UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

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SCIENCE ADVISORY BOARD

November 24, 2010

EPA-CASAC-11-001

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Review of the "Near-road Guidance Document – Outline" and "Near-road Monitoring Pilot Study Objectives and Approach"

Dear Administrator Jackson:

The Clean Air Scientific Advisory Committee (CASAC) Ambient Air Monitoring and Methods Subcommittee (AAMMS) met on September 29-30, 2010 to review EPA's Near-road Guidance Outline and Near-road Monitoring Pilot Study Objectives. The attached CASAC report was approved at a public teleconference on November 8, 2010. The impetus for the development of near-road monitoring guidance comes from the recent revisions to the primary National Ambient Air Quality Standard (NAAQS) for NO_2. In its revisions to the primary NO_2 NAAQS issued on February 9, 2010, EPA set out requirements for an NO_2 monitoring network that includes monitors at locations where maximum NO_2 concentrations are expected to occur, including within 50 meters of major roadways.

Although the requirement for near-road monitoring comes from the revised NO_2 rule, EPA's Office of Air Quality Planning and Standards (OAQPS) is developing guidance for an expanded monitoring capability to be used for a variety of pollutants, pursuant to the Agency's commitment to multi-pollutant monitoring approaches. OAQPS sought CASAC's advice in developing a guidance document for state and local monitoring agencies as they implement the NO_2 near-road network that is required to be operational by January 1, 2013. OAQPS also sought CASAC's advice on the objectives and design of a near-road monitoring pilot study that is intended to inform EPA, state and local air monitoring agencies on siting issues.

CASAC recognizes the importance for public health of better characterizing near-road pollutant concentrations. In implementing near-road monitoring in the context of the NO_2 NAAQS, EPA unavoidably faces major issues that are described in detail in the responses to the charge questions and highlighted in this letter:

- While NO_2 historically has been used as the indicator for ambient oxides of nitrogen (NO_x), it is one of multiple gases comprising NO_x,which also includes nitric oxide (NO), nitrous acid (HONO), and other species. CASAC notes that the ratio of NO_2 to NOx varies substantially, and NO_2 concentrations can significantly under represent NO_x levels in the near-road environment;
- The epidemiological evidence on NO_2 is largely based in the population-oriented monitor data. If these monitors are not maintained in sufficient number, continuity of data will be lost, both for health research purposes and for tracking trends of NO_2 concentration;
- In moving to implement near-road multi-pollutant monitoring, EPA will need to find a way to optimize siting for measuring concentrations of the various pollutants included in the platform. For example, the optimal siting for NO_2 may not be the same as for CO.

CASAC was asked to comment on two short documents: "Near-road Guidance Document – Outline" (a 1-page document) and "Near-road Monitoring Pilot Study Objectives and Approach" (a 4-page document).

EPA's draft Near-road Guidance Document – Outline provided a very preliminary list of the general factors that should be considered in developing a near road monitoring network, including those factors that should be considered in siting monitoring locations. However, the objectives of the network are not well defined in the current outline. High priority should be given to developing clear objectives and providing a rationale for each.

EPA's Near-road Monitoring Pilot Study Objectives was also a very brief overview of the objectives for a real-world pilot study in near-road monitoring implementation. With respect to the factors EPA is considering for siting monitors, we note that the primary focus of the monitor site selection process is on annual average daily traffic (AADT). However, the approach may place too much weight on these data. Other factors to be considered include the physical characteristics and the patterns of vehicle use at the site (e.g., fleet mix, roadway design, congestion patterns, terrain, etc.), modeling information, and preliminary monitoring studies (e.g., results of multiscale/saturation studies). CASAC suggests that EPA should allow states and local agencies to bring as much information to bear on the site selection process as is appropriate, with prioritization of installation of sites based on review of all relevant data in discussions between monitoring agencies and EPA offices.

We encourage evaluation of the use of a "true" NO_2 monitor and inclusion of this instrument in the near-road monitoring program. We endorse the views expressed in the letter of August 19, 2010 from the National Association of Clean Air Agencies to Assistant Administrator Paul Anastas encouraging ORD "to increase its focus on the development and advancement of ambient air monitoring reference, equivalent and other sampling and analytical methods." Measurement methods germane to near-road monitoring mentioned in that letter include those for $PM_{2.5}$, $PM_{10\text{-}2.5}$, and ultrafine particles. We also urge EPA to address known biases in measurements made with the NO_2 FRM.

As a general matter, CASAC is deeply concerned about the timing proposed for the current network deployment, as well as for the Pilot Study. The revised NO_2 NAAQS, issued on February 9, 2010, mandates that state and local air monitoring agencies deploy the near-road network by January 1, 2013. This ambitious schedule may make it difficult to absorb lessons learned from EPA's Pilot Study to evaluate and improve the siting and monitoring process. If possible, given this mandated date of deployment, EPA might consider deploying the network in stages over time, e.g., 10-20 sites the first year, 20-40 the next and the rest in the final year. As part of this staged approach, EPA should consider using near-road sites appropriately paired with sites from the National Core (NCore) monitoring network that is set to come online January 1, 2011 in the first round deployment. Consideration should be given to areas with larger populations. Such a staged approach would be consistent with the recommendations from the CASAC Oxides of Nitrogen Primary National Ambient Air Quality Standards (NAAQS) Review Panel (see Samet, Sept. 9, 2009). In this way, the network can evolve based on lessons learned from the Pilot Study as well as from the operation of the initial sites.

CASAC is concerned that there could be a decrease in the number of population-oriented NO_2 monitors in the new network. Many of the health studies that were considered in the latest NAAQS NO_2 review were based on the population-oriented monitors of the current network. CASAC strongly recommends that a great majority of these monitors be maintained, particularly those that have been used in past health-focused studies. By maintaining these monitors, air quality trends could be tracked without discontinuity.

Just as we recommended a staged approach to the deployment of the near-road monitoring network, CASAC also recommends a tiered approach to the design of the near-road monitoring sites. A few sites should be comprehensively equipped such that they can provide comprehensive information about the composition of mobile source emissions and how pollutant concentrations and mixtures change over time with changes in sources and control measures. The bulk of the sites could be more modestly equipped. For example, the modestly equipped sites would [also] include optical black carbon (as a surrogate for elemental carbon), carbon monoxide (CO), meteorology and ultra-fine particulate matter (PM) monitoring capabilities responsive to the needs for assessing attainment with the applicable standards and the extent of near-road pollution exposure, as well as for use in health studies. We provide more detail in our responses to the associated charge questions.

State and local resource constraints are another cause for concern, particularly in view of this schedule. For all of the criteria pollutants as well as for NO_2 specifically, CASAC encourages EPA to commit the resources necessary to focus on the development and advancement of ambient air monitoring methods, with specific attention paid to assessment and possible modification of the Federal Reference and Equivalent Methods. We are concerned that the current time frame for the NO_2 near-road network may not allow adequate time to appropriately plan and execute the Pilot Study and then to interpret and use the resulting findings in designing the near-road network. The decisions that will be made have broad implications related not only to NO_2, but to other criteria pollutants and the characterization of multiple-pollutant exposures from roadway sources.

CASAC appreciates the opportunity to provide input to EPA at this early stage in the process. The CASAC and AAMMS membership is listed in Enclosure A. CASAC's consensus responses to the Agency's charge questions are presented in Enclosure B. Individual review comments from the AAMMS are compiled in Enclosure C.

Sincerely,

/Signed/

Dr. Armistead (Ted) Russell, Chair
CASAC Ambient Air Monitoring & Methods Committee

/Signed/

Dr. Jonathan M. Samet, Chair
Clean Air Scientific Advisory Committee

Enclosures

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Enclosure A

U.S. Environmental Protection Agency
Clean Air Scientific Advisory Committee
Ambient Air Monitoring and Methods Subcommittee for the
Review of Near-Road Monitoring to
Support Measurement of Multiple National
Ambient Air Quality Standard (NAAQS) Pollutants

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Enclosure B

Consensus Response to Charge Questions on Near-Road Monitoring to Support Measurement of Multiple NAAQS Pollutants

Questions on Near-road Guidance Outline

1. **The accompanying draft guidance document outline provides an initial thought of the major topics required in the near-road monitoring guidance that will aid state monitoring agencies in the identification and implementation of NO_2 near road monitoring sites from a multi-pollutant perspective. Please comment on the overall content of the recommended topics in the draft outline. Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.**

It is not clear that EPA has identified the reasons (scientific and regulatory objectives) for the multi-pollutant monitoring. We recommend that EPA clearly identify the monitoring and associated scientific objectives for the near-road monitoring program, and then build the document around these objectives. A possible set of objectives focused on NO_2, for example, might be:

- Identification of hourly averaged NO_2 by the most artifact free method available.
- Identification of hourly averaged concentrations of other NAAQS pollutants which accompany the observed NO_2 concentrations.
- Identification of the atmospheric processes which contribute to the observed concentrations of NO_2.
- Identification of the sources which contribute to both measured concentrations of NO_2 and the other measured NAAQS pollutants

The document should then discuss fully the objectives and the scientific and regulatory bases for these objectives in the Introduction. This will, in turn, support the selection of the recommended pollutants to be monitored in the program and the protocols to be followed.

In addition, we suggest the following more minor areas where the Guidance Document needs strengthening.

- General. The success of the near-road pilot project is critical to the future deployment of the 126 near-road monitoring sites by the end of 2012. Thus timing (and resources) are tight. EPA needs to focus on defining the objectives for the program and identify those key elements of the program essential to meeting those objectives. EPA needs to identify how to leverage existing sites, how the sites will be operated, how the data analysis will be accomplished, and how many sites are needed to meet the objectives of the program. Finally we encourage EPA to evaluate the near-road excess (or deficiency) for key indicators, e.g. NO_2, CO, black carbon, ultrafine particles. This will necessitate background measurements (ideally made at an appropriate existing sites) which allow an estimation of the gradient away from the road.

- Background. The background should document the scientific and regulatory bases for the multi-pollutant objectives, as outlined in the bullets above. The literature review needs to be more comprehensive than at present. Some guidance on possible literature to site is included in individual responses. A conceptual model should be formed in this section that includes dispersion, deposition, chemical conversion and physical conversion. Special attention should be given to NO_2 formation by the titration of O_3 and NO_2 depletion by photochemistry. The Background section should acknowledge that finding a site where NO_2 and the various measured other pollutants all have the highest concentrations is not likely and compromises will be necessary and acceptable.

- Identifying Candidate Near-road Site Areas. We believe the criteria outlined for this section are generally adequate for the identification of a site where near maximum NO_2 concentrations near a given near-road site may be determined. However, there is an apparent assumption that AADT is the primary siting criteria. The importance of meteorological and terrain variables should be emphasized. Further, since NO_2 is a pollutant affected by both emissions from the roadway and nearby elevated pollutants (VOC, ozone, etc.), these factors should be considered in the site identification process. One critical element missing from the outline is the importance of the specific distance from the roadway chosen for study. The effect of differences in the gradient from the roadway of the multi pollutants studied needs to be acknowledged and discussed.

- Modeling. This section should include a discussion of the types of models available and databases that can be used to inform the siting process. The models discussed should include both emissions and air quality models.

- Monitoring. This section should provide a summary of methods used in past roadside measurement studies, passive and active monitors that can be efficiently deployed at many locations and methods to interpret the data acquired. The emphasis at this level should be on the identification of high "true" NO_2 hourly average concentrations. Care needs to be taken to insure that the use of mobile monitoring methods give results that do reflect the diurnal and seasonal locations of peak concentrations.

- Near-road Site Selection. The items outlined here seem reasonable. This section might draw from some of the existing guidance for sampler siting.

- Recommended Near-road Site Documentation. The adequacy of this section will depend on the EPA objectives for the Pilot Study in addressing the appropriate multi-pollutant monitoring objectives. This will be better defined as the objectives of the near-road monitoring program are better defined.

2. **EPA and NACAA envision the near-road guidance document to be written from a multi-pollutant perspective. What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g., benzene, toluene, xylene, formaldehyde, acrolein, or 1, 3, butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.**

The list and ranking of pollutants varied across the AAMMS members. Some questioned the usefulness of these indicators for the compliance purpose. The following ranking is based on the votes for the pollutants that had at least five votes from thirteen members of the AAMMS who submitted votes, taking into consideration the average ranking and its variability. The AAMMS believes meteorological parameters (wind speed and direction) should be one of the highest tier measurements considered as part of this network. Several members considered traffic counts as potentially important information. Other pollutants mentioned by some members include “true NO_2” measured by techniques such as photolytic conversion difference, hourly metals by automated on-line XRF, and nephelometer measurement.

CASAC recognizes that not all of the pollutants on the list can be measured at all the sites because of the level of the cost and operational logistics. Therefore, the AAMMS recommends a tiered approach, in which a few of the sites would collect a more comprehensive set of pollutants, while a majority of them would measure only the first tier of pollutants in the list. We recommend that all of the data be obtained on an hourly averaged basis to allow intercomparison. We recognize this ranking could change depending on EPA’s objectives for the monitoring network and the evolution of priorities.

Pollutant group	Rationale and comments
NO_2, NO, NOx	• Same instrument
Black carbon	• Diesel tracer • Potential health relevance • Continuous methods available • Not a direct measure of carbon
CO	• Gasoline vehicle tracer • Dilution factors • Potential health relevance

	• Continuous methods available • Pending new NAAQS
Ultra-fine particles / particle number concentration	• Strong roadside gradient • Potential health relevance • Continuous methods available
Particle-size distribution	• For a limited number of sites • Potential health relevance • More comprehensive health relevance than just particle number
$PM_{10-2.5}$	• Potential health relevance • Re-suspended roadside particles • Speciation for metals • Important in future PM NAAQS reviews
$PM_{2.5}$	• Continuous methods available • Potential health relevance • Speciation for metals, major components and organic marker compounds • Possibly include semi-volatiles
EC/OC	• Potential health relevance • Direct measure of carbon
CO_2	• Normalization of pollutants to CO_2 allows estimation of fuel-based emission factors • Could be important if signal large enough
Ozone	• To understand photo-chemical processes • Not to be used for health effects analysis
NOy	• Total nitrogen oxides and mass closure
SO_2	• To verify fuel content compliance • Pending new NAAQS
BTEX (benzene, toluene, ethylbenzene, and xylenes) and 1,3 butadiene	• Potential health relevance • Continuous methods available • Provides unique information as to how changing fuel characteristics and control systems are impacting emissions • Can provide additional info on which class of vehicle is impacting monitor

3. Identifying Candidate Near-road Site Areas

a. AADT & Fleet Mix – To consider fleet mix with regard to NO_2, an idea is to encourage states that have fleet mix information to take an approach that uses average, fleet-wide grams per mile emissions estimates (one for light duty vehicles and one for heavy duty vehicles), combined with AADT information to further weight which road segments in an area may be more conducive to produce peak pollutant concentrations. EPA would use the latest emission factor information to aid such a calculation. Given the variability in

emission rates from on-road vehicles based on vehicle technology, fuel, speed, environmental conditions, etc., does the subcommittee believe this approach is an appropriate way to "consider" fleet mix in near-road site selection or is a more refined inventory and modeling analysis required?

b. **AADT & Fleet Mix – Further, should the suggested approach above in question 4a to consider fleet mix via the use of average, fleet-wide emission factors, or the use of inventory and modeling analysis, take into account mobile source controls that are "on the books" but have not yet been fully realized due to fleet turnover? If so, how far out into the future should states consider their effects?**

c. **Roadway Design – Studies suggest and support the concept that roadway design influences pollutant dispersion near the road. The EPA suggests establishing sites at-grade with the road, without any nearby obstructions to air flow; however, the Agency recognizes that this might not always be feasible. Does the subcommittee agree with this recommendation for locating sites at-grade with no obstructions? What priority should be placed on this factor within the guidance, given the need for flexibility in identifying appropriate site locations?**

d. **Congestion Patterns – The congestion of a roadway can be estimated by the metric "Level of Service" (LOS). LOS uses a letter grade from A to F to identify a roadway's performance, with "A" the best conditions where traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes to "F" the worst congestion where travel time cannot be predicted and generally traffic demand exceeds the facility's capacity. Since motor vehicles generally emit more pollutants during congestion operations (although noting that NO_x and select other pollutant emissions can also increase with increasing speed), how important a parameter should LOS be in the determination of appropriate near-road monitoring sites? Does the subcommittee have a view on how reliable LOS estimates are across the country?**

e. **Terrain– State and local air agencies are required to consider terrain in the near-road monitoring site selection process, which in some cases may be inherently part of the roadway design. However, EPA recognizes that some states and local air agencies may have to make selections from amongst similar candidate sites that differ only by terrain, e.g. cut section versus open terrain, with or without vegetation, etc. Does the subcommittee agree that terrain and vegetation should be a consideration in the siting process? What priority should this parameter have in the overall process?**

f. **Meteorology – EPA took comment on, but did not finalize the requirement for near-road monitoring sites to be climatologically downwind of the target road segment. Reasons were because the additional limitations this would introduce in finding candidate sites would be in exchange for what may be a small increase in the**

opportunity to monitor peak NO_2 concentrations. Further, with sites being within 50 meters of target road segments, the phenomenon of upwind meandering (pollutant transport upwind due to vehicle induced turbulence) further reduces that absolute need to be climatologically downwind. Finally, EPA recognized that, logically, the potential for peak NO_2 concentration may very well occur when winds are calm or parallel (or nearly parallel) to the target road, allowing for pollutant build-up, as opposed to when winds are normal to the road. Although there is no requirement to be downwind, in the preamble to final NO_2 NAAQS rule, EPA encouraged it when possible. EPA and NACAA intend to do the same in the guidance document. Does the subcommittee agree with this approach?

The specific factors identified in this charge question can all usefully inform the selection of near-road monitoring locations. An additional factor that may exhibit characteristic gradients in larger metropolitan areas is the middle-scale oxidant or odd-oxygen concentration, $[O_3]+[NO_2]$. A factor that needs emphasis is the role of freeways with high truck traffic volumes. As NO_x and VOC emissions are continuously reduced over time, ambient oxidant levels will also go down, which means that titration of NO by ozone to form NO_2 will become less important in comparison to direct NO_2 emissions from new and retrofitted diesel trucks. NO_2 emissions are highest during cruise mode, not congestion conditions for these trucks. CASAC recommends against giving too much emphasis to AADT, noting for example that peak NO_2 concentrations can occur in areas where widespread congestion limits AADT. To account for such interactions between different determinants of NO_2 , the Agency should consider developing a conceptual or screening model to guide their integration. This model would be intended as a tool to help rank candidate locations, and would not require quantitative concentration predictions. Recognizing the near-road NO_2 measurement's intended focus on NAAQS compliance rather than population exposure, CASAC stresses the importance of exposure in the overall balance of siting considerations.

In response to specific elements of this charge question, CASAC's recommendations are as follows.

a. States and cities vary considerably in the resolution of information available for fleet characteristics and fleet mix. States can be encouraged to use all available data in their planning, including local features such as truck and bus corridors.

b. Ambient monitoring is conducted in the 'here and now'. Fleet turnover is too slow to require consideration of its future effects in the initial planning. However, the transition to 'cleaner' diesels may have the effect of increasing the ratio of NO_2 to NO_x in primary tailpipe emissions of NO_x.

c-e. CASAC agrees that roadway design, terrain, and congestion patterns all merit consideration. Information from loop monitors should also be considered. As noted above, it recommends that the interactions and tradeoffs among their effects be accounted for in a screening tool developed by the Agency for this purpose.

f. CASAC agrees that it is undesirable to site a near-road monitor climatologically upwind.

4. Modeling is another tool that may be useful in the identification of candidate near-road sites. In particular, the use of mobile source emissions modeling with MOVES and local-scale dispersion modeling with AERMOD, can be presented as part of the guidance document. Please comment on the available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.

Like the various considerations discussed in Charge Question 3, modeling tools can also be used to inform the likely location of the maximum NO_2 levels in an area. Taking a centralized (e.g., EPA led) approach, emissions and air quality models could be used to develop screening tools or screening criteria that incorporate many of the factors discussed in Charge Question 3. Alternatively, the models could directly be used by state and local agencies to inform the siting process. MOVES, along with other emissions inventory modeling tools, can provide valuable information about the spatial intensity of traffic-related NO_x emissions, as well as NO_x emissions from other sources. MOVES is a link-based model which has significant advantages for this application over the historical emissions models that were based on trip-average cycles. Air quality models, such as the CMAQ and CAMx chemical transport models and the AERMOD and CALINE dispersion models, can also be used to help identify candidate geographic areas within the metropolitan area and to compare and contrast candidate specific candidate monitoring sites, respectively. It is appreciated, however, that there significant uncertainties associated with the use of models for simulating the location of an extreme concentration statistic. The approaches used by AERMOD to simulate the conversion of NO to NO_2 are relatively crude, and guidance should be given as to which approach should be used. State and local agencies should be encouraged to use spatially-resolved emissions estimates, and air quality model results if readily available or available with relatively modest effort.

5. In regard to the process of identifying candidate near-road monitoring sites, beyond the evaluation of factors noted above in question 3, and the potential use of modeling, the use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process.

"Multi-scale" monitoring is a more specific term than saturation monitoring. Before the pilot study or site selection, a literature review should be conducted that summarizes past roadside measurement and modeling studies, passive and active monitors that can be efficiently deployed at many locations, and methods to interpret the data acquired. Roadside monitoring for site selection and long-term monitoring would benefit from small, portable sensors that don't require a large infrastructure (i.e., shelter, air conditioning, etc.) to operate. A pilot study plan should be assembled to clearly define the objectives of locating the sites (i.e., maximum hourly NO_2 concentration), rationale for the selection of the measurements, measurement principles, concentration range, minimum detection limits, and potential interferences and biases. It should also elaborate on method intercomparison and modeling approaches.

Sampling sites should be located at the prevailing downwind location in an array (e.g., to estimate perpendicular vs. effective distance from the road; Barzyk et al., 2009). The number of sampling sites would depend on the downwind distance in the micro- (10 – 100 m), middle- (100 – 500 m) and neighborhood- (500 m – 4 km) scales.

Portable active or passive monitors that can be easily and inexpensively deployed would provide a good indication of where concentrations might be highest. Levels are likely to vary by season and often show an exponential decrease with distance from the curbside. Passive monitors using NO_2-absorbing filters have some potential biases, but they have also been shown to be comparable and correlated with continuous measurements for integration times on the order of weeks. Passive samplers are a cost-effective and practical technology for mapping average spatial gradients as a prelude to sampler siting. However, the validity and sensitivity of the portable active or passive NO_2 sampling systems for hourly measurements needs to be verified. To get better precision, collocated continuous monitors with duplicate passive samplers are needed at some of the sites. Past studies show an average coefficient of variation for duplicate passive NO_2 measurements of 5 – 30%

a. **If a state were inclined to use saturation monitoring to aid in the selection of a near-road monitoring site, and considering that the NO_2 standard is a 1-hour daily maximum standard, what are the pros and cons to using passive devices to saturate an area to gather data?**

Pros are low expense and operating cost. The major con is the much longer than one-hour averaging time, unless the passive device is modified to obtain active hourly data. The key is to avoid the need to relate long-duration passive sampler NO_2 measurements to the one-hour NO_2 NAAQS, which is defined as the maximum allowable concentration in an area (primarily near major roadways), expressed as a three-year average of the 98th percentile of the annual distribution of daily maximum one-hour concentrations. One option is to collect samples from sub-daytime periods (e.g., morning and evening rush hours) that are integrated over several days. A timer-based sampler may be used for this application. If many of the passive samplers are used for multi-scale monitoring it is important to position the sampling inlet at the same height (2 - 7 m above ground) at all sites

b. **Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive Semiconductors (GSSs) for NO_2 and other pollutants of interest?**

Pros are short-duration samples, on the order of an hour or less. Cons are instrument procurement and operating expense, potentially higher than desired detection limits, and reliability of new technologies. There are several currently available or emerging technologies for microsensors. In addition to NO_2, NO can often be obtained from these same sensors. Miniature sampling systems have been used for remote monitoring, emission sampling, and unmanned aerial vehicles, and these might also be used for multi-scale monitoring These portable instruments need to be evaluated with regard to their sensitivity, stability, and accuracy.

c. **Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the near-road site selection process for NO_2 specifically as well as other pollutants of interest?**

Several mobile emissions systems or instrumented mobile vans have been applied to characterizing on-road and roadside concentrations. Pros are that these systems are moveable and obtain many different pollutant measurements. Unless state or local agencies are already equipped with a mobile sampling van, the disadvantages are the high cost of assembling or contracting these laboratories and the snapshot nature of their measurements. They often need to be attended and can be parked for only a short time period. However, mobile monitoring systems are useful for site selection if they can be parked at the same location and perform sampling for a few days to one week. The state or local agencies may also consider using a fully-equipped trailer rather than a mobile van for siting. Eventually, the trailer can be converted to a permanent monitoring location.

