criteria pollutants. At a lower average speed, the VSP approach overpredicts; likewise, at a higher average speed, the VSP approach underpredicts. In light of this, Ed Nam (Ford Motor Co.) is attempting to eliminate the bias through further refinement of the VSP equations. This effort is a work in progress, to be presented at CRC this year.

Mr. Slott described a presentation he has shared with several individuals that relates to VSP and fuel use. The analysis relates grams of pollutant per gram of fuel to grams of pollutant per mile. The original idea is from the Jimenez thesis, where he plotted VSP against fuel rate, which is of interest in the CO_2 model. In both low- and high-emitters, Mr. Slott's analysis shows a linear relationship between VSP (once VSP is greater than zero) and total carbon per second, which is proportional to the fuel rate. He analyzed a data set from UC - Riverside that consisted of 27 vehicles spanning the 1979 to 1996 model years, with a range of weights from the Geo Metro to greater than 8,000 pounds. Mr. Slott hopes to test the relationship against other data bases, including onboard instrumented vehicles and other second-by-second data bases. Mr. Koupal commented that there is room for refinement of the VSP equation, for which Jimenez used "stock" coefficients. Better results could be obtained if actual coefficients are obtained, from CERT data or a lookup table. This will be especially true at higher speeds, where the aerodynamic coefficient has greatest influence.

Vehicle Characterization

Mr. Koupal noted that the MOVES approach to vehicle characterization has evolved since initial proposals. MOBILE looks at vehicles in terms of weight class. MOVES looks at them in two ways: source use types, and source bins. Because the Highway Performance Monitoring System (HPMS) is a primary source of activity data, use types are designed to be subsets of HPMS classes.

MOVES GHG Source Bins

For the GHG part of MOVES, there will be two types of bins with which to differentiate vehicles–one type for fuel consumption/CO_2, and another type for CH_4/N_2O. Although having two types of bins is more complicated, it will result in a better model of reality.

With respect to the fuel consumption/CO_2 bin breakdowns, several options are being considered for the engine performance parameter: engine size; number of cylinders; and rated power. John German (Honda) said engine size may better correlate to fuel consumption, but there are other factors that may correlate too (such as turbocharging, which improves fuel economy).

Mr. Slott asked whether CO_2 could be modeled simply on the amount of fuel sold. Mr. Koupal responded that a benefit to the planned bottom-up approach for MOVES is that it tells us where, when, and by what vehicles the fuel is being consumed. The bottom-up approach can be validated against top-down data for CO_2 and fuel sales estimates. Mr. Slott noted that CO_2 is a global concern, so it is not necessary to know the locality. Mr. Tierney added that the bottom-up approach allows EPA to evaluate policy options that a top-down approach does not usually afford.

Mr. Koupal remarked that neither the fuel consumption/CO_2 nor the CH_4/N_2O source bins include age or odometer. Age/odometer is clearly important for criteria pollutants. Based on analysis he has seen, he does not think age/odometer is critical for fuel consumption or CO_2. Age/odometer is perhaps more of an issue for CH_4/N_2O, he acknowledged, but there may not be enough data to merit that breakdown.

Modal Binning Options

Mr. Koupal said that for fuel mode, it would make sense to simply use power bins, rather than VSP and weight bins, since power equals VSP times weight. Of course, EPA is interested in producing a streamlined model, and a benefit of using power bins for fuel would be a reduction in the number of bins needed.

For criteria pollutant mode, Mr. German said use of power bins would be less desirable than use of VSP bins, because the weight component of power would be extraneous. Mr. Koupal agreed, saying VSP is a more direct measure of how the vehicles are operating, so VSP bins would result in a better model formulation than would straight power bins. He explained that vehicle size is unimportant here, because regardless of vehicle weight, the vehicles are certified to the same standard. Mr. Koupal said one option that would likely result in the smallest number of bins is to express emission rate in grams per gallon (rather than grams per second).

Dilip Patel (California ARB) noted that an ERG document had recommended against using VSP for heavy-duty vehicles. Mr. Koupal clarified that ERG's recommendation was made at a time

when they had defined VSP simply as speed times acceleration, without including road load, but that the current definition of VSP does include road load. Mr. German commented that power bins might make more sense for heavy-duty vehicles, because the heavy-duty standards are in terms of grams per horsepower-hour.