6. **EPA recognizes that CO concentrations are primarily influenced by gasoline vehicles as opposed to NO_2 and $PM_{2.5}$ concentrations, which are currently more heavily influenced by heavy-duty (diesel) vehicle emissions. If EPA were to propose a new set of minimum monitoring requirements for CO near roads, the near-road monitoring stations created under the implementation of the NO_2 monitoring requirements may be an advantageous infrastructure for state and local air agencies to leverage. However, EPA believes there are two issues not specifically considered in the near-road NO_2 monitoring language that might influence where near-road CO monitors may be most appropriately placed. The two issues are 1) the consideration of where light duty vehicles are operating under 'cold-start' conditions, which may often not be on the larger arterials or highways in an area, and 2) the impacts of light duty vehicle congestion and idling in areas such as urban street canyons and/or urban cores.**
    a. **Does the subcommittee believe that the light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area? What priority should these factors be given when compared with the factors (AADT, Fleet Mix, Roadway Design, Congestion Patterns, Terrain, and Meteorology) already being considered for peak NO_2?**

The spatial distribution of cold start vehicles associated with urban commuting is in general broad and short term and their contribution to emissions associated with major highways adjacent to residential neighborhoods is likely small. To the extent cold start emissions contribute, they would mainly be in terms of CO and not NO_2 concentrations and would not likely influence peak CO concentrations. That being said, at least one exception comes to mind. The departure of motor vehicles from major events (e.g. stadiums) where 20-30K vehicles may be simultaneously started and caught in congestion for 10s of minutes to an hour or more. The cold start contribution, here again, is limited in time but could contribute significantly as an emissions hot-spot impacting commuter exposes and concentrations in nearby neighborhoods. The prioritization of congestion and cold start factors relative to AADT, fleet mix, roadway design, terrain and meteorology should consider sensitivity analyses using line source models as outlined by the FHWA's procedures for assessing traffic impacts for CO.

b. Does the subcommittee have an opinion on whether, and possibly how, these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal? Are there other factors that may affect peak CO concentrations and not affect peak NO_2 concentrations that should also be considered for any future CO monitoring proposal?

Factors that affect near-road CO and NOx concentrations will be the distribution of gasoline and diesel vehicles. The primary NO_2 fraction of NO_x exhaust emissions will vary with engine type (gasoline spark ignition or diesel) and control equipment, e.g., three way catalyst and diesel particle filter trap technologies. CO emissions come principally from the gasoline engine exhaust and their peak concentrations will occur in the immediate vicinity of the emission source. While NO_2 peak concentrations from primary emissions will behave similarly to CO, NO_2 peak concentrations from secondary reactions will lag behind as NO emissions react with entrained ozone to form NO_2. The entrainment and transformation time afford the opportunity for the exhaust plume to transport and diffuse resulting in peak NO_2 concentrations that are displaced in time and space as compared to CO.

Idling in urban street canyons is problematic and should be discouraged. If, as in most cases, it is due to major traffic congestion it will result in high exposures involving commuters, pedestrians and local residence. Decisions to monitor at such locations must consider these exposures relative to other near-road exposure environments associated with high density population regions.

7. Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?

The majority of panelists acknowledged that there is an increment to $PM_{2.5}$ in the near road environment. They did not suggest that the near road environment will represent the areas of highest $PM_{2.5}$ concentration. This is due to the variety of sources of $PM_{2.5}$ including the combination of primary emissions and secondary formation processes. The committee was also generally in agreement that mass based measurements and specifically the $PM_{2.5}$ FRM is not appropriate for use at the near road NO_2 sites. The $PM_{2.5}$ FRM measurement has poor capture efficiency for the highly volatile emissions from mobile sources and is not suitable for the collection of hourly averaged data. The use of this method in the near road network would underestimate the significance of mobile sources and under predict the risk associated with this source of $PM_{2.5}$.

In general, the locations where maximum $PM_{2.5}$ concentration are likely to be found include areas that are subject to regional transport and local stationary and area sources, are primarily urban, and are away from sinks of PM including ventilated roadways, heavy vegetation and water bodies.

The Panel also discussed other fractions of PM in the near road environment including ultrafine particle count and size distribution and coarse PM (PM_c). The siting for measurements of these size fractions are more suited to the near road environment. However, because the processes that affect downwind concentrations of NO_2, UFP and PM_c differ (Karner et al. 2010*), optimal downwind sites for those pollutants may also be different.

8. **In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?**

Other PM measurements that should be considered include sub 100 nm ultrafine particles (UFP), BC, and speciated coarse particles.

BC is an important vehicular emission that can be measured routinely in sampling networks. We recommend that it be measured.

Measurements of UFP could be made either with a condensation particle counter (CPC) or an aerosol mobility spectrometer. A CPC measures the total concentration larger than the CPC's minimum detectable size but provides no information about size. Mobility spectrometers provide information about particle concentration and size, which would be valuable for understating new particle formation and assessing health effects. Given current resource constraints, state and local agencies might be unable to collect and analyze data from mobility spectrometers. However, agencies might work collaboratively with interested universities. This would likely lead to a nested network design, with most

* Karner, A. A., Eisinger, D. S. and Niemeier, D. A. (2010). Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data. *Environ. Sci. Technol.* 44:5334–5344.

stations using CPCs and a more limited number aerosol mobility spectrometers. Mobility distributions are currently being measured routinely in sampling networks worldwide.

Vehicles emit coarse particles and resuspend coarse road dust that may be coated with toxic contaminants. We recommend measurements of the coarse particle metal content at the well instrumented sites.

Questions regarding the monitor siting criteria for microscale CO, microscale $PM_{2.5}$, and the new near-road NO_2 siting criteria

9. **To allow for near-road monitoring infrastructure to be multi-pollutant, and in reflection of the recently promulgated near-road NO_2 siting criteria, reconsideration of the existing microscale CO siting criteria presented in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E may be warranted. Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate?**

CASAC recommends that sampling criteria for CO and other monitors at sites installed to monitor near-road NO_2 match those for NO_2. The sampling configurations of existing micro-scale CO monitors should be assessed in terms of their own sampling objectives, and need not necessarily conform to those of near-road NO_2 monitors.

10. **Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale $PM_{2.5}$ and microscale near-road NO_2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?**

The Panel did not feel it had enough data to make a recommendation with respect to this charge question.

11. **Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?**

To define "urban street canyons" in relevant regulations, CASAC offers the following factors for EPA's consideration. EPA might also consult experts in other relevant disciplines to further refine this definition.

- Traffic information such as AADT, fleet mix, posted speed limit or/and actual speed, traffic light cycle
- Street geometry

    - Ratio of the height of street side buildings to the width of the street (H/W ratio). Some approaches need to be developed to treat the following scenarios for H/W ratio calculation
        - different heights of buildings on the two sides of the street – use the lower one or use the average. Using the lower one may be better.
        - tiered buildings – possibly use the average of all tiers, or use a graduated factor based on the angle between the vertical line and the line drawn along the tiered building – the larger the angle (more opening on the top of the street canyon), the lower the effective height (H_e) will be used in the H/W calculation.
    - One-way vs. two-way street (more plug flow in a one-way street and more turbulent flow in a two-way street).
    - Is the street lined with trees on the sidewalk? Tree canopy may have an effect of an umbrella and trap portion of pollutants at the street level.
    - Slope of the street – higher vehicle emission on steeper streets unless it is a one-way street and the traffic direction is downhill.
    - Some way to normalize the H/W ratio with respect to number of traffic lanes on the street. One approach would be modifying the H/W ratio to H*L/W, where L = number of lanes.
- Meteorological factors: Frequency of calm conditions and/or drainage flow may influence concentrations.
- Terrain: The angle between the street and prevailing wind direction (higher concentrations are expected if the angle is 90 degree).

Although a set of cut-off values reflecting the above mentioned factors could be used to define urban street canyons, it is not advisable to set some clear-cut criteria (insufficient information exists to set clear-cut thresholds). It may be more appropriate to consider a street an urban street canyon if more than a certain number of these conditions are met. This will be a qualitative approach to define urban street canyons.

For the definition of “urban core”, the CASAC has some suggestions for EPA to consider. EPA may use the U.S. Census Bureau definition of an “urban area” as a starting point. Per U.S. Census Bureau, an urban area is defined as "Core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile." Land features such as a river or a ridge may divide a CBSA into multiple urban cores. EPA may use population density to rank urban cores. EPA may further enhance this definition by factoring in “traffic density”, which could be calculated as the sum of AADT for every unit of road length (e.g., a length comparable to street block) in an area under consideration divided by the size of the area.

Questions regarding the near-road monitoring pilot study

12. EPA and NACAA will select the locations for permanent sites that are part of the near-road pilot study based on which state or locals volunteer to

participate and can process grant funds in a timely manner to deploy equipment. From this pool of volunteers, selection should be made on certain attributes that provide the best potential to fulfill pilot study objectives. In the attached draft white paper, EPA and NACAA have proposed some potential criteria for consideration in selecting where the fixed, permanent stations should be located. These considerations include choosing a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NO_X analyzer representative of neighborhood or larger spatial scales for comparison to the near-road NO_X analyzer, and an urban area with a cooperative (or non-cooperative) Department of Transportation. Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study?

Available funding constrains this near-road pilot to only 2 or 3 sites unless EPA leverages existing sites and infrastructure that are near-road-ish, possibly considering cities that are already conducting multi-pollutant assessment at multiple locations (Atlanta and New York City for example). Areas with existing "urban background" sites that have relevant near-road pollutant measurements in place (that may include ozone for a measure of total urban oxidants) are desirable to assess the near-road excess for key pollutants. The range of variables in this charge question cannot be fully evaluated with only a few sites. In reality, given the severe constraints of funding and timing for the pilot, the siting decision may be driven largely by which S/L agencies have the resources to support the pilot work and where they can find and deploy a reasonable site quickly. With only 2-3 sites, it may be appropriate to choose "generic" sites (avoiding extremes of topography, etc.) that are most likely to represent a large fraction of the final network and are near the middle of the 0-50 meter distance from the road (e.g., ~ 20-30 meters) and have HDD as a significant fraction of traffic. Reliance on AADT or an MSA's population are useful inputs but often may not be good indicators of the location of the maximum 1-hour NO2.

The pilot fixed sites are not likely to inform how a wide range of siting characteristics would affect 1-hour NO_2 concentrations. We might come closer to that goal by focusing the pilot on NO_2 saturation studies with less emphasis (e.g. funding) on the fixed sites, but that is not a practical solution to the other goals of this pilot. There is some evidence suggesting that core urban zones not at large roadways may have the highest 1-hour NO2 values for some urban locations; saturation studies are ideal for assessing these sites. Cooperation of the local DOT may be useful for local traffic pattern characterizations. It may be worth encouraging academic or private sector groups to add in-kind supplemental measurements if that does not create multi-organization logistical issues. Finally, EPA, California Air Resources Board and several research groups have mobile monitors that could be deployed to quickly assess potential locations of highest 1-hour NO_2 concentrations.

13. **EPA and NACAA have proposed that at least two urban areas should have permanent near-road monitoring stations (that would fulfill NO_2 near-road**

monitoring requirements) implemented for the pilot study. Please comment on the *minimum* equipment/pollutant measurement complement that should be deployed at each site and also the *ideal* equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO2, NOX, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3, butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts.

The majority of AAMMS supports the deployment of at least two pilot study sites with a minimum measurement suite of NO_2/NO/NO_x , black carbon, particle number concentrations (UFP), CO, meteorological parameters, and traffic counts; and ideally the pollutant measurements tabulated in the response to Charge Question #2. Measurements for vehicle class and speed distributions are also encouraged, especially if a screening tool will be developed because this information can be used in its evaluation. If an FEM-approved photolytic NO_2 monitor is available, its deployment along with an FRM NO_2 monitor at each site is strongly encouraged. Other AAMMS members support the deployment of a single site with more extensive measurements to provide insights into key science questions about NO_2. This would require a longer time commitment than currently programmed for the pilot study, but would ultimately better inform the regulatory process. Additional pilot study objectives could include the evaluation of passive sampling methods to be used in the saturation studies.

14. **EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on:**

    a. **The pollutants that should be measured with the saturation devices at each saturation site.**

    b. **The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.**

    c. **Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design,**

congestion, terrain, and meteorology as the top AADT road segment in the area.

The Subcommittee members expressed a wide range of views on the feasibility, ideal configuration(s) and potential usefulness of including a saturation monitoring component in the proposed pilot study. The pollutants sampled, number of sites per city, the number of cities and the kinds of sites for sampling need to be considered collectively, and in light of the limited budget and very short time frame available if the results are going to be of any use to the states in the establishment of permanent near-road sites. The kinds of sampling locations recommended by EPA and NACAA are reasonable, but may be overly prescriptive, considering uncertainties in the kinds of sampling approaches that could actually be implemented.

The simplest possible approach might be limited exclusively to the use of passive samplers and focused on NO_2-only using Ogawa-type passive devices. Disadvantages of this approach include the single pollutant focus and longer-term cumulative nature of the resultant data. Assuming there are reasonable correlations between peak hourly concentrations and long term averages (as there have been at near-road sites in the UK), the sample aggregation of passive samplers may not be a major problem. Advantages of this simple approach include the very minimal siting constraints, the low (sampler, labor and analytical) cost per sample, which would allow deployment at a much larger array of locations, and the current availability of units with well characterized performance specifications. To support this simplified approach, it would be helpful if EPA would analyze data from existing NO2 sites that are located reasonably near major roads to determine how well weekly mean NO2 from multiple sites predicts the daily 1-hour maximum NO2 concentrations for the same time period.

The more complex approach suggested by EPA would attempt to develop a portable compact "package" of active, continuous samplers for multiple pollutants of interest, including NO_2, CO, $PM_{2.5}$. Advantages include the ability to characterize and compare short-term hourly peak concentrations for different pollutants at different kinds of sites. Disadvantages include anticipated high cost per unit (fewer cities and sites), more constraining siting requirements (power, security), unproven track records for data quality, and anticipated time delays for equipment procurement, testing and field deployment.

A third "intermediate" approach that CASAC recommends considering would be to combine passive samplers with timed, battery operated pumps which would draw a fixed flow rate of air through a small chamber housing containing passive NO2 samplers (and possibly other passive samplers for NOx, BC, O3) during specific time periods such as the morning rush hour(s) and afternoon hours of expected maximum secondary formation. The sample pump would improve the sensitivity and reduce the sample variability compared to purely passive devices, and would retain the advantages of relatively low cost and flexible siting locations of the passive samplers. However, this approach is much more complex than a simple passive sampler, and thus would require substantial resources to properly develop the method and evaluate its performance before it could be used.

Without a significant amount of EPA technical support in method development and evaluation, the two more highly time-resolved saturation pilot study approaches described here are not practical; state and local air agencies do not have the resources to support this level of effort. We recommend that EPA provide appropriate resources to allow deployment of time-resolved saturation samplers such that these spatial studies can better inform the final network design.

One possible alternative to use of saturation samplers at fixed locations would be to employ mobile sampling platforms to explore spatial and temporal patterns for multiple pollutants. While the high costs of such units precludes their development with available pilot study funds, it is possible that some states may already have such mobile units available, and the committee recommends that their use be considered as an alternative to fixed site sampling in locations where such units may be available.

Enclosure C

Individual Comments from
Ambient Air Monitoring and Methods Subcommittee

Mr. George Allen

There are two major topics covered by this Advisory:
1. How to best determine the likely location of the annual maximum value for urban-area 1-hour NO2 concentration to assist in the siting of the both the pilot and 126 site network monitors.
2. In addition to NO2, what other near-road (near-road) relevant pollutants should be measured for both the pilot fixed-sites and the full network.

EPA should be acknowledged for moving forward with a multi-pollutant near-road network, an important initial step towards better understanding the exposure issues behind the observed near-road health effects. Although the initial focus of this network is NO2, measurements of other non-NAAQS pollutants are critical for characterization of near-road zones of influence.

The Charge Questions are broken down into several categories, some of which are not well defined or have substantial content overlap:
Guidance document development for the 126-site network
CO and PM network issues related to near-road monitoring
Harmonization of siting criteria for near-road multi-pollutant monitoring (including probe height)
near-road pilot studies -- saturation and fixed site designs: what to sample and where

EPA assumes that these NO2 sites will all be near major roads, but existing data suggest that may not meet the network goals. Thus, the term near-road (NR) as used here also includes congested urban core areas that may be locations of maximum 1-hour NO2 concentrations.

The NR pilot project is critical to informing the deployment of 126 NR NO2 monitoring sites by the end of 2012 (just over 2 years from now with siting plans due summer 2012). However, there is insufficient time to get and analyze all the data (saturation and fixed sites) from a pilot network; pilot studies must be done during both winter and summer seasons to account for potentially large seasonal NO2 variability; primary sources dominate in winter, with secondary sources a factor only during summer mid-day and afternoon when ozone may be present (not during morning rush-hour). EPA meeting materials (introduction to Charge Question 12) state that the saturation study should be performed before (to inform) deploying the fixed pilot sites, further extending the time needed to complete a proper pilot project.

I am very concerned about the level of available funding for this pilot, which includes mulitple multi-pollutant sites, several saturation studies, urban background monitoring for pollutants of interest, and assumes substantial in-kind support from S/L agencies. A major challenge will be how to get useful information from this pilot effort with limited available resources ($800k) and a very short time-frame to adequately inform the larger NR network deployment. EPA needs to address who will do the data analysis for this pilot (presumably a contractor), develop a plan for the analysis, and get external input on that plan. Because of these time constraints, if at all possible I recommend that the full network implementation be delayed or staggered or (ideally) both. If staggered, the first round of sites (10-15 in the largest urban areas?) could include additional (more intensive) measurements to better inform later phases.

As EPA notes in their background material, there are many factors to consider for NR monitor siting; all of them can not adequately be addressed without a relatively large-scale pilot program. Thus, it may be useful to leverage existing sites that meet some of the NR siting requirements in the NO2 rule, and enhancing those existing sites, rather than deploying new sites. This would allow for more pilot sites and speed completion of the pilot study, but limit the "ideal" pilot siting design. I'd expect the saturation studies to be of more value re: informing the siting process, and the fixed sites to support the saturation studies and vet new methods. To support consideration of this approach, it would be very helpful if EPA could supply a list of existing NO2 sites that could at least loosely be considered NR (e.g., micro-scale siting), along with additional site meta-data such as AADT, vehicle type mix, other pollutants currently measured, and available matching urban background measurements.

Finally, I strongly encourage EPA to evaluate the "NR" excess for key indicators (at a minimum: NO2, UFP and BC) as part of this pilot study. This requires a "matched set" of indicator measurements at the NR site and an appropriate "urban background" site - perhaps an NCore site if not too distant from the NR site. The "NR excess" metric allows an estimation of the gradient away from the road. Without the background measurements, the NR indicator data (BC, UFP) have no useful context.

Charge Question 1. Content/Topics of Guidance Outline for full network siting and implementation.

Since this is a brief outline, there is not a lot to comment on.

3b: AADT is over-emphasized as an initial step in site selection. It should be listed with the considerations in 3c. See other comments on AADT in response to charge question 3.

4. If modeling is going to be done by S/L agencies (that is my understanding), not EPA, it may have limited application. There is a wide range of expertise and resources across S/L air agencies for this kind of work.

5. Saturation monitoring may be the most effective approach for site identification, although the need for simplicity and low cost limits the use to multi-day samples rather than one to a few hours duration.

6. 6d seems to duplicate 3c.

Charge Question 2. "What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO2, NOX, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g., benzene, toluene, xylene, formaldehyde, acrolein, or 1, 3, butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects."

For the full network, NO/NO2,UFP (CPC), BC, and CO, and meteorological measurements are the most important. NO2 and CO are NR-relevant NAAQS; no further discussion needed. UFP (particle # concentration by CPC) and BC are robust indicators of NR pollution influence and critical (along with NOx) to determine the "NR excess" pollution influence. PM2.5 should also be done, although it is generally not a good "indicator" of NR pollutants since the urban background is already elevated. The air toxics listed here are very useful but are a second-tier group. Ammonia is not of much interest despite the SCRT NOx controls now used for HDD. The list can be broken into tiers as follows:

<u>Tier 1 - must do:</u>
For the 126 network site sites, NO/NO2, UFP (CPC), BC, CO, and meteorological measurements are the most important. NO2 and CO are NR-relevant NAAQS; no further discussion needed. UFP (particle # concentration by CPC) and BC are robust indicators of NR pollution influence and critical (along with NOx) to determine the "NR excess" pollution influence; # conc [UFP] has not been shown by itself to be of use for health effects yet. BC does show up as a significant predictor of a wide range of health outcomes, although it may [or may not] be acting as an indicator for other NR pollutants. Met (primarily wind) is critical to understanding temporal variations in NR pollutants. I would not recommend 3-d sonic for all sites [reliability issues at NR sites], despite the additional value those data have.

Guidance for NO2 must include data acquisition of large negative values and address issues related to NO-NOx channel balance (matched gain) to avoid degradation of hourly NO2 data when NO is high and rapidly varying. Guidance for CPC/UFP must address diffusional losses of particles < ~25 nm in the sample inlet train.

<u>Tier 2 - could do:</u>

PM2.5 should also be done despite issues with the FRM/FEM methods; although it is generally not a good "indicator" of NR pollutants since the urban background is already elevated, it is a NAAQS that may often be highest at NR sites. The air toxics listed here are very useful for health impact, but are probably too expensive; acrolein and HCHO can not be done at hourly time-scales using practical methods. PM-coarse, and metals are doable at 1-h time-scales, but are resource intensive with health implications unclear. Paired indicator measurements at urban background site (BC, UFP) would be very useful for assessment of NR excess and estimation of the shape of the gradient away from the road, but maybe not everywhere.

<u>Tier 3- could do at a small subset of sites [~10-15] to serve research needs:</u>
Hourly EC/OC, BTEX and other air toxics, SMPS or similar size-resolved UFP; hourly metals [automated on-line XRF]; true [photolytic] NO2, O3 [maybe NO chemiluminescent method to avoid measurement artifacts at low concentrations], CO2 [up and downwind], traffic counts or remote sensing of traffic. Paired indicator measurements at urban background site (BC, UFP). Dry nephelometers with pm-1.0 inlet cuts for fast-response PM-fine indicator. 3-D met at 3 and 10 meters. NOy paired with "true" photolytic NO2 may be useful for determination of total reactive nitrogen and NOz.

<u>Don't do:</u>
Ammonia is not of much interest despite the SCRT NOx controls now used for HDD, and not practical at 1-hour resolution. Nitrate (no reason to expect it to be a NR issue, and little to no value for health effects); if NOy is done, ammonium nitrate is included in the NOz species.

There was some discussion of commercial availability of a suitably robust UFP instrument (CPC) that could be successfully used in a large routine monitoring network. As of May 2010, a commercial water-based CPC is now available that appears to meet these needs; a brief evaluation of the shipping version (not pre-production) of this instrument is at:
http://home.comcast.net/~g_allen/TSI-3783-CPC_Allen.pdf

Charge Question 3. Guidance for Identifying Candidate NR Sites for the full network

AADT and fleet mix are two criteria of uncertain value. For NO2, HDD is the driving on-road primary source; highest NO2 might be found where there is a lot of HDD, significant congestion, and poor dispersion. If local ozone titration (summer only, secondary NO2) is a substantial driver of elevated NR NO2, the fleet mix becomes less important. AADT without related congestion data can be misleading; a free-flowing highway with high AADT is not likely to contribute to high NO2 levels.

Terrain is a major factor; see work by Wang and Zhang, "Modeling Near-Road Air Quality Using a Computational Fluid Dynamics Model, CFD-VIT-RIT", EST, 2009: 43 (7778–7783). Highest NR impact might be expected where the roadway is somewhat depressed relative to curbside terrain. Sound barriers and trees/vegetation (Baldauf-EPA work) may reduce NR impact for some parameters.