Mr. Koupal noted that for fuel consumption/CO_2, there is a definite model-year trend that is not tied to a specific technology (such as carburetor vs. fuel injection). That is, there is a definite improvement in fuel economy over the years for similar-weight vehicles. Therefore, MOVES may have model-year bins like MOBILE does. He referred to Mr. German's list of improvements in automotive technology over the years. Mr. German stated that improvements in automotive technology are continuous and gradual. He commented that into the 1980's, vehicle improvements were made to improve fuel economy. Since the 1980's, there is not such an obvious increase in fuel economy, because while engines have become more efficient, the efficiency gains have been used to improve performance rather than fuel economy.

Mr. Darlington referred to validation and proof of concept, as described in the GHG emission analysis report. He asked whether, considering the possibility of more aggregation of bin structure, the model structure will have to be re-validated. Mr. Koupal confirmed that re-validation would be required.

Mr. German raised concern with the proposal to use VSP bins with grams per gallon for emission rate, because of the absence of a weight factor. He stated that a grams-per-gallon result certainly depends on vehicle weight, noting that a smaller, lighter vehicle is going to use less fuel, so its grams per gallon are going to be higher. He said the optimum scenario in the handout is in the third row, where fuel uses power bins, criteria pollutants use VSP bins, and emission rates are in grams per second.

Related to minimizing the number of bins, Mr. German also raised his concern about using the same bin structure for fuel consumption as for a pollutant (CO_2). He suggested that for both heavy-duty and light-duty vehicles, engine-out should be modeled for fuel consumption, but for light-duty pollutants, tailpipe emissions should be modeled. Mr. Koupal commented that to change the model structure to model both engine-out and tailpipe emissions would be daunting. Mr. Slott commented that the key to reducing the number of bins is to have a greater number of well-understood relationships among the key variables. Mr. Slott added that an additional parameter for criteria pollutants is how the emission control system is working. Mr. German noted that vehicles are designed such that the higher the engine-out emissions are, the more efficient the catalyst system is. Mr. Slott also commented that one can model criteria pollutants from physical parameters <u>if</u> the vehicle is operating very well. However, the vehicles that are of most interest and are hardest to model are those that are not operating well. A good model must draw on on-road data from a huge number of vehicles.

Well-To-Pump Modeling

Mr. Koupal said that EPA has initiated a cooperative agreement with the U.S. Department of Energy (DOE) and Argonne National Laboratory (ANL) to integrate their GREET model with MOVES. The integrated model would be a complete well-to-wheel model. GREET would provide the well-to-pump piece, and MOVES would provide the pump-to-wheel piece. The integrated model would allow full lifecycle policy analysis.

Mr. Slott commented that to avoid inadvertent omission of some important real-world parameter, the well-to-wheel model should be peer-reviewed by a panel including academics, oil companies, and automobile manufacturers. Mr. Koupal said the well-to-wheel model would go through the peer-review process, and he added that it might make sense to have a different panel for that aspect of model development.

Modeling Hybrid Electric and Fuel Cell Vehicles

Mr. Koupal commented that there is not a single definition of a hybrid electric vehicle, because there are such different engine use strategies. MOVES will probably include several slots in the model for hybrid electric vehicles; if not, MOVES must make clear the assumptions on which a hybrid electric vehicle is modeled, allowing users to change the assumptions.

Mr. Slott asked whether inclusion of hybrid electric vehicles is a forecasting issue and whether it should postponed until they have been in use longer. Mr. Koupal replied that actually the main reason for using the model is to forecast. Mr. Tierney added that EPA is trying to fulfill the role of "honest broker" in showing relative emission impacts of the various alternative technologies. Mr. Slott commented that sometimes the forecast disturbs the system. For example, a big program in Arizona promoted use of dual-fuel vehicles. Many people purchased dual-fuel vehicles, but few actually used the alternative fuel. He is concerned that a model might make the hybrid electric vehicle look better than it really is. Mr. German noted that there are production vehicles on which to base a realistic estimate.

Mr. Slott suggested that in the future a standard might be set based on the best vehicle out there today, in terms of stationary source control technology. Mr. Tierney said the idea is not merely to look at vehicle emissions (for example, from burning hydrogen fuel) but to include well-to-pump, which is where the controversy mainly lies. Mr. Koupal said MOVES may have to rely on available data but also on other models developed more specifically to address vehicle operations. Just one example of such a model is ADVISOR, a hybrid electric vehicle simulation model developed by the National Renewable Energy Laboratory (NREL). Mr. Kishan encouraged EPA to allow flexibility to the user. Mr. Koupal said the model will have empty slots where the user can add emission rates.

Mr. Koupal noted that the technologies of direct hydrogen and onboard reforming of gasoline are being considered in the context of inventory models. Mr. Slott asked whether anyone is actually considering onboard reforming. Mr. Koupal responded that he is not in a position to say whether onboard reforming is good. Rather, the EPA is trying to provide tools to allow people to look at the issue from different angles. Mr. German noted that most manufacturers are backing away from onboard reforming, and he suggested that while work to incorporate onboard reforming should not be dropped entirely, perhaps it should be shelved.

Handout: Comments on MOVES Reports

Mr. Slott provided his comments on MOVES reports, focusing primarily on his review of the North Carolina State University (NCSU) study. He noted that his handout is halfway between a presentation and a report itself. His main concern is that the NCSU study did not include vehicle age in the binning strategy. He summarized his concerns in his handout's Slide 3 ("NCSU Study Limitations").

On Slide 19, Mr. Slott presented results of a multiple regression analysis on Missouri remote sensing data. Jeanette Clute (Ford) asked whether the data set would be the whole fleet that is out there now. Mr. Slott replied that the data set is the whole fleet in Missouri that went through the I/M (inspection and maintenance) program, had valid remote sensing readings, had an odometer reading within 3 months of the vehicle's I/M inspection, and was measured in the year 2000. Ms. Clute asked whether tier-level effects were evaluated, in relation to durability requirements. Mr. Slott responded that tier-level effects were not considered, because tiers were phased in after the data were collected.

Mr. Norowzi asked how odometer readings were taken. Mr. Slott answered that they were taken manually, and he added that some obvious errors came out of the analysis, among older vehicles. Mr. Norowzi asked what possible causes of the errors were, and Mr. Slott replied that errors can be attributed to a combination of factors–odometers rolling over 100,000 miles; incorrect readings; and odometer tampering (rolled-back odometers).

NCSU's Response to Comments

Mr. Koupal noted that the NCSU study was simply a proof-of-concept study that only looked at Tier 1 vehicles. Thus, no strong age effect would be expected. It was a limited study conducted over a limited time.

Chris Frey (NCSU) thanked Mr. Slott and Mr. Koupal for their comments, then provided a response to Mr. Slott's comments. His response was brief due to the short time remaining for the telephone conference line. He said NCSU had 10 key questions and focused on Tier 1. NCSU used a data set based upon dynamometer and onboard measurements of 95 vehicles (representing 230,000 seconds of data) to calibrate the model, and also did comparisons based upon a data set

of 200,000 vehicles measured using remote sensing dat in Missouri. Mr. Frey noted that there are siting limitations for remote sensing that make certain activity patterns difficult to study. In addition, the brief duration (less than 1 second) over which remote sensing data are measured limits the usefulness of the data relative to onboard data. In response to Mr. Slott's comment on Slide 4, he explained that the bootstrap simulation that was used in some cases is a numerical method for estimating confidence intervals. He added that uncertainty in fuel consumption would have to be considered if grams-per-gallon emission factors were used to estimate grams-per-second emissions, and that there was substantial variability in gram-per-gallon emissions among the VSP bins with respect to NOx emissions.

Mr. Slott agreed that remote sensing at the wrong site results in useless data. He was impressed with the NCSU finding that no gain results from extended the averaging time beyond 1 second. He agreed that onboard data are also necessary.

Discussion on Remote Sensing and High Emitters

Mr. Slott said there are three things we need to know in order to characterize a fleet: (1) the vehicle activity data, which is how often vehicles operate under different modes; (2) emissions as a function of operating characteristics in the different activity modes; and (3) vehicle-to-vehicle variation. What remote sensing provides is vehicle-to-vehicle variation. Dynamometer ("dyno") onboard measurements give us emissions as a function of operating mode, and driving studies give us a characterization of the different driving patterns.