Meteorology would ideally be measured at 10 meters to avoid the worst of road-induced turbulence (although at the time-scale of 1-hour, larger scale wind patterns would still likely dominate the wind data). It is not practical to require 3-d wind at all sites, although this could be useful. Sigma-Theta wind data may be useful as an indication of turbulence, as well as the different between 1-hour average scalar and resultant wind speed. Wind data should be sampled at 1-second intervals for these turbulence related metrics, and 5-minute averages may be very useful in a detailed assessment of periods of high concentration.
For Up/Down wind siting, I recommend avoiding sites that are upwind relative to prevailing wind direction. The highest impact may occur where prevailing winds are parallel to the roadway, at which point there is no real up or down-wind side of the road.

Charge Question 4. Use of modeling for NR Guidance Document

This is not my area of expertise, although the concerns stated in Q1 part 4 remain, as well as the demonstrated ability of the models under consideration to reasonably predict locations of 1-hour maximum NO2 concentrations. Mobile source oriented models do not take micro-scale ozone titration into effect, and thus are useful only where primary NO2 would be expected to be the driver of 1-hour maximum NO2.

Charge Question 5. Saturation and On-road Monitoring (Guidance Document)

Saturation monitoring is a very useful tool to screen potential sites and learn more about the characteristics of sites with likely maximum NR impact. Ideally, a saturation study does not have to be constrained to NO2; with modest firmware modifications to existing personal monitors, BC can now be monitored for in these studies. While the BC (optical method) is highly time-resolved, the most practical method for NO2 remains the TEA-based passive samplers; these have been well characterized. They could be adapted for use in this work to measure only morning rush hour over a 5-weekday period by making the flow "active": e.g., a timer, a suitable sampler "housing", and a small (~ 200 ccm) pump. Some initial effort in modification and characterization of existing passive NO2 samplers would be needed. The passive samplers should be run at a fixed monitoring NR pilot site (with NO2 and BC) to validate field performance. The variability inherent in passive NO2 methods will be substantially reduced, since wind speed effects on "effective sampling rate" are essentially eliminated. These passive samplers typically need 50 ppb-hour of NO2 to provide stable data. With active sampling, this number drops, perhaps by 2 times. For a 15-hour (3h x 5days) sample period, once might expect useful data down to a few ppb. Ozone could also be added to any passive sampler-based approach. With NO and NO2, perhaps assisted by addition of BC and O3, the influence of primary vs. secondary NO2 can be assessed with morning rush-hour samples and afternoon (~ 2-5pm local time) samples by looking at the ratios of these pollutants. This could answer one of the more complex questions for NO2 -- do primary or secondary process drive the maximum 1-h concentrations for a given site/season? For winter and morning rush-hour periods (minimal ozone), it is reasonable to assume that primary sources will dominate. For summer afternoons, that assumption can not be made. Taken together, this suggests that secondary processes are a potential driver of high NR NO2 only for summer mid-day and afternoon periods.

Finally, in addition to official NWS data, reasonably local wind data must be collected for any saturation study. These data may be available from NOAA-MADIS meso-net sites; these sites have automated QC (done by MADIS) that can be used to assess data quality, and highly time-resolved (sub-hourly) historical data are available on the web. Other than for BC personal samplers using optical filter techniques, I do not recommend "on-line" methods for the saturation study. Cost, complicated siting logistics, and data quality are the primary concerns here.

Having suggested this saturation study approach, the reality is that without significant EPA support, the best a S/L agency is likely to be able to do is a simple passive NO2 study, perhaps limited to weekday sampling rather than a full week. The Ogawa sampler can do NO2 and NOx in a single sampler, providing an indirect measurement of NO, which would be very useful. Since these samples would not be constrained to periods of likely NO2 maxima, existing NR-ish hourly data should be analyzed to determine how well a 5 or 7-day NO2 mean is correlated with the 1-h maximum for that period. This is an analysis EPA could easily do.

I do not recommend on-road monitoring for this pilot project, in part because it is very resource intensive to do in a useful manner, and with the limited resources available a saturation study has more value with regard to the relevant siting questions especially when seasonality is considered. An exception could be if a local organization has a suitable mobile monitoring platform and the resources to deploy it. A recent example of mobile van spatial characterization of NR pollution is "Short-term variation in near-highway air pollutant gradients on a winter morning" (Durant et al., ACP, 2010; http://www.atmos-chem-phys.net /10/8341/2010/

Charge Question 6. CO -- fleet mix, cold starts and urban canyons

On-road sources of CO are different than NO2; there is essentially no CO from HDD. Thus, the areas of highest CO impact may be very different. Cold starts, idling, and fleet mix in urban canyons (and existing data) all suggest that a site for highest NO2 impact in an urban area may not be the location of highest CO impact. Finally, urban canyon siting is generally going to be very close to the curb (horizontally at least) -- typically < 5-10 meters. But this pilot can not afford to address the urban canyon CO issue.

Charge Question 7. NR PM2.5 and PM10

Existing data has shown only a modest increment in NR PM2.5 in urban areas, primarily since the urban background is already elevated. PM2.5 is not generally a useful indicator of NR pollution excess gradients. Still, in urban areas without dominant industrial sources, the highest PM2.5 would normally be found near areas with substantial local traffic. PM10 would be expected to be somewhat higher at NR sites because of dust reintrainment; minimal hourly NR PM-coarse data exist, so it is difficult to assess this parameter at this time scale.

Charge Question 8. Other PM-related measurements desirable at near-road monitoring stations

See Q 2 above. It must be noted that for UFP (CPC particle # concentration), the inlet can not be at the height of NO2 and similar pollutants unless a carefully designed aerosol manifold is used. Diffusional losses of particles < ~20-30 nm can be large unless appropriate sample inlet trains are used, and it is common to see # concentration mode peaks in this size range at NR sites.

Charge Question 9. Would an adjustment of CO siting criteria to match those of microscale PM2.5 and microscale near-road NO2 sites be logical and appropriate?

Yes.

Charge Question 10. Should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?

Yes.

Charge Question 11. ...how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?

These terms may be difficult to define for rule language across all urban areas. Right now, the approach seems to be "you know it when you see it."

Charge Question 12. ...potential criteria for consideration in selecting where the fixed, permanent [NR pilot] stations should be located.

There will not be more than 2 or 3 of these sites in this NR pilot, as noted in the charge questions. Thus, the range of variables in this charge question can not be fully evaluated. In reality, giving the constraints of funding and timing noted above, the siting decision may be driven largely by what S/L agencies have the resources to support the pilot work and where they can find and deploy a reasonable site quickly. With only 2-3 sites, it may be best to choose "generic" sites that are most likely to represent a large fraction of the final network. We are not going to learn how a wide range of siting characteristics would effect results from this pilot. We might come closer to that goal by constraining the pilot to saturation studies, with no fixed sites. But that is not a practical solution to the broader goals of this pilot. Cooperation of local the DOT may be useful, but the kind of data that needs to be collected for this pilot might be real-time remote traffic sensing that can estimate % large truck traffic -- data not usually available from a DOT.

Charge Question 13. ...minimum equipment/pollutant measurement complement that should be deployed at each site and also the ideal equipment complement that each site should or could have...

See Q 2 above, and my background comments about the importance of having matched urban-scale monitors for evaluation of the "NR excess" for key indicator measurements. It may also be useful to have real-time remote sensing of traffic count as used in the Las Vegas NR MSAT study -- this can also give information on large truck vs. other vehicle traffic.

Charge Question 14.

EPA is proposing that saturation studies for NO2 would be conducted in 4 or 5 urban areas. This is a reasonable goal.

A) "The pollutants that should be measured with the saturation devices at each saturation site."
NO2 and maybe BC if resources allow. See Q 5 above. Met should be collected at one site in the area, possibly relying on existing MADIS meso-net data.

B) "The number of saturation devices per pollutant, both passive and/or continuous / semi-continuous, that may be deployed in each pilot city."
I assume this Q is "how many sites?". This is budget driven, but I suggest at least 6, with one of those being at a fixed site with robust NO2 and BC measurements (as a validation site). For those cities with a NR pilot fixed site, the collocation would be done there. For other cities, the most NR-ish site would be used for collocation of saturation study monitors.

C) "Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area."

All except #4 above, as well as one or more urban canyon or similar non-highway site and a collocation site with regulatory monitors for QC use.

Dr. Judith Chow

Subject: Preliminary Response to Charge Questions on NO_2 Near Road Monitoring to Support Measurement of Multiple NAAQS Pollutants

Date: September 20, 2010

1. Comment on the overall content of the recommended topics in the draft outline. Provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.

The Section 2 literature review needs to be more comprehensive than indicated. It should include a discussion of the relationships between the different pollutants at emission and the likely changes that they will experience with downwind transport from the roadway. It should emphasize the multipollutant (Chow et al., 2010a; Greenbaum and Shaikh, 2010; Hidy and Pennell, 2010; Mauderly et al., 2010) nature of near road exposure. A few reviews and meta-analyses of near-road concentrations have been published (Smichowski et al., 2008; Seigneur, 2009; Karner et al., 2010; Zhou and Levy, 2007) that can be used as starting points, although these are not specific to NO_2 concentrations. A conceptual model should be formed in this section that includes dispersion, deposition, chemical conversion and physical conversion. Special attention should be given to NO_2 formation by NO titration of O_3 and NO_2 depletion by photochemistry.

Section 3 should contain a definition of source zones of influence and receptor zones of representation, defining middle-, neighborhood-, and urban scales (Chow et al., 2002). Compromises necessary to obtain multipollutant characterization should be defined. The list of variables seems complete, but there is an apparent assumption that AADT is the primary siting criteria. Meteorological and terrain variables also probably have important effects. One might find high levels in street canyons than on open roadways with good ventilation.

Section 4 needs elaboration on the models to be considered and how their reported performance. There are several models that compare dispersion models with measurements, use new approaches such as computerized fluid dynamics (CFD) models to evaluate vehicle-induced turbulence and the effects of roadside obstructions, and that attempt to simulate chemical and physical transformations (Baik et al., 2007; Baker et al., 2004; Berkowicz et al., 2008; Buccolieri et al., 2009; Chakrabarty et al., 2000; Chan et al., 1995; Chang et al., 2009; Cheng et al., 2008; Cheng et al., 2009; Chu et al., 2005; Clarke et al., 2004; Di Sabatino et al., 2008; Dixon et al., 2006; Gidhagen et al., 2004b; Gidhagen et al., 2004a; Gokhale et al., 2005; Grawe et al., 2007; Gromke et al., 2008; Kang et al., 2008; Kondo et al., 2006; Kondo and Tomizuka, 2009; Kumar et al., 2009; Li et al., 2006; Liu and Leung, 2008; McNabola et al., 2009; Moussiopoulos et al., 2008; Murena et al., 2008; Murena et al., 2009; Ning et al., 2005; Oettl et al., 2006; Pohjola et al., 2003; Rodden et al., 1982; Sahlodin et al., 2007; Santiago and Martin, 2008; Solazzo et al., 2007; Tay et al., 2010; Tsai and Chen, 2004; Vardoulakis et al., 2002; Vardoulakis et al., 2003; Venkatram et al., 2007; Wang et al., 2006; Wang and Zhang, 2009; Xie et al., 2006; Yassin et al., 2008; Yassin et al., 2009; Yim et al., 2009; Zhou and Levy, 2008; Zhu and Hinds, 2005).

In Section 5, "multi-scale" monitoring is a more specific term than saturation monitoring. This section should provide a summary of roadside measurement studies, passive and active monitors that can be efficiently deployed at many locations, and methods to interpret that data acquired. The conclusion might be that roadside monitoring for site selection and long-term monitoring needs small, portable sensors that don't require a large infrastructure (i.e., shelter, air conditioning, etc.) to operate.

Section 6 might draw from some of the existing guidance for sampler siting (U.S.EPA, 1997; U.S.EPA, 1998). Site documentation in Section 7 should include coordinates, photographs of the siting probe, and pictures of the surroundings.

2. What pollutants and sub-species should be included for consideration and discussion in the near-road monitoring guidance and what should be the priority of measurement?

See response to question 13.

3. What external variables should be used to identify candidate near-road monitoring sites?
    a. Given the variability in emission rates from on-road vehicles based on vehicle technology, fuel, speed, environmental conditions, is the fleet mix in near-road site selection or is a more refined inventory and modeling analysis required?

Fleet mix is a good starting point, but this is likely to vary by time of day and the diurnal breakdown is unlikely to be available. Fleet mix should only be one variable considered in site selection.

    b. Should the suggested approach consider fleet mix via the use of average, fleet-wide emission factors, or the use of inventory and modeling analysis, take into account mobile source controls that are "on the books" but have not yet been fully realized due to fleet turnover? If so, how far out into the future should states consider their effects?

Real-world emissions are likely to be quite different from certification-type emissions. It will take a long time for fleet evolution. Better to establish monitoring sites soon so that improvements can be tracked through long-term trends. It may be that the emission reduction measures that are "on the books" are not as effective as originally thought.

    c. The EPA suggests establishing sites at-grade with the road, without any nearby obstructions to air flow; however, the Agency recognizes that this might not always be feasible. Does the subcommittee agree with this recommendation for locating sites at-grade with no obstructions? What priority should be placed on this factor within the guidance, given the need for flexibility in identifying appropriate site locations?

Higher concentrations will probably be found in more confined areas (e.g., street canyons) than near open roads with no obstructions. Obstructions between the vehicles and the monitors should be minimized.

d. How important a parameter should LOS be in the determination of appropriate near-road monitoring sites? Does the subcommittee have a view on how reliable LOS estimates are across the country?

Congestion varies throughout the day and on weekends vs. weekdays. LOS may provide a first-cut on roads that have congestion, but there is no evidence on how accurate it is as a congestion indicator.

e. Should terrain and vegetation should be a consideration in the siting process? What priority should this parameter have in the overall process?

Terrain is very important. Even small roadway dips can accumulate pollutants in hotspots (Bowen et al., 1993; Bowen and Egami, 1994).

f. Although there is no requirement to be downwind, in the preamble to final NO_2 NAAQS rule, EPA encouraged it when possible. EPA and NACAA intend to do the same in the guidance document. Does the subcommittee agree with this approach?

No. Sampling should take place downwind of the prevailing wind. Even under stagnant conditions the ram effect of the vehicles will create flows parallel to the roadway. See Figure 6 pollution rose from Oettl et al. (2006), as reproduced below. Nothing is detected when the sampling location is upwind of the roadway.

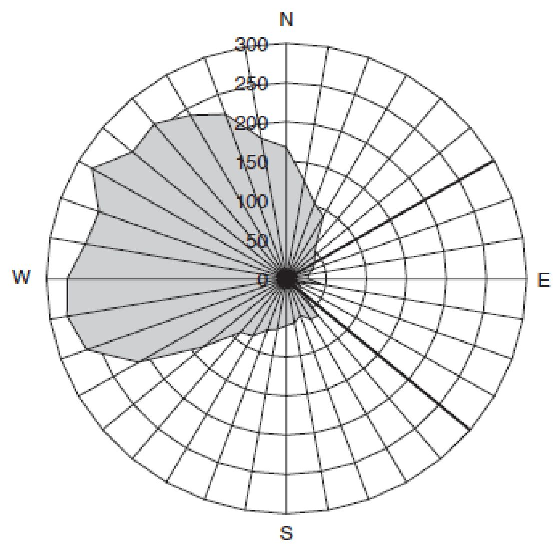

Fig. 6. Observed mean No_x-concentrations as dependent on wind direction at the site Vomp-Leiten for 2001–2003 in ($\mu g\,m^{-3}$).

(Oettl et al., 2006)

Comment on the available modeling tools, and their pros and cons.

See comments under Question 1. Roadway models must consider more than just linear dispersion of inert pollutants.

How might saturation and on-road monitoring be used for near-road site selection?

Portable active or passive monitors that can be easily and inexpensively deployed would provide a good indication of where concentrations might be highest. Levels are likely to vary by season, as noted in Figure 1 of Zou et al. (2006), and show an exponential decrease with distance from the curbside. Passive monitors using NO_2-absorbing filters have some potential biases, but have also been shown to be comparable with continuous measurements for integration times on the order of weeks (Ayers et al., 1998; Beckerman et al., 2008; Berkowicz et al., 2008; Crouse et al., 2009; De Fouquet et al., 2007; Douglas and Beaulieu, 1983; Faus-Kessler et al., 2008; Gilbert et al., 2003; Gonzales et al., 2005; Hauser et al., 2009; Heal and Cape, 1997; Heal et al., 1999; Heal et al., 2000; Henderson et al., 2007; Krochmal and Gorski, 1991; Mukerjee et al., 2004; Nash and Leith, 2010; Norris and Larson, 1999; Ozden and Dogeroglu, 2008; Parra et al., 2009; Piechocki-Minguy et al., 2006; Plaisance et al., 2004; Rava et al., 2007; Sekine et al., 2008; Shooter et al., 1997; Van Reeuwijk et al., 1998; Vardoulakis et al., 2009). This is probably a cost-effective and practical technology for mapping average spatial gradients as a prelude to sampler siting.

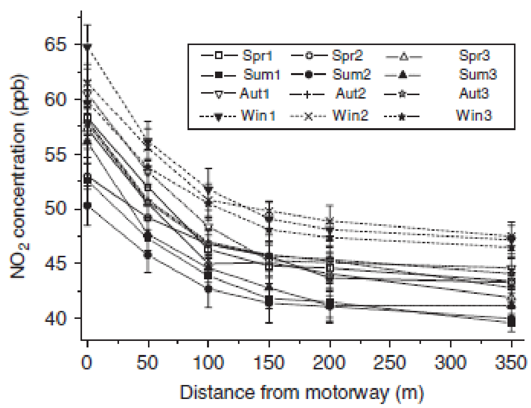

Fig. 1. NO_2 concentrations measured at different distances from the A20 highway in Shanghai ($3 \leqslant n \leqslant 6$) (Spr: spring, Sum: summer, Aut: autumn, Win: winter. 1, 2, 3 represents the different selected study area, respectively).

(Zou et al., 2006) Reprinted from Atmospheric Environment, 40, Zou et al., "Shifted power-law relationship between NO_2 concentration and the distance from a highway: A new dispersion model based on the wind profile model, Copyright (2006) with permission from Elsevier.

If a state were inclined to use saturation monitoring to aid in the selection of a near-road monitoring site, and considering that the NO_2 standard is a 1-hour daily maximum standard, what are the pros and cons to using passive devices to saturate an area to gather data?

Pros are low expense and operating cost. The major con is the long averaging time, much longer than 1 hour.

Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive Semiconductors (GSSs) for NO_2 and other pollutants of interest?

Pros are short-duration samples, on the order of an hour or less. Cons are instrument procurement and operating expense, potentially higher than desired detection limits, and reliability of new technologies.

Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the near-road site selection process for NO_2 specifically as well as other pollutants of interest?

Several mobile emissions systems have been applied to characterizing on-road and roadside concentrations (Bukowiechi et al., 2002; Bukowiecki et al., 2003; Cocker et al., 2004a; Cocker et al., 2004b; Durbin et al., 2007; Herndon et al., 2005; Isakov et al., 2007; Kittelson et al., 2004; Kittelson et al., 2006; Morawska et al., 2007; Nussbaum et al., 2009; Pirjola et al., 2004). Pros are that these systems are moveable and obtain many different pollutant measurements. Cons are the large cost of assembling or contracting these laboratories and the snapshot nature of their measurements, as they usually need to be attended and can be parked for only a short time period.

To what extent will light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area?

The cold start segment has been found to affect emissions for many pollutants, including CO (Cadle et al., 2001; Chan and Zhu, 1999; Chase et al., 2000; Cook et al., 2007; Cotte et al., 2001; Gullett et al., 2006; Huai et al., 2004; Joumard and Andre, 1990; Joumard et al., 2000; Kittelson et al., 2006; Korin et al., 1999; Lenaers, 1996; Lough et al., 2005; Ludykar et al., 1999; Maricq et al., 1999; Mathis et al., 2005; Pornet et al., 1995; Ristimaki et al., 2005; Schauer et al., 2008; Singer et al., 1999; Weilenmann et al., 2005; Weilenmann et al., 2009; Westerholm et al., 1996). This is of fairly short duration (minutes) and would most likely affect emissions in garages, driveways, parking lots and side streets rather on the heavily-travelled thoroughfares. If it is desired to characterize cold starts, sampling systems should be located near where cars turn onto major arteries from nearby neighborhoods. Even so, only those living most closely to the intersection will exhibit cold start emissions.

What priority should these factors be given when compared with the factors (AADT, Fleet Mix, Roadway Design, Congestion Patterns, Terrain, and Meteorology) already being considered for peak NO_2?

Priority should be low.

Do these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal?

This is probably better treated as an emission standard that would minimize cold start emissions through technological means.

Are there other factors that may affect peak CO concentrations and not affect peak NO_2 concentrations that should also be considered for any future CO monitoring proposal?

CO is relatively inert and is often used to normalize other pollutants for dispersion downwind of a roadway (Zhang and Wexler, 2004). It is expected that NO_2 emissions will disperse in a similar manner, although they still experience transformation processes that differ from those of CO.

Will siting considerations for identifying the location of peak NO_2 concentrations address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?

No. $PM_{2.5}$ is a combination of primary and secondary particles from a wide variety of emission sources. Roadside sampling is useful for characterizing the motor vehicle contribution, but it may bias the urban- and regional-scale $PM_{2.5}$ compositions and exposures. These monitors would be considered Special Purpose Monitors according to the PM siting criteria (U.S.EPA, 1997).

In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?
Particle size distribution and particle number by continuous methods. PM speciation on filters, including elements, ions, OC/EC, and organic markers, would be useful to develop source profiles for emission inventory speciation and receptor modeling.
To allow for near-road monitoring infrastructure to be multi-pollutant, and in reflection of the recently promulgated near-road NO_2 siting criteria, reconsideration of the existing microscale CO siting criteria presented in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E may be warranted. Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate?
40CFRPart58 Appendix E calls for CO roadside monitors to be located at 2 to 10 m from the nearest traffic lane for open roads. In a street canyon, the monitor is to be at least 10 m from an intersection. An NO_2 monitor might register higher concentrations near the 10 m downwind location owing to NO_2 formation by reaction of the NO_2 with O_3. It seems that a reasonable compromise on the setback could be derived that would serve both purposes. A more detailed examination of NO_2, NO, CO, and O_3 data is needed in the pilot study to better determine the optimum distance from the roadside.
Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale $PM_{2.5}$ and microscale near-road NO_2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?
The NO_2 and CO siting criteria should be the same. There is more to be gained from the multipollutant measurements than is lost by slight differences in maximum hourly concentrations.
Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?
There is a reasonable literature on measurements in street canyons (Baik and Kim, 2002; Bakeas and Siskos, 2003; Boddy et al., 2005a; Boddy et al., 2005b; Buccolieri et al., 2010; Cai et al., 2008; Caton et al., 2003; Chan et al., 2003; Cheng et al., 2009; Chu et al., 2005; Di Sabatino et al., 2008; Dobre et al., 2005; Eliasson et al., 2006; Genikhovich et al., 2005; Gromke et al., 2008; Hang et al., 2009; Kassomenos et al., 2004; Kim and Baik, 2004; Kumar et al., 2008; Kumar et al., 2009; Lam et al., 2008; Li et al., 2005; Li et al., 2009; Longley et al., 2003; Longley, 2004; Longley et al., 2004; McNabola et al., 2009; Molina, 1996; Moussiopoulos et al., 2008; Murena and Vorraro, 2003; Murena et al., 2008; Prajapati et al., 2009; Santiago and Martin, 2008; Scaperdas and Colvile, 1999; So et al., 2005; Stein and Toselli, 1996; Tay et al., 2010; Tsai et al., 2005; Venegas and Mazzeo, 2000; Voigtlander et al., 2006; Xie et al., 2003; Xie et al., 2005; Xie et al., 2006; Xie et al., 2007; Yassin et al., 2009), supplementing the street canyon modeling literature cited in the response to Question 1. These measurement and modeling studies need to be critically evaluated to answer this question. A quick survey suggests that there are various degrees of roadside obstructions that will have large effects on concentrations.

To what extent are the pilot study site selection criteria of a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NO_X analyzer representative of neighborhood or larger spatial scales for comparison to the near-road NO_X analyzer, and an urban area with a cooperative (or non-cooperative) Department of Transportation complete and adequate?.