Mr. Koupal said he and Mr. Tierney have been debating the role of remote sensing, and he is not convinced after going through the emission analysis plan for MOVES that a vehicle can be characterized based on just 1 second of data, especially with respect to criteria pollutants. He thinks remote sensing data could be utilized in order to understand distribution and to identify high emitters, but he does not think there should be a direct comparison to dyno data for emission rates.

Doug Lawson (NREL) said he has extensive experience in using remote sensing to identify high emitters, and remote sensing works very well for that. Remote sensing identifies high-emitting vehicles that are not represented in models. Mr. Koupal asked Mr. Lawson to comment on the difference between I/M and remote sensing. Mr. Lawson says the difference is due to human behavior. Through I/M data, the well-maintained part of the fleet (the "obedient motorist") is represented. However, unregistered vehicles and those vehicles that fail and continue to operate without repair are not so well represented by I/M data. In characterizing a fleet, Mr. Lawson is also concerned with the number of high emitters and their absolute emissions.

On the VSP issue, Mr. Lawson commented that VSP measurements are not as good for identifying high emitters. His example of a shortcoming of VSP considers a vehicle with a

clogged fuel injector. Although this vehicle would be a high emitter of CO, it would have a low VSP reading because the engine wouldn't respond to the fuel being pumped through the system.

Mr. Slott said he will be giving a presentation at CRC about variability of emissions for the Missouri remote sensing data base. In that data base are some vehicles that have been measured many times. He has looked at vehicles with differing CO readings at the same VSP and at concurrent NOx readings. It is easy to see graphically that some vehicles are running intermittently fuel-rich.

Larry Caretto (California State University - Northridge) said the real usefulness of remote sensing data is for distribution. Most remote sensing data show a higher fraction of high emitters than the kinds of data bases we use to develop models. He added that in his EMFAC (EMission FACtor model to estimate emission rates) work, he looked at age data but did not observe correlations between emissions and age like those shown by Mr. Slott. Mr. Lawson said the best correlation to emissions is maintenance (or lack thereof), rather than vehicle age. Mr. Slott agreed but noted that there is not a good metric for maintenance.

Mr. Koupal said there is a section in the emission analysis report on characterizing high emitters. Instead of using the high/normal split that MOBILE used, MOVES may include a parametric distribution.

Mr. Lawson asked about the role of the new Kansas City study. Mr. Tierney said that, depending on what Kansas City ultimately contributes to the project, EPA may have a nice lineup of data, including remote sensing, dyno, and PEMS data, on the same vehicles. That would give EPA a unique picture of how these different methodologies compare, in terms of characterizing emissions both from individual vehicles and from larger sets of vehicles. Mr. Kishan agreed that a good use of remote sensing would be to determine how many high emitters are in the fleet. Mr. Tierney acknowledged that the traditional approach used to characterize fleet emissions has probably understated by some (unknown) amount the contribution of high emitters. The Kansas City study goes to extraordinary lengths to recruit vehicles that would not have participated in a study based on normal incentives, in order to see if that subset is significantly different from the subset of vehicles that would more readily participate. Mr. Slott repeated a suggestion he had made earlier, to oversample volunteer vehicles as a means of identifying bias on volunteering. Mr. Tierney replied that the Kansas City study will be in a position to do just that, with a volunteer fleet of 2,400 vehicles and a goal of testing 500 of those. He will also look at vehicles outside of that population that are not part of the volunteer fleet. The result will be remote sensing data on all the subpopulations, and it remains to be seen what stands out as the program develops.

Mr. Slott reiterated that the history of vehicles' operating parameters (for example, speed and acceleration) does influence the relationship of criteria pollutants to VSP, and this is a source of variability in remote sensing measurements. That is why site selection is so important in

understanding remote sensing measurements. He described an ESP Corporation instrument, the RSD 4000, an enhancement of which will be commercially available in the summer of 2003. This remote sensing device will include multiple speed monitors and should improve the ability to analyze remote sensing measurements.