Additional criteria should include periods of morning stagnation and low inversion, differing morning O_3 levels that might enhance NO_2 through NO titration, cold as well as warm environments that might experience different emission levels owing to cold starts.

Comment on the *minimum* equipment/pollutant measurement complement that should be deployed at each site and also the *ideal* equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3, butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts.

As implied in the charge questions, a specialized multi-pollutant monitoring package should be assembled and applied in these studies. There are several examples of such packages that have been assembled for neighborhood-scale studies, on-board emissions sampling, and unmanned aerial vehicles that have contain potentially applicable sensors, but these would need to be evaluated with respect to their sensitivity, stability, and accuracy. Data should be acquired over 1 min averages or less so that individual plumes can be detected.

Nitrogen dioxide (NO_2). This is top priority because it is the focus of the study. There are several currently available or emerging technologies for microsensors (Brunet et al., 2008; Currie et al., 1999; Egashira et al., 1996; Forleo et al., 2005; Gurlo et al., 1998; Oto et al., 2001; Sitnikov et al., 2005; Talazac et al., 2001). NO can often be obtained from these same sensors.

Carbon dioxide (CO_2): Normalizing other pollutants to CO_2 allows fuel-based emission factors to be developed (Kean et al., 2000; Sawyer et al., 2000). Commercially available microchip IR sensors are available for CO_2 measurements (Chow et al., 2010b).

Black Carbon (BC): On a short-duration minute basis, this would allow cold starts and diesel exhaust to be separated from others and related to the NO_2 emissions from individual vehicle plumes. A portable aethalometer (Hansen and Mocnik, 2010) is available for filter transmission measurements of BC, and more portable photoacoustic measurement systems (Kok and Baumgardner, 2010) are emerging.

Carbon Monoxide (CO): CO is a priority pollutant and is an indicator of gasoline engine contributions, especially for cold starts and poorly maintained engines. Several small detectors are available (Do and Chen, 2007; Oto et al., 2001).

Ozone (O_3): This would be important for estimating NO titration to NO_2. Several microsensors are available or are emerging technologies (Do and Chen, 2007; Gurlo et al., 1998; Ulanovsky et al., 2001; Vallejos et al., 2007).

Particle number: This would indicate a potential adverse health effect. Portable CPC counters are available.

PM_{10} and $PM_{2.5}$: Coarse particles ($PM_{10-2;5}$) may be affected by road dust while $PM_{2.5}$ is largely from vehicle exhaust. Optical particle counters can provide a real-time surrogate for these components (Wang et al., 2009; Cheng, 2008; Heim et al., 2008; Linnainmaa et al., 2008).

EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on:

The pollutants that should be measured with the saturation devices at each saturation site.

See answers to Question 13.

The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.

Four sampling systems should be located downwind of the roadway at various distances. One should be located in a neighborhood near the road and one should be located upwind of the urban area.

Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.

These are good suggestions. Experiments should be designed to determine which variables most affect the ambient concentrations.

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Mr. Bart Croes

It's not clear what EPA is trying to accomplish with its proposed near road monitoring program. If it's to determine compliance with the new 1-hour national ambient air quality standard for nitrogen dioxide (NO_2), then it seems that the primary focus should be on monitoring population centers rather than siting monitors near roadways. For example, how will nonattainment boundaries be established for these microscale environments? California has had a one-hour standard for NO_2 for several decades and studied peak levels and trends throughout the State. Although future NO_2 levels will be increasingly driven by direct emissions from heavy-duty diesel vehicles, current peak locations in California are in intermediate downwind areas (e.g., eastern border of Los Angeles County) where photochemical conversion (and not just immediate ozone titration) has taken place, not in the source areas.

If the purpose is to conduct multi-pollutant monitoring to help inform exposure and health studies, then linkages with these types of research studies appears to be missing from the documents.

The timeframe for establishing a national network (by January 1, 2013) seems much too rushed to allow for full availability and analysis of results from the near road monitoring pilot study.

Charge Questions:

1. *The accompanying draft guidance document outline provides an initial thought of the major topics required in the near-road monitoring guidance that will aid state monitoring agencies in the identification and implementation of NO_2 near road monitoring sites from a multi-pollutant perspective. Please comment on the overall content of the recommended topics in the draft outline. Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.*

It's not clear what EPA is trying to accomplish with its proposed near road monitoring program. The goals should be clearly delineated in order to comment on this brief outline. It would also be helpful to see the target number of pages for each section and the extent of the literature review. As the outline points out, the available literature is extensive (see the Health Effects Institute special report on Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects) and a conducting a synthesis of existing near road and saturation monitoring datasets would be a useful addition.

2. *EPA and NACAA envision the near-road guidance document to be written from a multi-pollutant perspective. What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g.,*

benzene, toluene, xylene, formaldehyde, acrolein, or 1,3-butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.

Again, some clarity is needed on what EPA is trying to accomplish with its proposed near road monitoring program. If it's to determine compliance with existing air quality standards, then only NO_2 and CO are all that is necessary, as the roadway environment as not the peak location for PM2.5 and PM10 (because secondary PM is so important in determining peak locations). If the purpose is to follow motor vehicle criteria pollutant and air toxic emission trends, or to conduct multi-pollutant monitoring to help inform exposure and health studies, then NO_X, PM, black carbon, and the air toxics should also be included.

3. *Identifying Candidate Near-road Site Areas*

a. *Annual Average Daily Traffic (AADT) & Fleet Mix – To consider fleet mix with regard to NO_2, an idea is to encourage states that have fleet mix information to take an approach that uses average, fleet-wide grams per mile emissions estimates (one for light duty vehicles and one for heavy duty vehicles), combined with AADT information to further weight which road segments in an area may be more conducive to produce peak pollutant concentrations. EPA would use the latest emission factor information to aid such a calculation. Given the variability in emission rates from on-road vehicles based on vehicle technology, fuel, speed, environmental conditions, etc., does the subcommittee believe this approach is an appropriate way to "consider" fleet mix in near-road site selection or is a more refined inventory and modeling analysis required?*

   The highest CO sites in California are the ones with the highest AADT for light-duty vehicles and oldest fleet, and the peak one-hour levels occur during winter. In the past, the highest NO_2 levels were the same sites and season because of the reaction $2\ NO + O_2 \rightarrow 2\ NO_2$, which is important at low temperatures and $NO_X >$ 1 ppm. But future NO_2 levels will be dominated by heavy-duty diesel vehicles (HDDV) and near-source mixing with ozone. Thus, a key factor in roadside NO_2 levels is the fraction of heavy-duty diesel vehicles (HDDV) that are equipped (2007-2009 model year) or retrofitted with a catalyzed diesel particulate filter. In California, while most diesel vehicles emit 5% NO_2 (from Caldecott Tunnel data), this can increase to 17% for retrofits and 45% for 2007-2009 model year (although absolute NO_X, and consequently NO_2 is lowered by 50%). In other states that do not have California's NO_2 limit for retrofits (or just went into place in 2009), the NO_2 fraction can be much higher, although admittedly the number of retrofits is a much lower in the rest of the U.S. Since existing EPA emission models predict NO_X and not NO_2, this capability would need to be added.

b. *AADT & Fleet Mix – Further, should the suggested approach above in question 3a to consider fleet mix via the use of average, fleet-wide emission factors, or the*

NO_X and NO_2 emissions will continue to decrease as the 2010 model year HDDVs (with 90% NO_X control over pre-2007 vehicles) become a bigger fraction of the fleet. Since these decreases will take place somewhat uniformly across the nation, the purpose of this question isn't clear. Is the intent to forecast emission trends for States to get out of monitoring requirements?

c. *Roadway Design – Studies suggest and support the concept that roadway design influences pollutant dispersion near the road. The EPA suggests establishing sites at-grade with the road, without any nearby obstructions to air flow; however, the Agency recognizes that this might not always be feasible. Does the subcommittee agree with this recommendation for locating sites at-grade with no obstructions? What priority should be placed on this factor within the guidance, given the need for flexibility in identifying appropriate site locations?*

   Obstructions between the roadways and the monitors should be minimized, but shouldn't proximity to where people live be a more important consideration? A more practical consideration in site selection is the cost of leases. For an ARB freeway study in Lodi, rent started out at $750/month for both sites. Once the landowners realized that their proximity to the freeway was worthwhile to ARB they increased the rent to $1500/month.

d. *Congestion Patterns – The congestion of a roadway can be estimated by the metric "Level of Service" (LOS). LOS uses a letter grade from A to F to identify a roadway's performance, with "A" the best conditions where traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes to "F" the worst congestion where travel time cannot be predicted and generally traffic demand exceeds the facility's capacity. Since motor vehicles generally emit more pollutants during congestion operations (although noting that NO_X and select other pollutant emissions can also increase with increasing speed), how important a parameter should LOS be in the determination of appropriate near-road monitoring sites? Does the subcommittee have a view on how reliable LOS estimates are across the country?*

   As NO_X and VOC emissions are continuously reduced over time, ambient oxidant levels will also go down, which means that titration of NO by ozone to form NO_2 will become less important in comparison to direct NO_2 emissions from new and retrofitted diesel trucks. NO_2 emissions are highest during cruise mode, not congestion conditions for these trucks, and truckers avoid congestion. Experts at Departments of Transportation should be consulted on the reliability of the congestion metric.

e. *Terrain– State and local air agencies are required to consider terrain in the near-*

road monitoring site selection process, which in some cases may be inherently part of the roadway design. However, EPA recognizes that some states and local air agencies may have to make selections from amongst similar candidate sites that differ only by terrain, e.g. cut section versus open terrain, with or without vegetation, etc. Does the subcommittee agree that terrain and vegetation should be a consideration in the siting process? What priority should this parameter have in the overall process?

NO_X (and likely NO_2) emissions increase with grade, but these are unlikely to be areas of heavy congestion and truck traffic. Vegetation is a sink for particles and ozone, and heavily vegetated areas should be avoided.

f. Meteorology – EPA took comment on, but did not finalize the requirement for near-road monitoring sites to be climatologically downwind of the target road segment. Reasons were because the additional limitations this would introduce in finding candidate sites would be in exchange for what may be a small increase in the opportunity to monitor peak NO_2 concentrations. Further, with sites being within 50 meters of target road segments, the phenomenon of upwind meandering (pollutant transport upwind due to vehicle induced turbulence) further reduces that absolute need to be climatologically downwind. Finally, EPA recognized that, logically, the potential for peak NO_2 concentration may very well occur when winds are calm or parallel (or nearly parallel) to the target road, allowing for pollutant build-up, as opposed to when winds are normal to the road. Although there is no requirement to be downwind, in the preamble to final NO2 NAAQS rule, EPA encouraged it when possible. EPA and NACAA intend to do the same in the guidance document. Does the subcommittee agree with this approach?

An analysis of existing roadside CO data would be informative regarding this issue. In the peak Los Angles site, the highest levels were recorded during stagnant winter-time conditions with low-speed meandering winds, meaning that there was no consistent upwind or downwind direction.

4. Modeling is another tool that may be useful in the identification of candidate near-road sites. In particular, the use of mobile source emissions modeling with MOVES and local-scale dispersion modeling with AERMOD, can be presented as part of the guidance document. Please comment on the available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.

Modeling requires hour-by-hour local-scale data on the fleet mix (not just HDDV counts but also the proportions of retrofitted and MY 2007-2009 and 2010+ vehicles), driving conditions (average speeds), background air quality (NO_2, ozone), and meteorology (wind speed and direction, stability) that is unlikely to be available. I think a screening approach using the factors identified in my response to Charge

Question #3 (with appropriate weightings developed using a literature review and analysis of existing data) should be just as useful and much easier to apply.

5. *In regard to the process of identifying candidate near-road monitoring sites, beyond the evaluation of factors noted above in question 3, and the potential use of modeling, the use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process.*

a. *If a state were inclined to use saturation monitoring to aid in the selection of a near-road monitoring site, and considering that the NO_2 standard is a 1-hour daily maximum standard, what are the pros and cons to using passive devices to saturate an area to gather data?*

Given their relatively long sampling times, passive samplers would only be useful to determine likely peak 1-hour locations. In studies of pollution levels in Los Angeles communities near freeways and ports, both the passive samplers and mobile monitoring platform documented the sharp gradients in the vicinity of freeways. The Ogawa saturation monitors for NO_2 had a precision of ~1.5 ppb (5%) for 1-week integrated samples, and comparison with collocated FRM analyzers indicated good accuracy (m=1.0380 and r^2=0.9905).

b. *Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive Semiconductors (GSSs) for NO2 and other pollutants of interest?*

No comment, not my area of expertise.

c. *Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the near-road site selection process for NO2 specifically as well as other pollutants of interest?*

The ARB has a mobile monitor that has proven to be a very useful tool to identify near-source pollutant gradients. We use an electric vehicle to avoid self pollution issues and to have a large enough battery to run all the equipment. The vehicle and equipment cost are high, on the order of $250,000, and it takes expert staff to set up and operate the mobile monitor.

6. *EPA recognizes that CO concentrations are primarily influenced by gasoline vehicles as opposed to NO_2 and PM2.5 concentrations, which are currently more heavily influenced by heavy-duty (diesel) vehicle emissions. If EPA were to propose a new set of minimum monitoring requirements for CO near roads, the near-road monitoring stations created under the implementation of the NO_2 monitoring requirements may be an advantageous infrastructure for state and local air agencies to leverage. However, EPA believes there are two issues not*

specifically considered in the near-road NO_2 monitoring language that might influence where near-road CO monitors may be most appropriately placed. The two issues are 1) the consideration of where light duty vehicles are operating under 'cold-start' conditions, which may often not be on the larger arterials or highways in an area, and 2) the impacts of light duty vehicle congestion and idling in areas such as urban street canyons and/or urban cores.

a. *Does the subcommittee believe that the light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area? What priority should these factors be given when compared with the factors (AADT, Fleet Mix, Roadway Design, Congestion Patterns, Terrain, and Meteorology) already being considered for peak NO_2?*

b. *Does the subcommittee have an opinion on whether, and possibly how, these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal? Are there other factors that may affect peak CO concentrations and not affect peak NO_2 concentrations that should also be considered for any future CO monitoring proposal?*

The major factors in the location of peak CO levels are high light-duty vehicle volumes, high fractions of older and poorly maintained vehicle (e.g., high emitters), stagnant meteorology, and containment by nearby buildings (e.g., urban street canyons). Parking garages can be a hot spot because of cold starts and pollutant containment by the building, but the duration of high CO periods can be short, and population exposure is generally low, so they should not be a priority for a future national CO monitoring proposal. Rather a focus on high emitters in populated areas (i.e., environmental justice communities) would be a useful complement to the consideration of factors for high NO_2 levels.

7. *Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly PM2.5) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?*

The near roadway data for California from multiple studies shows that PM2.5, even in a coastal source area, is primarily from secondary formation. There was surprisingly little variation throughout the communities monitored in special studies. Several studies using ultrafine PM networks across a community showed large spatial and temporal variations associated with proximity to fresh combustion products.

8. *In addition to PM2.5 mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?*

In California special studies, we found that different BC and PM measurement methods have significant differences. They tend to agree qualitatively but not quantitatively. CPC ultrafine PM measurements are sensitive to the effective size cuts of the instruments and some instruments needed frequent calibrations. The different methods for measuring EC and OC also yield different concentrations. If near-road monitoring is going to be used for assessing compliance with air quality standards, the methods need to be comparable (equivalent) to the reference method. If near-road measurements are only to better understand the atmospheric processes and pollutant relationships, then only a good QA program is required to be useful. The most critical part of any near-road monitoring program will be the siting criteria for the monitors/samplers as a small change in distance (or possibly height), orientation to the high traffic volume direction during the light/calm winds in the morning commute, and number of vehicles during the period of typically stable air (surface inversion and light/calm wind) could all have a strong impact on the concentrations measured.

9. *To allow for near-road monitoring infrastructure to be multi-pollutant, and in reflection of the recently promulgated near-road NO_2 siting criteria, reconsideration of the existing microscale CO siting criteria presented in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E may be warranted. Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale PM2.5 and microscale near-road NO_2 sites be logical and appropriate?*

Yes, consistency seems warranted.

10. *Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale PM2.5 and microscale near-road NO_2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?*

No comment, not my area of expertise.

11. *Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?*

No comment, not my area of expertise.

12. *EPA and NACAA will select the locations for permanent sites that are part of the near-road pilot study based on which state or locals volunteer to participate and can process grant funds in a timely manner to deploy equipment. From this pool of volunteers, selection should be made on certain attributes that provide the best potential to fulfill pilot study objectives. In the attached draft white paper, EPA*

and NACAA have proposed some potential criteria for consideration in selecting where the fixed, permanent stations should be located. These considerations include choosing a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NO_X analyzer representative of neighborhood or larger spatial scales for comparison to the near-road NO_X analyzer, and an urban area with a cooperative (or non-cooperative) Department of Transportation. Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study?

Because of the potential influence of high NO_2 emissions from retrofitted or post-2007 HDDV on roadside levels, a freeway with high heavy-duty truck traffic volumes should be the primary consideration in site selection. It is also important that an ozone measurement be co-located with the neighborhood scale NO_X analyzer so that total oxidant levels can be determined. USEPA, ARB, and several research groups have mobile monitors that could be deployed to quickly find the location of highest NO_2.

13. *EPA and NACAA have proposed that at least two urban areas should have permanent near-road monitoring stations (that would fulfill NO_2 near-road monitoring requirements) implemented for the pilot study. Please comment on the minimum equipment/pollutant measurement complement that should be deployed at each site and also the ideal equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3-butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts.*

The list of pollutants is appropriate and in priority order, although air toxics could be dropped to conserve resources. Meteorological parameters (wind speed, wind direct, temperature) and light- and heavy-duty truck counts would also be useful.

14. *EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on:*

a. *The pollutants that should be measured with the saturation devices at each saturation site.*
b. *The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.*

c. *Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.*

I think mobile monitoring measurements are much more useful, and more relevant to the averaging time of the NO_2 standard. EPA staff can look at the details of ARB's year-long saturation monitoring study in the communities downwind of the Ports of Los Angeles and Long Beach for information on methods, quality assurance, data analysis techniques, and results that may be useful in designing the pilot study. (http://www.arb.ca.gov/research/mobile/hcm/sat-mon/sat-mon.htm)

Dr. Kenneth Demerjian

Charge Questions

Questions regarding the near-road monitoring guidance document

1. The accompanying draft guidance document outline provides an initial thought of the major topics required in the near-road monitoring guidance that will aid state monitoring agencies in the identification and implementation of NO_2 near road monitoring sites from a multi-pollutant perspective. Please comment on the overall content of the recommended topics in the draft outline. Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.
2. EPA and NACAA envision the near-road guidance document to be written from a multi-pollutant perspective. What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g., benzene, toluene, xylene, formaldehyde, acrolein, or 1, 3, butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects. Tier I - NO_2, NO_X, NO, CO, CO_2, SO_2, EC/OC, BTEX aerosol size distribution and total number concentration for routine near-road monitoring. Tier II - PM organics (HOA, OOA), NH_3, HONO, H_2CO and 1,3 - butadiene.
3. Identifying Candidate Near-road Site Areas
    a. AADT & Fleet Mix – To consider fleet mix with regard to NO_2, an idea is to encourage states that have fleet mix information to take an approach that uses average, fleet-wide grams per mile emissions estimates (one for light duty vehicles and one for heavy duty vehicles), combined with AADT information to further weight which road segments in an area may be more conducive to produce peak pollutant concentrations. EPA would use the latest emission factor information to aid such a calculation. Given the variability in emission rates from on-road vehicles based on vehicle technology, fuel, speed, environmental conditions, etc., does the subcommittee believe this approach is an appropriate way to "consider" fleet mix in near-road site selection or is a more refined inventory and modeling analysis required? First cut at identifying potential near-road monitoring sites should be to consider the application of GIS methods for traffic exposure. These and other methods were recently reviewed by HEI, Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects, Special Report 17, January, 2010.
    b. AADT & Fleet Mix – Further, should the suggested approach above in question 4a to consider fleet mix via the use of average, fleet-wide emission factors, or the use of inventory and modeling analysis, take into account mobile source controls that are "on the books" but have not yet

been fully realized due to fleet turnover? If so, how far out into the future should states consider their effects?

c. Roadway Design – Studies suggest and support the concept that roadway design influences pollutant dispersion near the road. The EPA suggests establishing sites at-grade with the road, without any nearby obstructions to air flow; however, the Agency recognizes that this might not always be feasible. Does the subcommittee agree with this recommendation for locating sites at-grade with no obstructions? What priority should be placed on this factor within the guidance, given the need for flexibility in identifying appropriate site locations? The choice of sites with minimal roadway design influences affect pollutant dispersion should be a priority, but not an absolute requirement. Microenvironments with high pollutant exposures near local neighborhoods should be considered and will likely reflect some combination of terrain, road grade, traffic volume and congestion influences.
d. Congestion Patterns – The congestion of a roadway can be estimated by the metric "Level of Service" (LOS). LOS uses a letter grade from A to F to identify a roadway's performance, with "A" the best conditions where traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes to "F" the worst congestion where travel time cannot be predicted and generally traffic demand exceeds the facility's capacity. Since motor vehicles generally emit more pollutants during congestion operations (although noting that NO_x and select other pollutant emissions can also increase with increasing speed), how important a parameter should LOS be in the determination of appropriate near-road monitoring sites? Does the subcommittee have a view on how reliable LOS estimates are across the country? I have no firsthand knowledge on estimating LOS, but it seems that there are likely many innovative approaches that could be offered up by DOT and the traffic engineering community who deal with congestion mitigation issues on a daily basis. Discussions with this community regarding estimating LOS should be EPA's first priority.
e. Terrain– State and local air agencies are required to consider terrain in the near-road monitoring site selection process, which in some cases may be inherently part of the roadway design. However, EPA recognizes that some states and local air agencies may have to make selections from amongst similar candidate sites that differ only by terrain, e.g. cut section versus open terrain, with or without vegetation, etc. Does the subcommittee agree that terrain and vegetation should be a consideration in the siting process? What priority should this parameter have in the overall process? Terrain and vegetation should be considered and documented as part of the siting process, but should not be a major priority factor in the selection process.
f. Meteorology – EPA took comment on, but did not finalize the requirement for near-road monitoring sites to be climatologically downwind of the target road segment. Reasons were because the additional limitations this

would introduce in finding candidate sites would be in exchange for what may be a small increase in the opportunity to monitor peak NO_2 concentrations. Further, with sites being within 50 meters of target road segments, the phenomenon of upwind meandering (pollutant transport upwind due to vehicle induced turbulence) further reduces that absolute need to be climatologically downwind. Finally, EPA recognized that, logically, the potential for peak NO_2 concentration may very well occur when winds are calm or parallel (or nearly parallel) to the target road, allowing for pollutant build-up, as opposed to when winds are normal to the road. Although there is no requirement to be downwind, in the preamble to final NO_2 NAAQS rule, EPA encouraged it when possible. EPA and NACAA intend to do the same in the guidance document. Does the subcommittee agree with this approach? The siting of monitors in local neighborhoods in the proximity of major roadways (i.e., <500 meters) is more important than its placement at a location that is climatologically downwind. That being said, if EPA wants to address the influence of climatology on monitor siting, the application of traditional climatological line source models would be the starting point.

4. Modeling is another tool that may be useful in the identification of candidate near-road sites. In particular, the use of mobile source emissions modeling with MOVES and local-scale dispersion modeling with AERMOD, can be presented as part of the guidance document. Please comment on the available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document. As mentioned above the application of traditional line source models to address siting issues with respect to climatology is fairly straight forward. The application of more sophisticated emissions and exposure models does not seem necessary to address the climatology issue.

5. In regard to the process of identifying candidate near-road monitoring sites, beyond the evaluation of factors noted above in question 3, and the potential use of modeling, the use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process.

a. If a state were inclined to use saturation monitoring to aid in the selection of a near-road monitoring site, and considering that the NO_2 standard is a 1-hour daily maximum standard, what are the pros and cons to using passive devices to saturate an area to gather data? Saturation monitoring for NO_2 is temporally limited to 24 hr averages. The diurnal pattern of NO_2 varies with season and max 1 hr averages can occur at mid-morning and mid-afternoon depending on season. Spatial mapping of NO2 (and other) concentrations with fast response monitoring technologies (e.g. QCL multipath IR spectroscopy) can provide significant insights to near road exposures in local neighborhoods.

b. Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive

Semiconductors (GSSs) for NO_2 and other pollutants of interest? QCL multipath IR spectroscopy have been demonstrated for NO_2, HONO, H_2CO, CO, and 1,3–butadiene and have been operated from mobile platforms providing spatial mapping or gradient measurement associated with fixed site monitoring.

c. Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the near-road site selection process for NO_2 specifically as well as other pollutants of interest? This is the method of choice, but the availability of specially outfitted mobile measurement platforms is limited, as are the dollars to support such measurements.

Questions regarding the CO monitoring network and near-road monitoring

6. EPA recognizes that CO concentrations are primarily influenced by gasoline vehicles as opposed to NO_2 and $PM_{2.5}$ concentrations, which are currently more heavily influenced by heavy-duty (diesel) vehicle emissions. If EPA were to propose a new set of minimum monitoring requirements for CO near roads, the near-road monitoring stations created under the implementation of the NO_2 monitoring requirements may be an advantageous infrastructure for state and local air agencies to leverage. However, EPA believes there are two issues not specifically considered in the near-road NO_2 monitoring language that might influence where near-road CO monitors may be most appropriately placed. The two issues are 1) the consideration of where light duty vehicles are operating under 'cold-start' conditions, which may often not be on the larger arterials or highways in an area, and 2) the impacts of light duty vehicle congestion and idling in areas such as urban street canyons and/or urban cores.

a. Does the subcommittee believe that the light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area? What priority should these factors be given when compared with the factors (AADT, Fleet Mix, Roadway Design, Congestion Patterns, Terrain, and Meteorology) already being considered for peak NO_2? The spatial distribution of cold start vehicles associated with urban commuting is in general broad and short term and their contribution to emissions associated with major highways adjacent to residential neighborhoods is likely small. That being said, at least one exception comes to mind. The departure of motor vehicles from major entertainment events (e.g. a football or baseball stadium) where 20-30K vehicles may be simultaneously started and caught in congestion for 10s of minutes to an hour or more. The cold start contribution, is again limited in time but could contribute significantly as an emissions hot-spot impacting commuter exposes and concentrations in nearby neighborhoods.

b. Does the subcommittee have an opinion on whether, and possibly how, these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal? Are there other factors that may affect peak CO concentrations and not affect peak NO_2 concentrations that should also be considered for any future CO monitoring proposal? The near-road NO_2 concentrations are closely tied to secondary reactions with urban ozone concentrations and entrainment processes into highway line source NOx plumes. This in part, contributes to seasonal differences in near-road NO_2 concentrations and its fractional contribution to NOx. Other factors affecting near-road NO_2 monitoring is the distribution of gasoline and diesel vehicles. Example data analyses depicting the effects of these factors on NO_2 measurements are available upon request.

Questions regarding the PM monitoring network and near-road monitoring

7. Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration? Monitoring of number concentration of ultrafine particles has spatial and temporal characteristics that do not sync all that well with that of NO_2. But it remains to be seen if the health community can make the case for health outcomes for particles <100nm.

8. In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)? Mobile measurement platforms are capable of performing fast response measurements (<1 minute) of key primary emission components (in addition to NO_2) of interest to health effects community. These include aerosol size distribution, EC, PM organics (HOA, OOA), NH_3, HONO, H_2CO, CO, CO_2 and 1,3 - butadiene.

Questions regarding the monitor siting criteria for microscale CO, microscale $PM_{2.5}$, and the new near-road NO_2 siting criteria

9. To allow for near-road monitoring infrastructure to be multi-pollutant, and in reflection of the recently promulgated near-road NO_2 siting criteria, reconsideration of the existing microscale CO siting criteria presented in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E may be warranted. Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate? The CO siting criteria should be adjusted to match those of microscale PM2.5 and near-road NO2 so there is consistency in the near-road multi-pollutant monitoring infrastructure.

10. Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale $PM_{2.5}$ and microscale near-road NO_2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited? Carry over of the urban street canyon or urban core microscale CO siting requirements should be done, keeping in mind the multi-pollutant consistency requirements mentioned in question (9).

11. Does the subcommittee have an opinion on how “urban street canyons” or “urban core” might be defined, perhaps quantitatively, and with regard to use in potential rule language? Consider emission density and spatial volume defining the urban street canyon and in the case of the urban core consider emission density and temporal persistence.

12. EPA and NACAA will select the locations for permanent sites that are part of the near-road pilot study based on which state or locals volunteer to participate and can process grant funds in a timely manner to deploy equipment. From this pool of volunteers, selection should be made on certain attributes that provide the best potential to fulfill pilot study objectives. In the attached draft white paper, EPA and NACAA have proposed some potential criteria for consideration in selecting where the fixed, permanent stations should be located. These considerations include choosing a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NO_X analyzer representative of neighborhood or larger spatial scales for comparison to the near-road NO_X analyzer, and an urban area with a cooperative (or non-cooperative) Department of Transportation. Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study? EPA should competitively fund several extramurally pilot studies in conjunction with matching state environmental monitoring funds to address this question.

13. EPA and NACAA have proposed that at least two urban areas should have permanent near-road monitoring stations (that would fulfill NO_2 near-road monitoring requirements) implemented for the pilot study. Please comment on the *minimum* equipment/pollutant measurement complement that should be deployed at each site and also the *ideal* equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3, butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts. Optimal deployment would consider one permanent near-road monitor station with a mobile measurement platform. The minimum complement of measurement parameters at the fixed site would include NO_2, NO_X, NO, CO, CO_2, aerosol size distribution and total number concentration, PM2.5 and PM10 mass, EC/OC, BTEX and ammonia. The minimum complement of measurement parameters for the mobile platform include aerosol size distribution, EC, PM organics (HOA, OOA), BTEX, NH_3, HONO, H_2CO, CO, CO_2 and 1,3 -butadiene.

14. EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on: I am not convinced this is a viable method. The only passive devices deployed systematically for saturation monitoring have been Ogawa badges for NO_2. Jury is still out on saturation monitoring using battery operated PM samplers. With some R&D investment in wireless unmanned saturation sensors/samplers, routine saturation monitoring could be in the future. The proposal to use of current passive measurement devices is less than inspiring.

a. The pollutants that should be measured with the saturation devices at each saturation site.

b. The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.

c. Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.

Dr. Delbert Eatough

The nature of the advice which AAMMS might give to EPA on the Charge Questions outlined in the material provided to the committee will be dependent on the objectives of the multiple pollutants studies to be conducted as part of the near road monitoring program put in place in response to monitoring requirements outlined in the new NAAQS for NO_2 released in February of this year (EPA CFR Parts 50 and 58, 2010).

As stated by EPA in the Charge Questions document provided to AAMMS:

Purpose of the Advisory

EPA is seeking CASAC advice on the concepts and information that should be included in the forthcoming near-road monitoring guidance document, advice on how future near-road monitoring requirements, for pollutants such as Carbon Monoxide (CO) and Particulate Matter (PM), may be drafted in a way to mesh with the existing Nitrogen Dioxide (NO_2) requirements and foster a multi-pollutant monitoring infrastructure, and the objectives, approach, and execution of the near-road monitoring pilot study.

This is a bold new direction being taken by EPA which will move the concept of multi-pollutant monitoring in support of Clean Air objectives forward in a significant way. While reasonable detail is given in the charge questions related to the approach to be used and execution of the near-road monitoring pilot study, little detail is given on the scientific objectives of both the pilot study and the near-road monitoring program which is required under the NO_2 NAAQS. I will start these comments by framing some of my thoughts on the possible objectives of this program, with the belief that the nature of the advice which might be given in very dependent on the identified objectives. I should emphasis that the literature cited in my comments is illustrative only and not intended to be a complete review of what is currently know.

I. Objectives of the Near-Road Monitoring Program.

A. NO_2 Monitoring Time Scale.

As outlined by EPA, the advice must consider the near-road monitoring requirements of the NAAQS for NO_2, which is to have ambient monitoring conducted at the location of maximum NO_2 concentrations in an area, which at a minimum is directly attributable to mobile source emissions. While not explicitly stated in the charge questions, I assume that this means that the monitoring to be conducted will be focused on the 1-hour time period requirement of the NAAQS. This is an important point because the information one can gain from the near-road monitoring program is dependent on the time period chosen for study. For example, 1-hour average monitoring allows the identification of the effects of many diurnal variations which the identification of such details as diurnal changes in sources and atmospheric processes (Eatough, 2008). However, there are important processes which occur on a much shorter time period which will not be as well identified in the program (Zhu 2002a, b). My comments here are limited to considerations for a 1-hour average monitoring program.

B. NO_2 Monitoring Objectives Other than Identification of Maximum Concentrations.

If we were discussing the identification of the maximum concentration of TSP Pb, the sampling objectives would be relatively straightforward because particulate Pb is a species which is expected to be relatively conserved in the atmosphere after emission. However, the story is much more complex with respect to NO_2 if one wants to know, in addition to identification of maximum concentrations, the atmospheric factors which contributed to the maximum concentrations observed and the effect of the NO_2 formation pathways on other NAAQS pollutants such a ozone, or the effect of ambient ozone on the formation of NO_2.

The great majority of primary nitrogen oxides are currently emitted from combustion sources in the form of NO (g) (Finlayson-Pitts, 2000). In the presence of ozone, $HO_2\cdot$ or $RO_2\cdot$, NO is oxidized to NO_2,

$$NO\,(g) + O_3\,(g) \rightarrow NO_2\,(g) + O_2\,(g) \qquad (1)$$

$$NO\,(g) + HO_2\cdot\,(g) \rightarrow NO_2\,(g) + OH\cdot\,(g) \qquad (2)$$

$$NO\,(g) + RO_2\cdot\,(g) \rightarrow NO_2\,(g) + RO\cdot\,(g) \qquad (3)$$

Ozone, in turn is formed from the photolysis of NO_2, $OH\cdot$ from the photolysis of O_3 and

$HO_2\cdot$ and $RO_2\cdot$ from the reaction of $OH\cdot$ (and at night $NO_3\cdot$) radicals with gas phase organic compounds. Thus, the relative concentrations of NO_X and gas phase organic compounds control the concentration of ozone in a complex manner described by ozone isopleths (Finlayson-Pitts 2000), and, in turn, these processes control the concentrations of NO_2. In general, at low NO_X concentrations the concentration of ozone is little effected by the concentration of VOC and the system is NO_X limited. However, at low concentrations of VOC, the concentrations of ozone can decrease with increasing NO_X concentrations as NO reacts with ozone and NO_2 competes with VOC for the $OH\cdot$ radical by the irreversible formation of nitric acid,

$$NO_2\,(g) + OH\cdot\,(g) \rightarrow HNO_3\,(g) \qquad (4)$$

Concentrations of NO_2 observed at a site will be effected by this complex chemistry. Complete understanding of the etiology of NO_2 concentrations identified in a near-road monitoring program will require the identification of each of these factors (Kuprov 2010). I have assumed that understanding these chemical contributions to the observed NO_2 concentrations will be one of the monitoring objectives.

C. Multi-Pollutant Monitoring Objectives.

The multi-pollutant monitoring portion of the near-road monitoring program plan being developed for the NO_2 requirements could have several objectives:

- Identification of concentrations of other NAAQS pollutants which accompany the observed NO_2 concentrations.
- Identification of the contribution these and other key pollutants make to the observed NO_2 concentrations (see my comments in B.)
- Identification of the atmospheric processes which contribute to the observed concentrations of NO_2 and the other monitored pollutants (e.g. Kuprov, 2010; Wilson 1977).
- Identification of the sources which contribute to both measured concentrations of NO_2 and the other measured NAAQS pollutants (e.g. Eatough 2008).

My comments assume that meeting all of these objectives is important in the design of the program. Another possible objective of the monitoring program is the identification of toxic compounds to inform health studies. While this is an important objective, it is somewhat less directly related to the above and I have not given this objective high priority.

I have not attempted to frame an individual response here to all charge questions as there are some where I am not an expert. The charge questions are given in the consensus report.

II. Response to the Charge Questions.

Charge Question 1.

I suggest the following are areas where the Guidance Document may need strengthening above what I think is intended in the outline:

- Introduction: Based on the material in the Pilot Study draft, it is not clear that EPA has yet identified the reasons (scientific objectives) for the multi-pollutant monitoring. I have discussed this issue in I.C. I recommend that EPA decide which of the scientific objectives outlined there are included in its vision (I have indicated I think all should be) and discuss fully these objectives and the scientific basis for these objectives in the Introduction. This will, in turn, support the selection of the recommended pollutants to be monitored in the program.

- Background. The background should also contain the scientific basis for the multi-pollutant objectives, as outlined in the bullet above.

- Identifying Candidate Near-road Site Areas. I believe the criteria outlined for this section are adequate for the identification of a site where maximum NO_2 concentrations near a given near-road site may be determined. However, since NO_2 is a secondary pollutant and its concentrations will be effected by both emissions from the roadway and from any other nearby elevated sources (VOC, ozone, etc.). These factors should be considered in the site identification process.

- Modeling. I am not an expert in this area. However, modeling should take into account the factors I have discussed above.

- Monitoring. One potential problem with saturation sampling is that if all data are not collected under identical conditions, certainly with respect to time and traffic flow, the comparison of results for the various saturation samplers may not be meaningful. I am also concerned about this issue in connection with the use of mobile monitoring. How will assurance be obtained that a comparison of measurements at two locations at different times gives the same result as a comparison of measurements at two different sites at the same time. How will diurnal variability be taken into account? These issues are discussed in the consensus report.

- Near-road Site Selection. The items outlined here seem reasonable.

- Recommended Near-road Site Documentation. The adequacy of this section will be dependent on the adequacy of the EPA objectives for the Pilot Study in addressing the appropriate multi-pollutant monitoring objectives. This will be an area discussed under other Charge Questions.

Charge Question 2.

I have suggested in I.C. objectives that should be part of the multi-pollutant monitoring scheme. My thoughts on species which should be included to meet each of these scientific objectives (the objectives are repeated here) are given below. Again, all these measurements need to be made on a one-hour time basis. It is also recognized that most of these measurements will not be made at all sites but only at the limited number of advanced sites as discussed in the consensus document.

- Identification of concentrations of other NAAQS pollutants which accompany the observed NO_2 concentrations. *(CO, PM_{10}, $PM_{2.5}$*, Ozone and {probably for some, but not all sites} sulfur dioxide)

- Identification of the contribution these and other key pollutants make to the observed NO_2 concentrations (see my comments in B.) *(VOC related to ozone formation, NO_X, NO_Y {including a minimum of gas and particulate nitrate in addition to NO_X}).*

- Identification of the atmospheric processes which contribute to the observed concentrations of NO_2 and the other monitored pollutants (e.g. Kuprov, 2010, Wilson 1977). *(The species listed in the two proceeding bullets.)*

- Identification of the sources which contribute to both measured concentrations of NO_2 and the other measured NAAQS pollutants (e.g. Eatough 2008). *(Fine particulate OC and EC, BC and UV C. In addition techniques are now becoming available for the hourly measurement of fine particulate elements and organic markers on an hourly basis. These last two measurements would be lower priority, but where they can be measured would greatly add to meeting this objective).*

I have not listed any of the toxic gases included in the charge question, but they are relevant to health objectives and might be added if EPA wants to add an objective for this specific purpose. That is a little different than the atmospheric chemistry objectives on which I have focused.

Charge Question 5.

Saturation monitoring can aid greatly in the identification of a suitable near-road monitoring site. My only concern with respect to this Charge Question is that it be made clear that the saturation monitoring must meet two key objectives:

- The data must be available on a one-hour average basis, consistent with NAQQS requirement for NO_2.
- All saturation data must be obtained at all locations on the same time basis so the results are not significantly confounded by the diurnal and seasonal variations in NO_2 emissions and formation chemistry.

Because of the inherent problems in meeting the items in the above two bullets, care needs to be taken in the use of an outfitted vehicle to assist in the road-site selection process.

Charge Question 7.

While peak concentrations of ultrafine particles will frequently be associated with emissions from vehicles, the concentrations of $PM_{2.5}$ will not. In almost all urban studies I am aware of, the maximum concentration of $PM_{2.5}$ are not dominated by primary emissions but the secondary formation of nitrate and organic material, and in the east by regional sulfate. None of these contributions can be elucidated from near-road monitoring. However, the total pollutants suggested here to be monitored in the program can inform the secondary formation processes which lead to these elevated PM concentrations.

Charge Question 8.

I have outlined my thoughts on this charge question in the response to Charge Question 2.

Charge Question 13.

I have listed my thoughts on equipment needed as outlined in this Charge question in my response to Charge Question 2, with an indication of contributions to be expected for each measurement. The relative priority which might be assigned depends on whether or not EPA agrees with my outline of objectives in Section I. It is recognized that these measurements will be made at a limited number of sites. My priority order and suggested measurements are:

1. Top priority (measurement of NO_2 and NAAQS pollutants):

    - NO2, hourly averaged data by an artifact free measurement as well as an FRM or FEM technique.
    - Ozone, hourly averaged data by an FRM or FEM technique.
    - PM10 and PM2.5 by a dichot FDMS TEOM method (to avoid the loss of volatile material).

2. Second priority (measurement of species which will inform NO_2 chemistry.

- VOC, hourly averaged data.
- NOX, hourly averaged data by an FRM or FEM technique.
- Ozone hourly averaged data by an FRM or FEM technique (also listed in 1.).
- NOY hourly averaged data.
- Nitric acid and particulate phase nitrate, hourly averaged by an IC technique (e.g., the URG AIM) where nitrate is known to be high, e.g. LA or western mountain valleys.

3. Third priority (data to aid in source apportionment, including separation of gasoline and diesel vehicle contributions).

- Hourly average EC and OC, preferable by a Sunset dual oven instrument.
- BC and UV hourly average Aethalometer data.
- Hourly averaged fine particulate elemental and trace organic marker data.

Charge Question 14.

First a general comment. The saturation studies are intended to aid in the identification of near-road sites which will give maximum NO_2 concentrations. These then will become the site(s) which are used to meet the NO_2 near-road monitoring requirements. To meet this requirement the key data each saturation study must provide are hourly average NO_2 concentrations which define at least a couple of weeks diurnal variation in the NO_2 concentrations. Less than hourly and less than complete diurnal coverage will not truly inform on maximum concentrations. I am not certain that a passive device can meet this need, so I assume a semi-continuous device or a modified passive sampler (see the consensus report) would be used.

a. NO_2

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b. I would think 4 to 6 is a reasonable number, but I defer to others who have conducted saturation studies.

c. Of the criteria listed in the charge question, 1) and 2) seem most important. I would also pick a site where impact from VOCs nearby is important.

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Mr. Dirk Felton

Questions regarding the near-road monitoring guidance document

1. **Please comment on the overall content of the recommended topics in the draft outline. Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.**

The background section should include language suggesting that finding one near-road location where all pollutants of interest have the highest concentrations is not likely and compromises will be necessary and acceptable. For example, NO_2 concentrations may well be higher in dense urban neighborhoods away from well ventilated busy highways. This section should also include a discussion of the limitations of the various monitoring methods in the near-road environment. The PM-2.5 FRM has demonstrated poor capture efficiency for volatile fresh emissions from mobile sources and CO monitoring for a health based NAAQS near roadways may not be warranted.

Modeling and saturation or mobile monitoring should not be required in the site selection process. This type of work is beyond the capacity of many monitoring agencies, and since these methods have not been uniformly demonstrated or well documented, they are not likely to provide much assistance. If monitoring agencies have existing information that could provide this type of information, they certainly should consider the information and make it available to their Regional EPA office during the site approval process.

The last section on site documentation should not be burdensome to the monitoring agencies. Much of the "NCore type" of site characterization documentation was designed so that EPA staff would have a convenient way to review monitor siting. If this type of information is important to the EPA then they can collect the data when they visit the sites.

2. **EPA and NACAA envision the near-road guidance document to be written from a multi-pollutant perspective. What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g., benzene, toluene, xylene, formaldehyde, acrolein, or 1, 3, butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.**

The discussion of potential species for consideration in the near road monitoring guidance is complicated by the currently available methods for some of these pollutants. PM and specifically PM-2.5 would certainly be considered to be a candidate but the EPA does not have an acceptable method for measuring PM-2.5 in the near-road environment. The EPA should consider the development of a suitable method for PM-2.5 to be of the utmost necessity.

CO monitoring is recommended and the siting requirements should be modified to be identical to the near road NO_2 requirements. CO may or may not be found at high enough concentrations to be a health issue, but it will be useful as a tracer of primary emissions.

Ultrafine monitoring is recommended but an appropriate minimum and maximum size range must be considered. Ultrafine particles have been found to affect health and data from near road sites will assist in the understanding of how mobile sources interact with ambient ultrafine levels.

BC is a combustion tracer so it should only be contemplated for installation at a near road site if there is another BC instrument within the same CBSA. Since the NATTs program requires BC, it makes sense to only install these instruments in the near road sites that also have a NATTs site. This limited deployment should provide some information on the gradient of BC between the near road environment and a central monitor.

This program should include air toxics that have been identified as known human carcinogens. This would include benzene, formaldehyde and 1, 3 - butadiene. Air toxics monitoring at the near road air sites should be encouraged in the CBSAs that also have a NATTs site. This would allow for comparisons between the near road and community scale monitors. Over time, the changes in vehicle technology and fuels will continue to impact concentrations of these air toxics which large segments of the population are exposed to daily. Currently, concentrations of these specific air toxics already exceed acceptable concentrations in many areas of the country. A critical evaluation of the impacts of these changes on the concentration of these air toxics in urban areas across the U.S. is extremely important.

3. **Identifying Candidate Near-road Site Areas**
    a. **AADT & Fleet Mix – does the subcommittee believe this approach is an appropriate way to "consider" fleet mix in near-road site selection or is a more refined inventory and modeling analysis required?**

Monitoring agencies should be permitted to use the best available information in order to help with site selection. There are too many disadvantages to specifying a one size fits all standard approach to site selection. Each CBSA has its own set of variables such as roadway restrictions on vehicle type or vehicle type at certain hours of the day, tolls that vary as a function of vehicle type, bridge restrictions, weather conditions such as cold weather or high winds and differences in required vehicle emission controls. Additionally, congestion in dense urban areas with numerous roadways in close proximity to one another can lead to higher NO_2 concentrations than AADT and fleet mix would indicate.

Some monitoring agencies also have very good inventories and existing modeling work done for specific CBSAs and not as much information for others. The guidance document should encourage the monitoring agencies to utilize all available tools and sources of information to help select the most appropriate monitoring locations.

    b. **AADT & Fleet Mix – Further, should the suggested approach above in question 4a to consider fleet mix via the use of average, fleet-wide emission factors, or the use of inventory and modeling analysis, take into account mobile source controls that are "on the books" but have not yet been fully realized due to fleet turnover? If so, how far out into the future should states consider their effects?**

Ambient monitoring is concerned with the current exposure to the population from sources of pollutants. Fleet turnover in most cases is a long term process especially for the largest trucks unless there is a specific program in place to help replace these vehicles more quickly. The EPA has the ability to review monitor siting once a year when the monitoring agencies submit their annual network plan. This should provide ample opportunity for the EPA to suggest changes to the monitoring network in light of changes in AADT and fleet turnover.

c. **Roadway Design – Does the subcommittee agree with this recommendation for locating sites at-grade with no obstructions? What priority should be placed on this factor within the guidance, given the need for flexibility in identifying appropriate site locations?**

The design of the roadway is extremely significant and it makes sense to recommend that the preferred installation be at grade with no obstructions. That said, the guidance document should expand on why this is important and where low or high concentrations are likely to be found. Low concentrations may be found adjacent to roadways elevated on piers, near coastlines or large water bodies. High concentrations may be found adjacent to roadways situated in dense urban areas surrounded by tall buildings, next to below grade roadways or near roadways that are also influenced by tunnel ventilation systems. These high concentration locations may be the preferred locations for some CBSAs particularly if they are also significant for population exposure.

d. **Congestion Patterns – how important a parameter should LOS be in the determination of appropriate near-road monitoring sites? Does the subcommittee have a view on how reliable LOS estimates are across the country?**

It is likely that on stagnant days the roadways with poor level of service, including congested slow moving traffic will cause levels of pollutants to accumulate to higher than expected levels. LOS information should be used to qualify the AADT data on a CBSA specific basis.

e. **Terrain – Does the subcommittee agree that terrain and vegetation should be a consideration in the siting process? What priority should this parameter have in the overall process?**

Terrain and vegetation are very important and should rank near the top of the site selection criteria. Both of these factors drastically affect path length, population exposure, effective probe height and an agency's ability to site a monitor. Vegetation can be a sink of many pollutants as well as a screen for the efficient transport of pollutants between the source and the monitor.

f. **Meteorology - Although there is no requirement to be downwind, in the preamble to final NO_2 NAAQS rule, EPA encouraged it when possible. EPA and NACAA intend to do the same in the guidance document. Does the subcommittee agree with this approach?**

The importance of other factors such as AADT, terrain and population exposure should take priority over the prevailing wind direction. If the monitoring agency has candidate locations that are otherwise equal it is preferred to select the one that is predominantly downwind from the near road emissions.