Mr. Lawson expressed appreciation for EPA's work on remote sensing. He stated again his opinion that remote sensing emissions data may be difficult to use in MOVES but that remote sensing is useful in determining the number of high-emitting vehicles. He then brought up the issue of emissions during a "cold, cold start" (a vehicle starting cold, in cold ambient air). In fact, even emissions from a hot-stabilized car are substantially elevated in Phase 2 of the FTP (Federal Test Procedure), when the ambient temperature is below the 68 to 75 degree range. How is MOVES going to deal with non-room temperature ambient data? Mr. Lawson said he does not know whether the emission measurement difference is a percent difference or an absolute difference, but the model should account for it. The temperature issue is especially important for the well maintained part of the fleet. Mr. Koupal said MOVES will probably use temperature corrections like MOBILE does. Mr. Slott suggested that the temperature corrections be based on real data collected with onboard instruments. Mr. Koupal said the binning concept for MOVES cannot cover every aspect.

Rick Barnett (Colorado Dept. of Health) asked whether, if remote sensing turns out to be the best way to determine the distribution of high emitters, much work has been done to see if there is variation across vehicle type or model year, or from site to site, or from State to State, or through comparison of I/M programs to non-I/M programs. Colorado's Greeley study, which was looking at an entire municipality, found that you had to move remote sensors around to find unique vehicles. Mr. Slott mentioned the CRC's interim report on the E-23 project for remote sensing measurement of real world vehicle high-exhaust emitters. He said the E-23 project has data from Denver, Chicago, Phoenix, and Los Angeles, and additional data are accepted from areas using the E-23 protocol. There are 5 years of data from Raleigh-Durham, and hopefully next year Georgia Tech's data will meet the protocol. In addition, there are the Missouri data, and there are new Arizona data. The E-23 interim report looks at model year and VSP.

Referring to Mr. Barrett's question about site-to-site variation, Mr. Slott said California had tried to look at the issue in Sacramento but was unsuccessful due to administrative and technical problems. He believes the Missouri data will answer Mr. Barrett's question, but he has not yet looked at it site-to-site. When he compares sites, he said, he likes to have a site that has a very similar VSP distribution among all vehicles. Mr. Lawson said skewness from one site to another is unavoidable. People tend to drive their cars in the same places all the time, and maybe higher emitters will be found in certain places due to socioeconomic differences. Mr. Barrett said his point is that, in order to use remote sensing to determine the vehicle distribution, one needs to know how representative of the entire population the selected sites are. Mr. Lawson added that only remote sensing captures the high-end emitters.

REVISED May 23, 2003

Workgroup Participants/Attendees

Name	Affiliation
Andary, Cass	AAM
Bailey, Brent*	CRC
Barber, Mary McGarry*	Texas CEQ
Barrett, Rick	Colorado Dept. of Health
Boardman, Martin*	Texas Transportation Institute
Caretto, Larry*	California State University - Northridge
Clute, Jeanette	Ford Motor Co.
Darlington, Tom	AIR
Diegel, Harry	Ford Motor Co.
Edgerton, Stephen	EC/R Inc. (EPA contractor)
Frey, Chris*	North Carolina State University
German, John	Honda
Heirigs, Phil*	Sierra Research
Keenan, Mike*	New York DEC
Kimbrough, Sue*	EPA/ORD
Kishan, Sandeep	Eastern Research Group (ERG)
Koupal, John	EPA/OTAQ
Lawson, Doug	National Renewable Energy Laboratory (NREL)
Lax, David	API
Lenox, Katey*	Oak Ridge National Laboratory
Maxwell, Bob*	Consultant (representing AIAM)
Michaels, Harvey	EPA/OTAQ
Nam, Ed*	Ford Motor Co.
Norowzi, Behshad*	North Carolina DOT
Patel, Dilip*	California ARB
Pierson, Jim*	Georgia Tech

Workgroup Participants/Attendees (cont'd)

Name	Affiliation
Slott, Bob	Consultant
Smith, Lawrence	Southwest Research Institute
Sutton, Lisa	EC/R Inc. (EPA contractor)
Tierney, Gene	EPA/OTAQ
Wenzel, Tom*	Lawrence Berkeley National Laboratory

* Participated by telephone.