4. **Modeling is another tool that may be useful in the identification of candidate near-road sites. In particular, the use of mobile source emissions modeling with MOVES and local-scale dispersion modeling with AERMOD, can be presented as part of the guidance document. Please comment on the**

available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.

5. **In regard to the process of identifying candidate near-road monitoring sites, beyond the evaluation of factors noted above in question 3, and the potential use of modeling, the use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process.**

General Comment: All of these tools are resource intensive and are likely to be beyond the scope of many monitoring agencies. The use of these tools should not be required.

a. **what are the pros and cons to using passive devices to saturate an area to gather data?**

The NO_2 standard is a 3-Yr average of 1-Hr maximum values, so a typical passive sampler which is exposed for days to weeks will provide better information if the traffic signature is relatively consistent throughout the course of a day. This is likely to be the case in the largest CBSAs. Passive samplers will not provide as much information in smaller CBSAs with variable traffic congestion and the affects of other significant sources of pollutants.

b. **Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive Semiconductors (GSSs) for NO_2 and other pollutants of interest?**

The concept is good but, of course, the real issue with many of these instruments is the comparability to data from the FRM. If a monitoring agency is able to use several of these instruments to look at potential sites in relation to each other, not to a nearby FRM, then these non-regulatory instruments could be useful.

c. **Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the near-road site selection process for NO_2 specifically as well as other pollutants of interest?**

This could be a very expensive component of the site selection process and would only be likely to occur if the monitoring agency already had access to this type of vehicle. The advantage is that candidate areas can be identified relatively quickly compared to other screening methods. The disadvantages to these types of measurements are that they are a snapshot in time that could have little relationship to the periods when the concentrations are expected to be the highest.

Questions regarding the CO monitoring network and near-road monitoring

6. **The two issues are 1) the consideration of where light duty vehicles are operating under 'cold-start' conditions, which may often not be on the larger arterials or highways in an area, and 2) the impacts of light duty vehicle congestion and idling in areas such as urban street canyons and/or urban cores.** ***Questions regarding the PM monitoring network and near-road monitoring***

7. **Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?**

The answer to this question is complicated by the fact that the NO_2 regulation incorrectly identifies near-road environments as the areas where NO_2 concentrations will always be highest. Secondly, the traditional method of measuring PM-2.5, the FRM is not well suited to capturing the highly volatile emissions emitted from mobile sources. Thirdly, a significant portion of PM-2.5 in most areas is either due to transport or due to secondary particle formation, neither of which have anything to do with micro-scale NO_2 siting criteria.

A PM-2.5 network design that only includes locations that are near-road micro-scale sites will only provide information about that source. An adequate PM-2.5 network must include sites that also provide information that are relevant for upwind assessment, population exposure, seasonal differences that can be evaluated in terms of particle formation and lastly micro-scale source attribution.

PM-2.5 is more likely to be highest in dense urban neighborhoods away from the well ventilated roadways. These areas are subject to emissions from transport, domestic heating and cooking, stationary sources and mobile sources.

8. **In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?**

The EPA must define how it intends to collect PM-2.5 mass. The FRM will miss a significant fraction of the volatile component of the mobile source emissions. This will create the situation where the apparent risk from these sources or from living in one of these areas is under estimated. In general, it is not advisable to err on the side of underestimating a health risk when establishing a NAAQS oriented monitoring program. It is preferable to delay a requirement to monitor PM-2.5 at these locations until the EPA develops a suitable method that reliably includes a majority of the volatile component of PM-2.5. One suggestion is for the EPA to encourage the manufacturers of continuous PM-2.5 monitors to develop instruments without the FEM algorithms that reduce PM concentrations in an attempt to emulate the filter based FRM. This will provide a more realistic indication of the actual PM concentrations that the populations in these areas are exposed to everyday.

UFP number monitoring is on its way to becoming an acceptable monitoring technique but it is not quite ready for routine use. The EPA should invest in limited deployment monitoring demonstrations to assist the vendors as they develop better more reliable instrumentation. Some of the issues that need to be resolved include, how small do we need to go, which bins are appropriate from a health perspective and how do we QA these instruments. UFP data could provide valuable information for the health community as they investigate air quality related health effects.

The EPA has a BC monitoring requirement in place at the NATTs sites but this data is rarely used. The data is also subject to artifacts due to filter changes and interference from co-pollutants on the filter substrate. The EPA should really determine if there is a need for this data before the requirement to monitor for a non-criteria pollutant is added to this network.

EC/OC data is more interesting because it provides information that can help regulators understand the losses from the PM-2.5 FRM and to develop potential pollution control programs. This information may only be necessary in the MSAs where the PM NAAQS could be exceeded and control strategies are required.

PMcoarse is of limited value because the quality of the PM-2.5 data is poor and because of the small scale that the resultant data represents.

Questions regarding the monitor siting criteria for microscale CO, microscale $PM_{2.5}$, and the new near-road NO_2 siting criteria

9. **Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate?**

The 3 questions (9,10 and 11) assume that there are high enough CO concentrations at typical near-road locations to justify including health related NAAQS CO monitors at these sites. The EPA must determine if this is the case before establishing a new, expensive and potentially un-necessary monitoring requirement.

The siting criteria for CO does need to be updated if CO is included at a near-road monitoring location. The more restrictive height requirement is not necessary for sites where turbulence is expected to create well mixed conditions at these monitors. The criteria used for micro-scale PM and NO_2 is acceptable.

10. **should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?**

The micro-scale PM and NO_2 siting requirements are adequate for street canyon CO monitoring. The existing CO canyon monitoring guidance included a wind direction provision that is un-necessary and made it more difficult to find suitable locations.

11. **Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?**

It is useful to be able to refer to an area as a street canyon or as an urban core. Street canyons are relatively easy to define because they are defined by the structures in their immediate vicinity. Urban Cores have to be defined on a larger MSA basis.

Street Canyons have the following attributes. They are relatively narrow in comparison to the height of the structures on either side of the street. It should be relatively easy to model an optimum or minimum width to height ratio that would define a street canyon. A ratio of (1) width to (1 or 1.5) height might be a good starting point.

Urban Cores can be defined by a number of parameters such as the reasonable geographic center of an MSA, the approximate centroid of emissions sources, area of densest population or highest congestion. Very large MSAs could easily have multiple urban cores due to geography and neighborhood layout such as in NYC where boroughs in some ways can emulate small cities.

Questions regarding the near-road monitoring pilot study

The EPA ORD has been operating near-road monitoring locations for more than a year in a couple of locations including Las Vegas. The results from these campaigns should be used to determine if the NO_2 and other pollutant concentrations were high enough to warrant further development of near-road monitoring efforts. The data should also be evaluated to determine if the selected monitoring methods were appropriate for these locations.

12. **Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study?**

The reliance on a CBSA's population is too simplistic. The population of a CBSA does not specifically provide information about how roadways are used within a CBSA. For example, this ranking does not include the number of people who commute from outside of the CBSA every day or use car pools or mass transit including busses, trains, subways and ferries.

13. **Please comment on the *minimum* equipment/pollutant measurement complement that should be deployed at each site and also the *ideal* equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO_2, NO_X, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3, butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts.**

It is acceptable to deploy more monitoring parameters at the pilot sites than at the routine sites, however, the EPA must be aware of the resources necessary to operate these sites. The pilot sites should have NO2, CO, ultrafine and BC monitors. PM-2.5 should be included only if PM-2.5 FEMs are operated without the algorithms that reduce the mass to match the FRM. These instruments could utilize the EPA parameter description 88500 which cannot be compared to the PM2.5 NAAQS and is defined as total atmospheric PM-2.5.

The pilot sites should be selected based on the availability of NCore and NATTs sites within the same CBSA to permit data comparisons with the near-road site.

14. **EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on:**

The deployable semi-continuous package that EPA is considering is not practical for use by monitoring agencies. The unit is expensive, may or may not provide data that is comparable to criteria monitors and would require power and security wherever it is deployed.

a. The pollutants that should be measured with the saturation devices at each saturation site.

The saturation devices only have to be able to monitor NO_2. Once the high NO_2 site is found, other parameters can be included when the monitoring site is fully established.

b. The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.

The most effective use of saturation samplers is to help rank the top 2-4 sites that have been identified through the rest of the site selection process. It would be too expensive and labor intensive to use saturation monitoring to select sites across wide areas in a CBSA.

c. Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.

It is sensible to use saturation monitors to compare sites that cannot be ranked in another way. The monitoring agency should include the feasibility of establishing a monitor in a specific area in the initial consideration of potential sites. Saturation samplers can help the agency differentiate a feasible site on one type of roadway to another feasible site on another type of roadway.

Dr. Kazuhiko Ito

Note: The charge questions below are truncated to save space.

General Comment:

I understand the importance of measuring NO_2 near roadways, but I am very concerned about a possible reduction in the number of community-wide monitors that can result from the new network plan. According to EPA, there are currently about 400 NO_2 monitors nationwide, many of which are community-wide monitors, and very few (3?) are micro-scale monitors. The new network plan will create 126 near-road monitors, but only 53 community-wide monitors will be required to operate. The epidemiological studies that reported short-term associations between NO_2 and respiratory morbidity used the community-wide monitors. Because the near-road monitors may not adequately reflect the entire city's residents' exposures, we may be reducing the number of NO_2 monitors that can be used for community based epidemiological studies. I have more comments on this as part of response to Charge Question 2.

Questions regarding the near-road monitoring guidance document

Charge Question 1: Please comment on the overall content of the recommended topics in the draft outline (of the near-road monitoring guidance document). Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.

Comment:

The overall content and the topics listed in the outline look generally adequate. I have a few comments below.

In addition to the literature review mentioned as part of Background, EPA can conduct analysis of the existing data (though the monitors are not sited in the required near-road scale) to describe the relationship between NO_2 and other pollutants (e.g., CO, EC, etc.).

In identifying candidate near-road areas, it may not be just AADT but the density of high AADT areas that are important, particularly in cities with high population density areas.

Charge Question 2: What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.

Comment:

I need to first comment on my general rationale of measuring co-pollutants at the proposed near-road monitoring location before discussing the prioritizing co-pollutants. I feel that there is a gap between the recognition of the short-term associations between NO_2 and respiratory morbidity in the observational epidemiological studies, the results from human laboratory studies, and the suggestion to measure hourly NO_2 values at near-road locations and set a standard level at such locations with the 1-hr averaging time. I understand that this has been already decided, but I think we should keep the options to evaluate the implication of this decision in case we may need to reconsider this strategy. The issues I need to raise are the following:

• The observational studies that reported short-term associations between NO_2 and respiratory morbidity mentioned in the FR (40 CFR Parts 50 and 58) used NO_2 data from monitors that were not near-road monitors. Unless the associations were due to exacerbations of respiratory conditions in the sub-populations who lived near roads, it is possible that the data to be collected at near-road monitors may not correlate well with the measurement at the existing NO_2 monitors, and they may not even correlate well with the citywide respiratory morbidity time-series because the near-road measurements may be highly influence by local sources that are not relevant to the rest of the city.

• Correlations between NO_2 and co-pollutants at near-road monitors may be different from those at non-near-road monitors (i.e., those used in the observational epidemiological studies). Therefore, it is possible that these co-pollutants measured at near-road monitors have different impacts on the health effects models compared to those reported in the past epidemiological studies.

Because of these issues, I think it is essential to retain at least some of the existing non-NR NO_2 monitors until the issues are resolved. Otherwise, it is possible that we end up with discontinuation of data that are useful for epidemiological studies.

The review of epidemiological studies in the NO_2 ISA concluded that the associations between NO_2 and respiratory morbidity were robust to the inclusion of other co-pollutants (i.e., no strong indication of confounding) in the health effects models, but these co-pollutants were mostly other criteria pollutants (PM_{10}, $PM_{2.5}$, ozone, CO, SO_2) with a few exceptions in studies outside US that examined non-criteria pollutants (e.g., benzene, coarse particles, ultra-fine particles). Determining confounding by co-pollutants that come from the same source(s) as NO_2 is methodologically difficult, but it would be beneficial to measure, at least in a pilot study, the pollutants that may also have the health effects (including effect modification or synergism) or may be useful as markers to distinguish among the sources that emit NO_2. When the EPA mentions "a multi-pollutant perspective", I assume that there are several rationales for the idea. Ranking/prioritizing individual pollutants is difficult because there are uncertainties about the importance of specific pollutants, but they can be grouped in terms of the rationale for measuring them, and the rationale may be ranked.

Pollutant group	Rationale (objective and feasibility) and comment
NO_2, NO, NOx	• Same instrument
CO	• Marker of gasoline vehicles • Multi-pollutant assessment using the instruments already used for NAAQS • Potential health relevance
Black carbon	• Diesel traffic marker • Potential health effects
Ultra-fine particles / particle number concentrations	• Potential health relevance • Expected to be high near-roadways
$PM_{10-2.5}$, and their chemical constituents such as Br, Zn, Cu, Sb	Traffic: re-suspended dust, tire ware, brake ware.
$PM_{2.5}$ and its chemical constituents such as EC, OC	• To determine "excess $PM_{2.5}$" beyond urban background • Potential health effects
SO_2	• Sources other than traffic that produce NO2.

Charge Question 3 (Identifying Candidate Near-road Site Areas):

Comment: All of these items (a) through (f) (and population density, which was mentioned in the outline but not here) seem important to consider in identifying candidate near-road sites. However, without actually determining the relationships between these factors and the NO_2 levels, presumably through the pilot project, it would be difficult to evaluate the adequacy of siting a monitor based on the information alone. EPA should look for studies that attempted to investigate these issues. The data from the New York City Community Air Survey (NYCCAS) may be useful. They have been conducting 2-week sampling measurements of NO_2, SO_2 (winter only), ozone, $PM_{2.5}$ and its chemical constituents at 150 locations within New York City. They are conducting land-use regression of the measured pollutants including NO_2 as a function of a number of geo-coded emission data including traffic volume and other local combustion sources (e.g., residual oil burning). The information from the analysis of the NYCCAS data may be useful in evaluating the limitation of AADT data.

Charge Question 4: Please comment on the available modeling tools (e.g., MOVES, AERMOD, etc.), and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.

Comment: I have not used these models and have not seen the model validation of these models as applied to NO_2 and other traffic air pollution. Therefore, I cannot comment on this.

Charge Question 5: The use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process.

5 (a): What are the pros and cons to using passive devices to saturate an area to gather data?

Comment: The obvious pros include the low cost and small dimension. The obvious cons include the long sampling period required for the detection limit of the passive sampler. However, the spatial distribution of NO_2 constructed from such sampling would be still useful in determining the siting of a sampler. The relationship between the 1-hr peak NO_2 data and the data from passive samplers can be determined from a pilot study. The NYCCAS data mentioned above may be useful to do this, since the study already collected 2-years of data (to identify the high NO_2 area) and the study is still going on (to measure hourly data at the high NO_2 areas to compare the two-week vs. hourly data).

5 (b): What are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO_2 or Gas Sensitive Semiconductors (GSSs) for NO_2 and other pollutants of interest?

Comment: The pros: Ability to measure hourly data: The cons: Need to validate the correspondence with the FRM/FEM measurements. A pilot study is required for this.

5 (c): What would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements?

Comment: I am not sure what the pros would be unless all the other information leaves a kind of uncertainty that can be resolved by the mobile measurements. The cons include the cost and resources required to conduct the measurements.

Questions regarding the CO monitoring network and near-road monitoring

Charge Question 6 (a): Does the subcommittee believe that the light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area?

Charge Question 6 (b): Does the subcommittee have an opinion on whether, and possibly how, these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal?

Comment: I don't know the data regarding the impact of cold start conditions on CO peaks and therefore cannot comment.

Questions regarding the PM monitoring network and near-road monitoring

Charge Question 7: Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?

Comment: It depends on the region of US, but PM (particularly $PM_{2.5}$) may be dominated by regional background PM levels, so the impact of the near-road pollution on the monitor will need to take into consideration (subtract) the data from non-NR PM monitor. I guess the NCore sites will be sufficient for this purpose where they exist.

Charge Question 8: In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?

Comment: All of these would be "desirable", but are funds available to measure these in the new near-road monitors?

Questions regarding the monitor siting criteria for microscale CO, microscale $PM_{2.5}$, and the new near-road NO_2 siting criteria

Charge Question 9: Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate?

Comment: I appreciate the historical background and the original reasons for the siting criteria for different NAAQS pollutants. None of these criteria of data collection were originally meant for epidemiological studies. However, since the researchers used these data from the regulatory monitors for observational epidemiological studies, and because the findings from these studies are in part influencing the process of setting NAAQS, it is inevitable that the siting criteria will need to accommodate the need to use the data for epidemiological investigation. These studies often use multi-pollutant regression models to examine potential confounding effects, which tacitly assumes that pollution variables equally represent the population exposures. The reported short-term associations between CO and mortality and cardiovascular morbidity raise a concern that these associations are observed despite the potential inadequacy of the exposure metric to represent population exposure (i.e., potential attenuation of associations). For this reason, I think it is appropriate to adjust CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites.

Charge Question 10: Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale $PM_{2.5}$ and microscale near-road NO_2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?

Comment: If we are assuming that there can be CO monitors for different purposes (and there is sufficient funds), yes, I think there should be consideration to maintain CO monitors that will measure the maximum impact that is separate from the population epidemiology.

Charge Question 11: Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?

Comment: Establishing such definitions would require some analysis of available data to characterize the relationship between the pollution levels and emission/environment conditions (AADT, building density, etc.).

Questions regarding the near-road monitoring pilot study

Charge Question 12: EPA and NACAA will select the locations for permanent sites … these considerations include choosing a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NO_X analyzer … Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study?

Comment: Given the limited budget, EPA should consider the cities that already have infrastructure to conduct a pilot study or the cities that are already conducting multi-pollutant assessment at multiple locations. Atlanta and NYC come to my mind.

Charge Question 13: EPA and NACAA have proposed that at least two urban areas should have permanent near-road monitoring stations (that would fulfill NO_2 near-road monitoring requirements) implemented for the pilot study… Specifically, what pollutants and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods?

Comment: See my comment on Charge Question 2 for the list of pollutants. In terms of other information any geo-coded information related to traffic and other emission sources would be useful. The reports from the NYCCAS project for such information may be useful (available from http://www.nyc.gov/html/doh/html/eode/nyccas.shtml).

Charge Question 14: EPA and NACAA have proposed four to five urban areas to have saturation monitoring …Please provide comment on:

a. The pollutants that should be measured with the saturation devices at each saturation site.

b. The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.

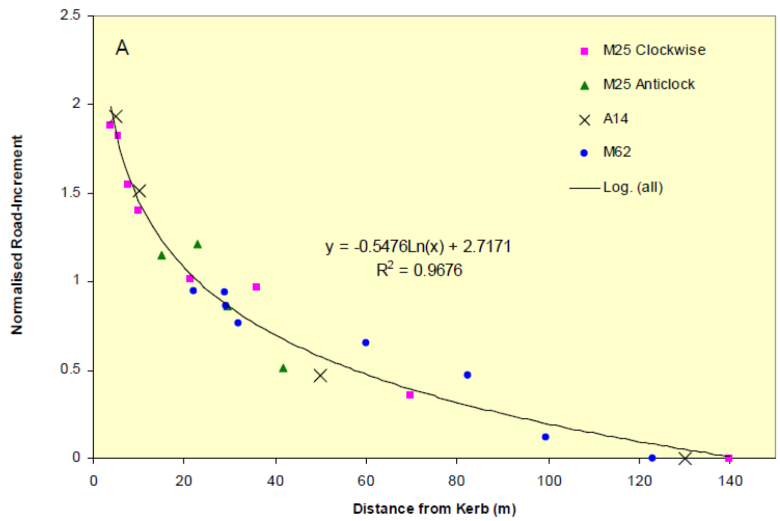
c. Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.

Mr. Rich Poirot

Comments on Near Road Monitoring

1. The accompanying draft guidance document outline provides an initial thought of the major topics required in the near-road monitoring guidance that will aid state monitoring agencies in the identification and implementation of NO2 near road monitoring sites from a multi-pollutant perspective. Please comment on the overall content of the recommended topics in the draft outline. Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable.

I think the draft outline for the guidance document seems reasonably complete and contains no unnecessary topics. One critical topic which seems missing from the outline is the importance of the specific distance from the roadway. I think "within 50 meters" is too broad a range, and that most of the near-road influence falls off within, rather than beyond, that distance. Extensive, long-term experience sampling near-road NO_2 in the UK (where "roadside" monitors are within 5 meters from the road and where additional "kerbside" monitoring is conducted within 1 meter – both at heights between 2 and 3 meters) indicates that the "roadside increment" declines, predictably, with the log of distance from the road, as illustrated in the attached figure.



From: NO2 Concentrations and Distance from Roads (2008) Air Quality Consultants Ltd.
http://www.airquality.co.uk/laqm/documents/FallOffWithDistanceReptJuly08.pdf
This effect of distance is considered sufficiently predictable that a nomograph is available that estimates concentrations at any distance from measurements at any other distance (within 50 m).
http://www.airquality.co.uk/laqm/tools/NO2withDistancefromRoadsCalculatorIssue2.xls
While these estimates are derived from annual average concentrations, a similar relationship will occur for hourly near-road concentrations (of NO_2 and other mobile source pollutants like BC, ultrafines, CO, etc.). Location changes within the 50 meter distance could easily result in changing the incremental roadway contributions by a factor of 2 or 3. I think there is a need to further constrain this distance range in the guidance, or perhaps the standard could be expressed in terms normalized to a specific distance (say

10 or 20 m). For ultrafine particles, especially those in the < 25 nm size range, the roadside gradient is likely to be even steeper. See for example:
Zhu et al. 2004: "Aerosol Science & Technology: Seasonal Trends of Concentration and Size Distribution of Ultrafine Particles Near Major Highways in Los Angeles." 38(suppl 1):5–13; Sioutas et al., 2005 Exposure Assessment for Atmospheric Ultrafine Particles (UFPs) and Implications in Epidemiologic Research. Environ Health Perspect 113(8): doi:10.1289/ehp.7939; Durant et al., (2010) Short-term variation in near-highway air pollutant gradients on a winter morning, Atmos. Chem. Phys. Discuss., 10, 5599–5626.
I also think the emphasis on AADT as the primary focus for site selection is overstated relative to "other near-road considerations" which are likely more important (in addition to the specific distance) Note for example the following Table A3.6 from the 2007 Air Quality Expert Group report on *Trends in Primary Nitrogen Dioxide in the UK*, that maximum hourly (98th percentile) NO_2 correlates poorly ($R^2 = 0.24$) with counts of total vehicles, but shows a much higher correlation ($R^2 = 0.66$) with counts of (diesel) bus traffic, based on measurements at 53 roadside sites in the UK.

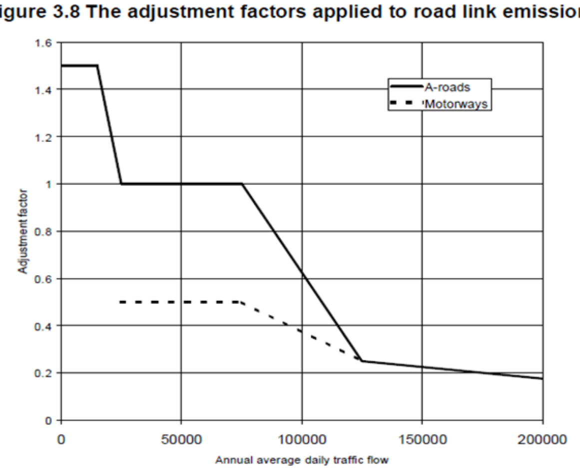
Table A3.6: Correlation coefficients for 53 roadside monitoring sites.

	NO_x annual mean	NO_2 annual mean	98 %ile	Exceedences	Count all	Count - car	Count - bus	Count - LGV	Count HGVr[1]	Count HGVa[2]	Count motor bike	NO_x all	NO_x car	NO_x bus	NO_x LGV	NO_x HGVr[1]	NO_x HGVa[2]	NO_x motor bike
NO_x annual mean	1.00																	
NO_2 annual mean	0.96	1.00																
98 %ile	0.94	0.98	1.00															
Exceedences	0.75	0.78	0.78	1.00														
Count – all	0.35	0.26	0.24	0.11	1.00													
Count – car	0.32	0.22	0.21	0.08	1.00	1.00												
Count – bus	0.57	0.67	0.66	0.64	0.14	0.10	1.00											
Count – LGV	0.28	0.21	0.18	0.10	0.93	0.91	0.12	1.00										
Count – HGVr[1]	0.27	0.17	0.17	-0.01	0.81	0.80	-0.05	0.70	1.00									
Count – HGVa[2]	0.06	0.00	0.02	-0.05	0.58	0.56	-0.14	0.63	0.49	1.00								
Count – motorbike	0.49	0.54	0.50	0.20	0.56	0.51	0.43	0.55	0.40	0.09	1.00							
NO_x all	0.38	0.30	0.28	0.17	0.75	0.72	0.17	0.77	0.69	0.51	0.46	1.00						
NO_x car	0.25	0.16	0.14	0.06	0.95	0.95	0.05	0.87	0.77	0.64	0.44	0.76	1.00					
NO_x bus	0.61	0.71	0.69	0.66	0.13	0.08	0.99	0.10	-0.05	-0.18	0.47	0.18	0.02	1.00				
NO_x LGV	0.32	0.26	0.22	0.13	0.90	0.87	0.18	0.98	0.67	0.58	0.60	0.79	0.86	0.18	1.00			
NO_x HGVr[1]	0.33	0.25	0.24	0.03	0.75	0.74	0.03	0.65	0.97	0.39	0.49	0.67	0.70	0.05	0.64	1.00		
NO_x HGVa[2]	0.08	0.02	0.03	-0.04	0.59	0.56	-0.12	0.66	0.51	1.00	0.11	0.54	0.64	-0.15	0.61	0.42	1.00	
NO_x motor bike	0.39	0.41	0.39	0.15	0.72	0.68	0.30	0.71	0.57	0.36	0.91	0.64	0.66	0.31	0.72	0.59	0.37	1.00

[1] Heavy goods vehicle – rigid
[2] Heavy goods vehicle – articulated

From: UK air quality modelling for annual reporting 2007 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC
http://www.airquality.co.uk/reports/cat09/0905061048_dd12007mapsrep_v8.pdf

Figure 3.8 The adjustment factors applied to road link emissions



Long-term experience with roadside NO_2 monitoring and modeling in the UK has also indicated that the enhanced dispersion effects of vehicle speed more than offset slight increases in NOx emission rates, leading to decreasing per-vehicle NO_2 impacts with increasing AADT, especially on high speed "motorways" (analogous to US Interstates). Note the attached Figure 3.8 "adjustment factors" used to reduce per/vehicle NO2 emissions for modeling near-road NO_2 impacts in the UK.

From: Trends in Primary Nitrogen Dioxide in the UK (2007) Air Quality Expert Group Report, Annex
http://www.defra.gov.uk/environment/quality/air/airquality/publications/primaryno2-trends/index.htm

Other minor suggestions include:

- The relative age of the fleet may be an important component of the fleet mix, which may vary among cities and within urban neighborhoods. (This may be somewhat less important for NO_2 than for other near-road pollutants).
- The "load" on vehicles during rush hour(s) could be an important factor. For example, diesel vehicles in stop-and-go traffic and/or on an uphill grade will lead to high NO_2 regardless of AADT.
- The "expandability" of a site – i.e. the ability to accommodate additional samplers for various other mobile source pollutants – should also be a site selection consideration.
- The availability (or establishment) of a "representative" urban background site (for NO_2 and ideally for other MV pollutants) should also be an important consideration. Identification of "roadside increments" for the multiple pollutants is critical, as is the ability to project measurements from specific microscale sites to larger population exposures.
- The measured or expected neighborhood-scale background may also be important. Other things being equal, a high traffic road in the midst of other high traffic areas is likely to experience higher concentrations than a similar roadway on the edge of the urban area.

2. EPA and NACAA envision the near-road guidance document to be written from a multi-pollutant perspective. What pollutants and sub-species does the subcommittee believe should be included for consideration and discussion in the near-road monitoring guidance? Some potential species for consideration include NO2, NOX, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (e.g., benzene, toluene, xylene, formaldehyde, acrolein, or 1, 3, butadiene), and ammonia. Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.

Since NO_2 is the focus of the revised NAAQS and new monitoring requirements, it (and the NO & NOx which typically come along with it) has to be given top priority. It seems possible however that of the many, various mobile source pollutants, NO_2 may be one of the least health-relevant, and a new, large monitoring network measuring just NO_2 would be a waste of scarce resources. All of the other pollutants listed above would also be of interest, but would be prohibitively expensive to add at all sites. I also wonder whether the near-road influence of these many mobile source pollutants (or even of just NO_2 alone) is something that can be or should be addressed in a large network approach. Rather than prioritizing the above list and seeing a few species measured at a large number of (similar) sites, I would prefer to see a nested network, within which many/most of the above species could be added at a smaller subset of sites. Instrument costs and the availability of reliable, continuous samplers should also be an important consideration.

I think black carbon (preferably multi-wavelength) should be given high priority, given its relevance to health (& climate & visibility) effects, its strong influence – like NO_2 – from diesel emission sources, and the availability of reliable continuous instruments. Continuous OC (OC/EC) data would also be useful at some sites to help assess effects of fleet mix, SOA formation, condensation, destruction, etc. If reliable instruments are available and affordable, particle number count (including ultrafine particle sizes) would also be an important measurement, and likely to increase rapidly near roadways (well within 50 meters). I would give BC and number count a higher priority than $PM_{2.5}$ mass, and it seems likely that FRM/FEM $PM_{2.5}$ samplers will substantially understate the semi-volatile fraction near roadways (although FDMS TEOMS have not generally performed well in the field). There is likely a steep PM coarse gradient near roadways, but PM_{10} (subtraction) measurements would be a poor way to characterize this. Collection of PM in different size fractions in large (aggregated) sample volumes – to support molecular level organic analysis and bioassay work - could also be useful at a few sites. CO measurements would be especially useful for contrasting pollutant mixes at sites (or times) with different diesel vs. spark engine fleet mixes. The "toxic" species listed above would likely show strong roadway increases, but are also likely to be prohibitively costly (or too labor intensive) to add at most sites. I wonder if there's any possibility of moving or establishing one of the NAATS sites to a near-road location? Our (very small) VT state agency has recently had reasonable success operating a continuous BTEX instrument from Synspec – for which I believe a 1,3 butadiene option is available. Results from the Las Vegas MSAT near-road toxics study could be quite relevant here, and some consideration might be given to modifying planned future phases of that study to make it more relevant to the objectives of the new near-road NO2, CO NAAQS requirements and related multi-pollutant monitoring plans.

I don't know the availability, reliability or costs of continuous NH_3 instruments, but better characterization of MV NH_3 emissions would be desirable at a few sites at least. Possibly some periodic UC Davis DRUM sampling would be a useful complement at a few sites – if equipped with a streaker or somesuch to add time resolution to the ultrafines. I haven't actually seen that configuration in action, and don't know about current analytical capabilities at the DELTA Group. Ozone measurements might be useful at selected sites (including the urban background sites), as the contribution of secondary NO_2 formation, even in near road environments, isn't necessarily trivial, and interesting changes may occur with efforts to attain new ozone and NO_2 standards.

In addition to the above pollutant species list, and meteorological measurements, other measurements that should be considered include traffic counters (which can separate light & heavy duty MV) and or possibly cameras (which can be especially useful for evaluating extreme events). It should also be noted that the important objective of characterizing incremental roadway contributions for any of the above pollutants would benefit (as for NO_2) from a measurements at a paired urban background site. Some (nearby) remote sensing (FEAT) could also be useful, or perhaps establishing near-road sites near locations where FEAT-type measurements have recently conducted (and may be periodically repeated).

http://www.feat.biochem.du.edu/assets/databases/Cal/Tricity_NH3_SO2_NO2_2008_Report_ARB.pdf

3. Identifying Candidate Near-road Site Areas

a. AADT & Fleet Mix

As indicated above, I think AADT alone is a poor indicator.

b. AADT & Fleet Mix

A metric which 'diesel-weighted' the AADT would be preferable to AADT alone, but again, count is not really the key issue, especially on high speed highways. Two trucks passing the monitor at 60 mph will not cause twice the impact of 1 truck at 30 mph… Also, given the 1-hour standard, the traffic and fleet mix on weekday morning rush hours are likely to be most important.

c. Roadway Design

Assuming that you mean "no obstructions" between the road and the monitor, this seems reasonable, and it seems unlikely that that no suitable sites without such obstructions will be available. Barriers beyond the monitoring site that constrain the further dispersion of roadway pollutants should not be avoided and (in urban street canyons) may well lead to some of the highest population exposures. Conceivably, adding barriers - sound barriers, trees, etc. - might be considered as an exposure mitigation strategy. It might also be noted that large fractions of the population spend time within a 5 or so meters of congested urban streets, but population proximity to the edges of high-speed interstates with maximum AADTs is typically more distant.

d. Congestion Patterns

Conceptually, "level of service" sounds like an important indicator, although I don't know how reliable such data is on a national scale. As indicated earlier, I think NO_2 emission increases with speed are relatively small and offset by increased dispersion. I would expect higher concentrations during times/places of highest congestion, rather than during high speed driving conditions.

e. Terrain

Terrain could be an important, especially during the winter in mountain/valley locations, in urban street canyons, or near roadway dips which are below grade.

e. Meteorology

I think the Agency's proposed approach – strongly encouraging but not formally requiring "downwind" location is reasonable for all the reasons given. Ideally the "downwind" location would concurrently reflect the periods of highest traffic congestion and lowest wind speeds and mixing heights. In case of doubt, saturation sampling could help determine locations of maximum expected impact. Established sites which met measurements indicate are persistently upwind during rush hour should be replaced.

4. **Modeling is another tool that may be useful in the identification of candidate near-road sites. In particular, the use of mobile source emissions modeling with MOVES and local-scale dispersion modeling with AERMOD, can be presented as part of the guidance document. Please comment on the available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.**

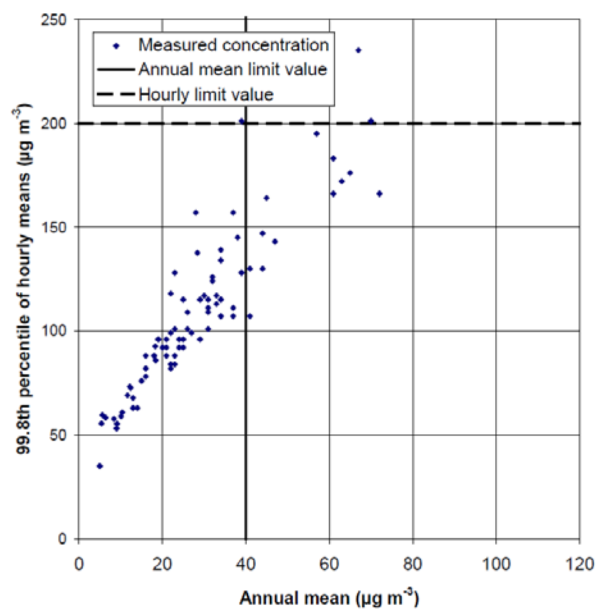
Modeling may be a useful tool, but unless site-specific meteorology and vehicle mix, volume and congestion data are available, I'm not sure it would lead to a better site selection than a "common sense" approach. AERMOD also often performs poorly in complex terrain.

5.

a. **If a state were inclined to use saturation monitoring to aid in the selection of a near-road monitoring site, and considering the NO2 standard is a 1-hour daily maximum standard, what are the pros and cons to using passive devices to saturate an area to gather data?**

Unless the time periods for saturation sampling turn out to be atypical, the longer (than 1 hour) aggregation times for passive samplers may not be that big a problem. Based on the long-term, multi-site data from roadside sites in the UK, the peak hourly and annual average concentrations are well correlated across space, as indicated in Figure 3.3 pasted here. Note also the high correlation (R2 =0.98) between annual average NO_2 98th percentile hourly values from 53 UK roadside sites in Table A3.6 above.
From:
http://www.airquality.co.uk/reports/cat09/0905061048_dd12007mapsrep_v8.pdf

Figure 3.3. Plot of annual mean against 99.8th percentile hourly NO_2 concentrations in 2007



A disadvantage of passive samplers is that while reasonably accurate units are available for NO_2, NO, NOx & BC, there may not be comparably accurate units for CO. This limits the ability to explore different NO_2/CO ratios in a saturation approach. An advantage of passive samplers is their low cost and subsequent ability to deploy many units inexpensively. If passive sampling were limited to NO_2 & NO, a relatively dense exploratory saturation sampling program could be considered, including innovative mounting of passive samplers on (and/or in) busses, commuter cars, taxis ect. This will open the can of worms regarding whether there's intent to protect people in their cars at rush hour, but that issue probably needs to be addressed at some point. See also George Allen's recommendations combining passive samplers with active, timed inlets.

b. **Likewise, what are the pros and cons to using non-passive devices, such as near real-time or continuous devices including, but not limited to portable, non-FEM chemiluminescence methods for NO2 or Gas Sensitive Semiconductors (GSSs) for NO2 and other pollutants of interest?**

Potential advantages include the ability to collect data with higher time resolution and for more species than passive samplers allow. I don't know the current instruments, and defer to others on the committee.

c. **Finally, what would be the pros and cons, to a state or local agency attempting to use a specially outfitted vehicle to collect mobile measurements to assist in the**

near-road site selection process for NO2 specifically as well as other pollutants of interest?

Other than the prohibitive cost, this could be an excellent way to help select sites and characterize the space/time patterns of exposures to multiple roadway pollutants. I wouldn't automatically rule this out, as it may turn out that some states or research groups may have access to such mobile sampling equipment and would be willing to operate it at reasonable costs. In my view the pilot studies should be conducted in fewer, rather than more locations, and this might be a good way to produce some useful data in a few (1 or 2) study areas. If only EPA had an adequately funded Office of Research and Development… There may also be some useful low-tech ways to combine "ordinary" mobile sampling vehicles (buses, taxis, commuter vans etc.) with passive samplers that could provide some useful information.

6.

a. Does the subcommittee believe that the light duty cold start and congestion factors will significantly influence the location of peak CO concentrations in an area? What priority should these factors be given when compared with the factors (AADT, Fleet Mix, Roadway Design, Congestion Patterns, Terrain, and Meteorology) already being considered for peak NO2?

Yes, these are important considerations. I don't believe however that maximum NO_2 and CO will necessarily occur at vastly different kinds of locations, and that some kinds of sites would be suitable for quantifying near-road influences from both pollutants. A relatively high fraction of diesel vehicles does not necessarily mean that emissions from spark engine vehicles will not be high as well. Congested sites where vehicle mixes change by time of day and day of week will be especially informative. Having concurrent, collocated data for multiple species, while searching for single pollutant "hot spots" is not likely to improve understanding of population exposures, help discern effects of co-varying pollutants, nor lead to development of effective abatement strategies.

b. Does the subcommittee have an opinion on whether, and possibly how, these two issues of vehicles operating under cold start conditions and light duty vehicle congestion and idling in urban street canyons and/or urban cores be considered in a future, nationally applicable, CO monitoring proposal? Are there other factors that may affect peak CO concentrations and not affect peak NO2 concentrations that should also be considered for any future CO monitoring proposal?

CO will also be influenced by residential wood combustion and other space heating emissions and so northern mountain valley locations with high traffic counts and congestion plus limited dispersion on cold winter mornings (when secondary NO_2 formation is minimal) may see relaticely higher CO concentrations. As with NO_2, I'm not convinced that CO is the most (or second most) health-relevant component of roadway emissions, and would hope that suitable near-road sites could be identified to address both pollutants, with a smaller number of sites added to address specific CO-specific concerns when the CO NAAQS revision is final. For both pollutants, I think the objective should be to characterize near-road population exposures to mix of traffic-related emissions, and not just to witch-hunt for the worst-case locations of maximum single-pollutant concentrations.

7. Does the committee believe that siting considerations for identifying the location of peak NO2 concentrations will likely address all of the high priority siting considerations for PM (particularly PM2.5) as well? If not, what other factors should be considered and what are the advantages in considering these factors for identifying the location of maximum PM concentration?

While there is likely a significant near-road enhancement of local $PM_{2.5}$ concentrations, I think this roadway enhancement is proportionally much smaller for $PM_{2.5}$ mass - compared to the roadway enhancement of NO_2, BC, ultrafines, etc., and that $PM_{2.5}$ should not be a priority consideration in siting. Also, since diesel emissions are major contributors to roadway NO_2 and $PM_{2.5}$ there should not be much conflict in siting objectives.

8. In addition to PM2.5 mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?

As indicated above, I would give all of the above a higher priority than $PM_{2.5}$ mass measurements, and would push more for continuous instruments that would better characterize the entire particle size distribution. Roadway fine particle concentrations are also likely to include a substantial semi-volatile component, which is not well characterized by $PM_{2.5}$ FRM (or FEM) instruments. The roadway increment in coarse particle concentrations is likely to be proportionately greater than for fine particles, and coarse-only sampling should be given a higher priority at some of these sites. Past consideration of setting an "urban" coarse particle NAAQS, was based on an assumption of greater inherent toxicity in urban areas. But this (logical) assumption was not supported by much measurement data. The carbon species (BC and/or EC/OC) and particle number information will be more useful than $PM_{2.5}$ mass for health effects studies and source attribution, especially given the longer averaging times – 24-hour and annual – for the $PM_{2.5}$ NAAQS and currently stated intent to keep the annual standard "controlling".

9. To allow for near-road monitoring infrastructure to be multi-pollutant, and in reflection of the recently promulgated near-road NO2 siting criteria, reconsideration of the existing microscale CO siting criteria presented in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E may be warranted. Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale PM2.5 and microscale near-road NO2 sites be logical and appropriate?

As previously indicated, I think the 50 meter range proposed for "near-road" NO_2 is too large and should be tightened prior to attempting to harmonize the various microscale criteria for various pollutants. Conceptually, near-road measurements for multiple pollutants might "standardized" to expected concentrations at a single fixed distance, or perhaps a (closer than 50 m) maximum and a minimum sampling distance could be specified, with a smaller number of "research" sites encouraged that could collect useful data very close to roadsides (inside the minimum distance) that would help characterize the roadway contribution without being used for compliance determination.

10. Even if the adjustment of microscale CO siting criteria in sections 2, 6.2, and table E-4 in 40 CFR Part 58 Appendix E to match that of microscale PM2.5 and microscale near-road NO2 is appropriate and proposed, should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited?

Off hand, I don't see why near-road distances for CO and NO_2 should be different, or why CO should be relaxed to NO_2 distances.

11. Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language?

No opinion.

12. EPA and NACAA will select the locations for permanent sites that are part of the near-road pilot study based on which state or locals volunteer to participate and can process grant funds in a timely manner to deploy equipment. From this pool of volunteers, selection should be made on certain attributes that provide the best potential to fulfill pilot study objectives. In the attached draft white paper, EPA and NACAA have proposed some potential criteria for consideration in selecting where the fixed, permanent stations should be located. These considerations include choosing a large and a relatively small urban area based on population, an area with varied or complex terrain, an urban area with an operational NOX analyzer representative of neighborhood or larger spatial scales for comparison to the near-road NOX analyzer, and an urban area with a cooperative (or non-cooperative) Department of Transportation. Does the Subcommittee agree with these considerations? Further, are there other considerations that should be evaluated in selecting pilot cities to house permanent near-road monitoring stations as part of the pilot study?

I'm not sure sufficient funds are available to address so many different kinds of locations. It will be necessary to take maximum advantage of existing sites (including urban background sites and those operated by research groups) to the extent possible. The availability/participation of academic or private sector groups to add supplemental measurements should also be encouraged. With such limited funds, is it necessary to intentionally include a small city or an area with a non-cooperative DOT? If small cities are included (or not), selected sites should be adjacent to roadways with high volumes of diesel traffic and frequent rush hour congestion. Given the rapid decline of roadway influence with distance, priority should be given to sites which are substantially closer than 50 meters from the road (10 to 20 meters max). Possibly the effects of complex terrain could be more effectively studied in a winter saturation study than with permanent monitors, although the exaggerated diurnal stagnation patterns and extent to which these correspond to rush hour periods would be useful to characterize with continuous instruments. It would also be useful to consider urban areas which have different kinds of public transportation systems, bus and taxi fleets and associated fuels, etc.

13. EPA and NACAA have proposed that at least two urban areas should have permanent near-road monitoring stations (that would fulfill NO2 near-road monitoring requirements) implemented for the pilot study. Please comment on the *minimum* equipment/pollutant measurement complement that should be deployed at each site and also the *ideal* equipment complement that each site should or could have, respectively. Specifically, what pollutants (e.g., NO2, NOX, NO, CO, PM (Ultrafine, 2.5, and 10), black carbon, air toxics (such as benzene, toluene, xylene, formaldehyde, acrolein, or 1,3, butadiene) and ammonia) and other information should the pilot study measure or gather at the fixed, permanent monitoring stations, and by what methods? This list should be in priority order, as feasible, and can include any NAAQS or non-NAAQS pollutant by any method (FRM/FEM and/or non-reference or equivalent methods), any particular type of other equipment for gathering supporting data such as meteorology or traffic counts.

The objectives seem to be somewhat mixed here. To a large extent the proposed pilot study seems to be focused on gaining insights into the process of citing near-road monitors (for NO_2 and to a lesser extent for CO NAAQS compliance determination. The emphasis is on understanding the relative importance of various traffic and roadway indicators (of varying and often unknown quality) to guide NO_2 site selection, the logistical and institutional difficulties associated with establishing new sites in challenging environments, etc. From this perspective, the subsequent use of any resulting measurement data (other to confirm whether NO_2 and/or CO are exceeding or close to NAAQS) is almost irrelevant. Retaining several of the fixed location sites, and building them into much more comprehensive sites where the objective is to actually learn something about near-road multi-pollutant exposures is an entirely different (but no less desirable) objective.

In selecting these few comprehensive sites, I would try to assure that they are close enough to roadways to capture the extreme gradients for pollutants like NO_2 and ultrafines, and also make sure there's a relatively nearby representative urban site with similar measurements to help quantify the roadway increment. Because roadway emissions, and to a large extent population exposures in near-road locations tend to have large diurnal variability, I would generally limit the measurements to species that can be quantified continuously. Beyond that I defer to others on the committee to prioritize the species.

14. EPA and NACAA have proposed four to five urban areas to have saturation monitoring, using either passive devices and/or continuous/semi-continuous

saturation type multi-pollutant monitoring packages (i.e., several types of monitors in one mountable or deployable "package"). Please provide comment on:

a. **The pollutants that should be measured with the saturation devices at each saturation site.**
b. **The number of saturation devices per pollutant, both passive and/or continuous/semi-continuous, that may be deployed in each pilot city.**

I don't have much expertise here, but think that (especially given the very limited budget), the selection of species and number of sites are inter-related and depend on available methods and costs. Ideally, the minimum species for saturation sampling would include at least NO_2, NOx, CO, BC, but I don't believe there are sufficiently reliable passive samplers for CO. Possibly a nested approach could be applied with larger numbers of passive NO_2 samplers where applicable and smaller numbers of portable continuous devices for other key species. Note also George Allen's suggestion to combine passive samplers with timed pump inlets – which might improve both pollutant sensitivity and temporal resolution. See also previous comments

c. **Whether placing saturation monitoring devices near certain road segments should include, at a minimum: 1) the highest AADT segment in an area, 2) the road segment with the highest number of heavy-duty truck/bus counts, 3) at a road segment with more unique roadway design, congestion pattern, or terrain in the area, and 4) if feasible, at a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area.**

All of the above seem like reasonable (but somewhat idealized) kinds of locations. I question whether it will really be possible to identify "a lower AADT segment with a similar fleet mix, roadway design, congestion, terrain, and meteorology as the top AADT road segment in the area" or if in doing so it could realistically be assumed that differing AADTs were the sole cause of any differences in concentrations. The effect of differing AADTs might better be explored by sampling during different time periods along a single road segment. To the extent possible, it would be useful if these sites were located at similar distances from, and at rush hour downwind directions from the associated roadways. Assuming this may not be possible, lines of additional passive NO_2 sensors might be added at each site, perpendicular to roadways and in upwind and downwind directions. Meteorological measurements may also be needed at some or all of these sites, and similar kinds of species measurements should be added a non-road representative urban site to help define the roadway increments from the different saturation sites.

Dr. Jay Turner

1) *Please provide suggestions on any missing subjects that should be included in the guidance document and any unnecessary topics that are currently listed in the attached draft, if applicable*.
   The outline for the guidance document is fine.
2) *Please prioritize the recommended pollutants and provide the rationale for their ranking, including how this pollutant measurement will contribute to scientific and regulatory knowledge of near-road air quality and adverse human health effects.*
   In general, the priority should be to monitor for indicator compounds for motor vehicle exhaust. In descending order of priority: (i) NO/NOx, opportunistic because the NO_2 measurement method will likely by NO_2 by difference (NOx minus NO); (ii) BC, as a second indicator for diesel emissions and thus sharpen the interpretation of the NO_2 data; (iii) CO, a stronger indicator for gasoline-fueled vehicle emissions, to compare and contrast with the indicators for diesel emissions; (iv) air toxics, an indicator for vehicle emissions; and (v) PM as an indicator for diesel emissions, albeit with confounding by road dust (depending on the PM site that is monitored). For many of these pollutants there is the potential for confounding by high upwind concentrations – that is, the measurement (absolute concentration and/or concentration variations) may not necessarily be a dominated by vehicle emissions from the roadway.
3) *Identifying Candidate Near-road Site Areas…*
   Is the objective to monitor at the highest NO_2 site within 50m of a roadway, or at the site with highest NO2 attributed to the proximate roadway? That is, should there be consideration of aggregate upwind effects, e.g. from a dense roadway network, that leads to high background NO2 at the roadway to be monitored. Or, is the interest in selecting a roadway with high NO2 difference across the roadway? If it is the former case then an expanded list of considerations for identifying candidate sites is needed. In general, I support the development of a screening tool to guide the site identification process. Screening tools have been used for hot spot analyses and a similar approach could be used in the site selection process. One approach is to use dispersion modeling to create look-up tables to semi-quantitatively) relate roadway (and other sites) characteristics to potential impacts. A more refined analysis could subsequently be taken to prioritize the sites identified from the screening process.
   a) The proposed approach to consider AADT and fleet mix is reasonable as long as there is also a consideration of vehicle speed (e.g. through the LOS, below) to capture the speed dependence of emission rates. Emission rate estimates based on more sophisticated and/or site-specific inputs could be used if the area has such information readily available, but is not a high priority.
   b) The consideration of on-the-books vehicle emission controls is a low priority in the site selection process. Perhaps more important out-year considerations would be any programmed or planned changes to the roadway corridor.
   c) A preference to sites at grade with no obstructions is a reasonable objective. There should be some flexibility, however, especially if the impact of other

designs or obstructions is such that a specific candidate site is still expected to a highNO_2 concentration zone.

d) The consideration of LOS is best handled through a screening tool that is grounded in dispersion modeling (see my preamble this question, above). The key is to capture the speed dependence of emissions.

e) I am less concerned for vegetation if the focus is on NO_2 as long as the vegetation does not lead to a significant airflow obstruction. This might be important factor, however, for other candidate pollutants.

f) Upwind pollutant meandering is certainly observed especially when winds are light and variable (in which case, the meandering is driven wind direction variations) and/or the vehicle-induced turbulence dominates over the prevailing air flow. That said, preference should be given to site locations that are nominally downwind for the meteorological conditions leading to highest impacts. Perhaps a screening tool could be used to identify the conditions. A key aspect is overlaying the prevailing diurnal wind patterns with the diurnal traffic patterns to estimate conditions – and thus near-field locations – for maximum impacts.

4) *Please comment on the available modeling tools, and their pros and cons, that the subcommittee believes may be appropriate to discuss and/or recommend for use in the near-road monitoring guidance document.*
The use of MOVES and AERMOD might be overly burdensome for the site selection process. As previously described, I advocate a screening tool be developed that is grounded in dispersion modeling that provides semi-quantitative estimates of impacts. I agencies have MOVES outputs, which are link-based rather than trip-average and thus likely more relevant to the specific roadway environment, then this information could be used as input to the screening model. However, for many agencies it might be too burdensome to generate MOVES output for the near-roadway site selection process.

5) *The use of saturation monitoring and on-road monitoring are also possible tools that state and local air agencies may choose to utilize in the near-road site selection process…*

Saturation monitoring could be helpful in prioritizing candidate sites. There is substantial literature on saturation studies with passive monitors, but in these cases the integration times are typically long. The crux for this application is a saturation monitoring strategy that has sufficiently high time resolution to be relevant to 1-hour conditions (this does not mean that 1-hour resolution is needed). Given there is typically diurnal structure to both traffic patterns and dispersion conditions, one strategy is to collect samples for sub-daily time periods but integrated over several days (e.g. a battery of timer-based saturation samplers).

6) If EPA were to propose a new set of minimum monitoring requirements for CO near roads, the near-road monitoring stations created under the implementation of the NO_2 monitoring requirements may be an advantageous infrastructure for state and local air agencies to leverage. However, […].
I have no preliminary comments on this matter.

7) *Does the committee believe that siting considerations for identifying the location of peak NO_2 concentrations will likely address all of the high priority siting considerations for PM (particularly $PM_{2.5}$) as well?*
It might be adequate if the emphasis of the PM monitoring is on that component related to diesel exhaust emissions, and the emphasis in all of the monitoring is on roadway-specific impacts and not cumulative impacts which include consideration of upwind sources. With improved vehicle emissions control technology, the relative contribution of road dust, tire wear, and brake wear to the traffic-induced PM becomes more important. If the goal is to capture these impacts in the PM monitoring, this could lead to diverging siting considerations for NO_2 and PM.

9) *In addition to $PM_{2.5}$ mass, what other PM-related measurements are desirable at near-road monitoring stations (e.g., UFP number, black carbon, EC/OC, PM coarse, etc.)?*
While in the ideal case it might be desirable to monitor for various PM components, practical considerations likely make UFP number and black carbon the most reasonable candidates. UFP number can be highly variable and confounded by other atmospheric dynamics events. Thus, its measurement is most useful as site pairs across the roadway. Thus might be impractical. Black carbon would be of interest in its own right and to compare and contrast to NO_2.

10) *Does the subcommittee believe that reconsideration of microscale CO siting criteria is appropriate? Specifically, would an adjustment of CO siting criteria to match those of microscale $PM_{2.5}$ and microscale near-road NO_2 sites be logical and appropriate?*
I have no preliminary comments on this matter.

10) *Should there be consideration to maintain the requirement on how urban street canyon or urban core microscale CO sites should be sited*?
I have no preliminary comments on this matter.

11) *Does the subcommittee have an opinion on how "urban street canyons" or "urban core" might be defined, perhaps quantitatively, and with regard to use in potential rule language*?
I have no preliminary comments on this matter.

12) *Does the Subcommittee agree with the stated considerations for selecting sites for the pilot study*?
The stated considerations are reasonable, although there relative weighting needs to be defined because some considerations are more important than others. Assuming resources will be limited, preference should be given to large urban areas with sufficient exiting monitoring infrastructure to place the road-side measurements in context.

13) *Please comment on the minimum equipment/pollutant measurement complement that should be deployed at each pilot study site and also the ideal equipment complement that each site should or could have, respectively*.
The minimum additional measurements should include NO/NOx, CO, black carbon, meteorology (perhaps at a setback or other nearby representative location), and traffic characterization (vehicle count, class, and speed). CO_2 could also be useful. It would be ideal to have each of these parameters (but certainly NO_2) measured at a representative "background" site (background from the perspective of the roadway). The measurement matrix should take into consideration whether the data would be used to evaluate any screening tool(s) developed to aid in site selection. Beyond this

minimum list of measurements, others could be added to fulfill specific study objectives. It is possible that research groups would be interested in adding measurement which would leveraging the investment in site infrastructure, and it would be great to accommodate this to the extent practicable.

14) *Please comment on the saturation study design details*.
The details are reasonable but it might be worthwhile to refine the saturation study objectives and then revisit the study design details. For example, is it desired to harmonize certain details within an urban area (or between areas, if possible) to more clearly evaluate the impact of other details? In one design the saturation monitors could be placed about the same distance from roadways, while in another design they could be placed at different distances from the roadways. If distance from roadway is a key parameter, then this could impact the data and its interpretation. Inconsistencies in upwind/downwind siting could strongly influence the interpretation of data from short-term saturation monitoring studies. If a screening tool was developed, one objective might be the evaluation of this tool through careful design of the saturation studies.

Dr. Warren H. White

AADT, fleet mix, roadway design, congestion, terrain, and meteorology all affect ambient concentrations, in complicated and interdependent ways. However, the combined near-road effect of all these influences can be described with just a few degrees of freedom. The framework outlined below is hardly new (*e.g.* White, 1977), but seems worth revisiting in light of the new rule.

The key to a simple description is that not much chemistry has a chance to occur in the short time air spends near the road. A cross-road wind component of only 1 m/s, for example, carries air from 150 m on one side to 150 m on the other in just 5 minutes. On such a time scale the complex chemistry of smog formation can be considered determined by the surrounding air, independent of the fresh emissions. More precisely, the only reactions needing consideration are the rapid scavenging of O_3 by NO

[1] $O_3 + NO \rightarrow O_2 + NO_2$,

and the rapid photolysis of NO2 to yield

[2] $O_2 + NO_2 \rightarrow O_3 + NO$

after additional steps. These reactions leave unchanged the concentrations of odd oxygen $[O_x] = [O_3] + [NO_2]$ and nitrogen oxides $[NO_x] = [NO] + [NO_2]$, and their relative rates establish a photostationary state that is generally fairly well approximated in the atmosphere:

[3] $[O_3][NO]/[NO_2] \approx k_2/k_1$.

Since O_x and NO_x are chemically conserved near the road, their concentrations respond only to physical dilution and mixing. They can be modeled as the sum of a variable contribution from roadway vehicle exhaust and a uniform background supplied by the surrounding air. For given concentrations $[O_x]_0$ and $[NO_x]_0$ at the monitor, the reactive species can be expressed in terms of NO_2:

$[NO] = [NO_x]_0 - [NO_2]$ and $[O_3] = [O_x]_0 - [NO_2]$.

Substituted into the photostationary equilibrium [3], these identities yield a quadratic equation in $[NO_2]$ that can be solved for $[NO_2]$ in terms of $[O_x]_0$, $[NO_x]_0$, and k_2/k_1. The following plots illustrate some features of the relationship.

The conservation of odd oxygen limits microscale NO_2 maxima to the sum of directly-emitted primary NO_2 plus the reservoir of odd oxygen available in the surrounding air. An important siting consideration is therefore the middle-scale ozone background, which I did not see mentioned in the Study Approach or Charge Questions. This background bounds the NO_2 produced from primary NO emissions, contrary to the impression one might get from statements such as this (FR v74, n134, 7/15/2009, p34441): "However, since the rate of conversion of mobile source NO to NO2 … is a generally rapid process, (*i.e.*, on the order of a minute (ISA Section 2.2.2)), NO2 behaves like a primary pollutant in the near-road environment, exhibiting peak concentrations on or closely adjacent to roads."

I will be happy to supply the spreadsheet used to generate Figures 1-3 to anyone else who might like to play with it.

Reference:
White, Warren H. (1977) NOx-O3 photochemistry in power plant plumes: comparison of theory with observation. *Environmental Science & Technology 11*, 995-1000.

scenario		1	2	3	4	5	determinants
NO_x = [NO+NO_2], ppb	values	range	range	range	range	range	
oxidant = [NO_2+O_3], ppb		50	50	50	50	50	middle-scale background
photostationary ratio = O_3NO/NO_2, ppb		10	10	10	10	10	temperature and photolysis rate
exhaust NO_2/NO_x		5%	10%	15%	20%	25%	diesel fleet characteristics

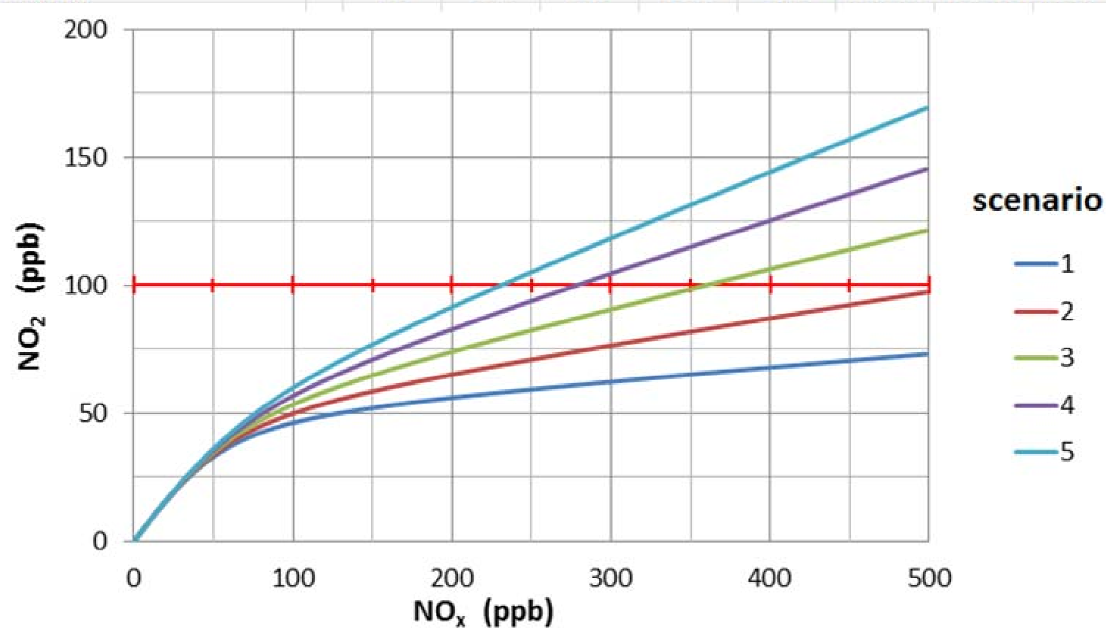


Figure 1. If oxidant background is 50 ppb (~ 50 ppb O_3 PRB + <1 ppb NO_2 PRB), then even 25% NO_2 in the fleet exhaust and 200 ppb near-road NO_x is not enough to make 100 ppb NO_2.

scenario		1	2	3	4	5	determinants
NO_x = [$NO+NO_2$], ppb	values	range	range	range	range	range	
oxidant = [NO_2+O_3], ppb		100	100	100	100	100	middle-scale background
photostationary ratio = O_3NO/NO_2, ppb		0	5	10	15	20	temperature and photolysis rate
exhaust NO_2/NO_x		10%	10%	10%	10%	10%	diesel fleet characteristics

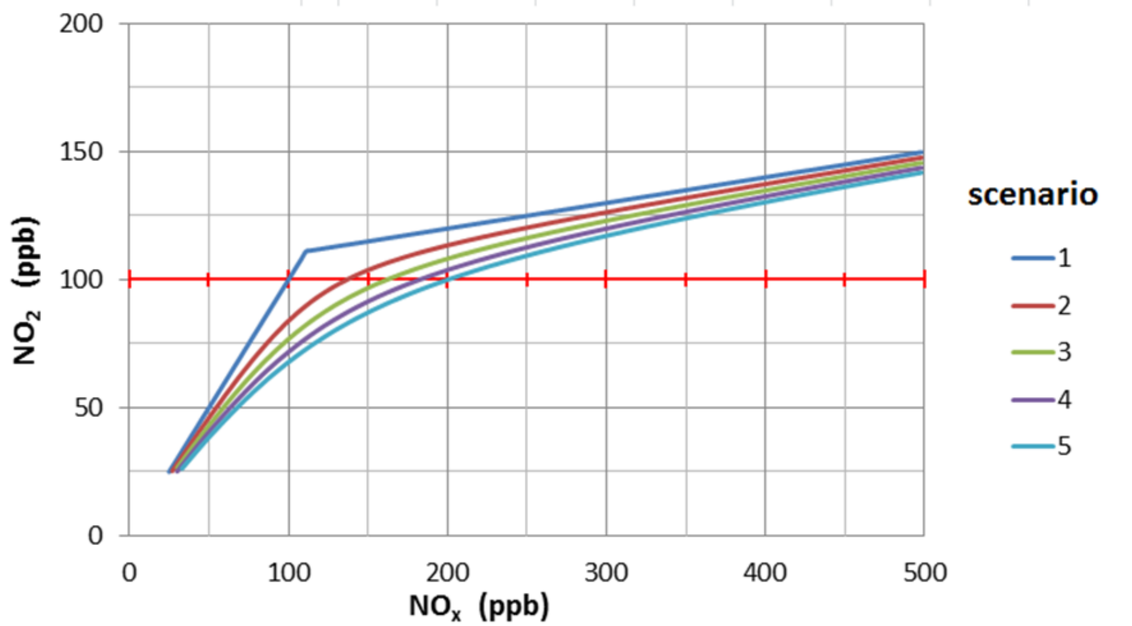


Figure 2. The most favorable condition for NO_2 at a typical background oxidant level (75 ppb O_3 + 25 ppb NO_2) is a dark sky (small photostationary ratio) to minimize NO_2 photolysis.

scenario		1	2	3	4	5	determinants
NO_x = [NO+NO_2], ppb	values	range	range	range	range	range	
oxidant = [NO_2+O_3], ppb		75	100	125	150	175	middle-scale background
photostationary ratio = O_3NO/NO_2, ppb		10	10	10	10	10	temperature and photolysis rate
exhaust NO_2/NO_x		10%	10%	10%	10%	10%	diesel fleet characteristics

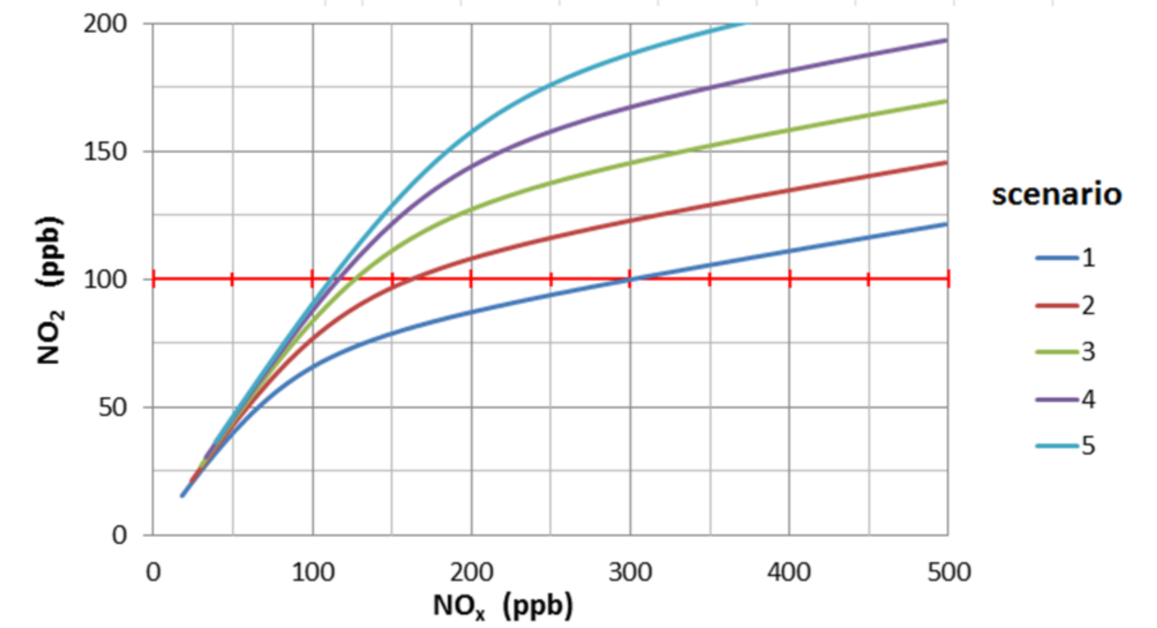


Figure 3. In the absence of elevated exhaust NO_2/NO_x ratios, background oxidant is needed to convert the primary NO emissions.

scenario		1	2	3	4	5	determinants
NO_x = [NO+NO_2], ppb	values	range	range	range	range	range	
oxidant = [NO_2+O_3], ppb		75	100	125	150	175	middle-scale background
photostationary ratio = O_3NO/NO_2, ppb		10	10	10	10	10	temperature and photolysis rate
exhaust NO_2/NO_x		10%	10%	10%	10%	10%	diesel fleet characteristics

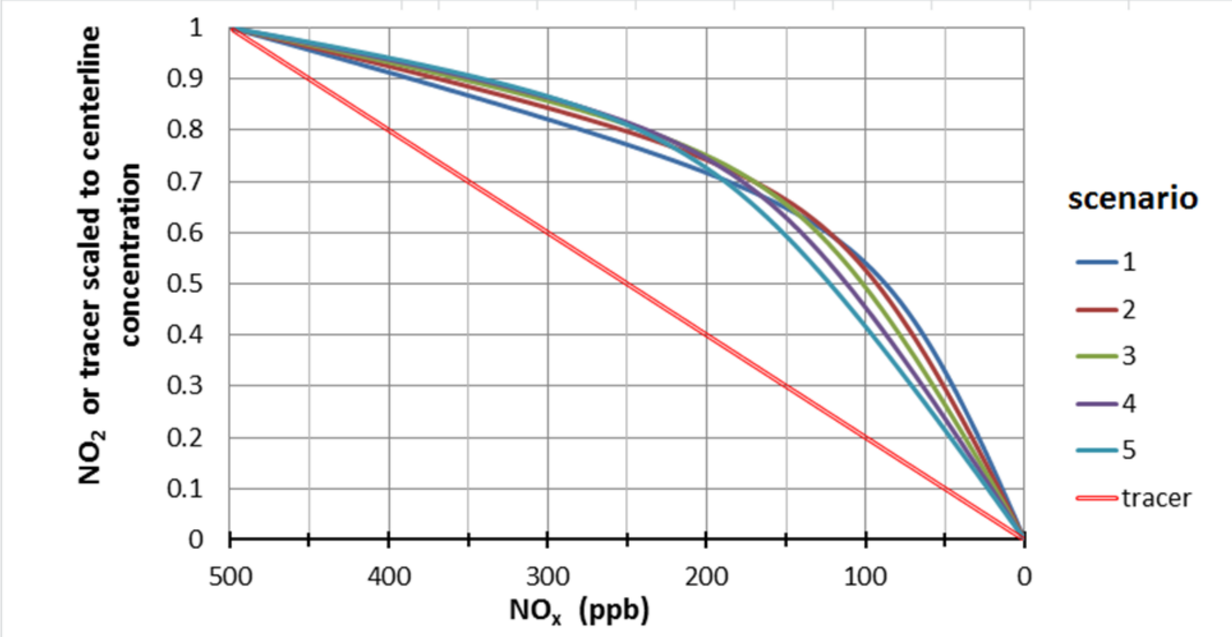


Figure 4. Concentrations of conserved primary emissions like CO (“tracer”) fall off more rapidly with distance from the roadway than those of NO_2 do.

Questions for EPA:

I am not convinced that a substantial near-road monitoring program for NO_2 and other traffic-related species is a good use of Agency resources. I think it will be hard to implement in a meaningful way, and I don't see great potential value in the data it will produce. I recognize that the decision has been made already, and that I am not required to understand the reasons behind it. I could better focus on our charge questions, however, if I had answers for the following questions of my own.

1. What is meant by hourly NO_2 concentrations – should they be equivalent to actual arithmetic averages of instantaneous concentrations? Exhaust concentrations at a near-road sampling inlet can vary greatly within a few seconds. In a given setting (background oxidant levels and meteorology), NO_2 concentrations depend nonlinearly on exhaust concentrations. Under these conditions an instrument's time response – and the nature of any 'internal averaging' – requires careful characterization. The reliance on a difference method (NO_x-NO) further heightens the challenge for measurements near the road, where the signal/noise ratio is least. Is the goal, as it was with the $PM_{2.5}$ FRM, to replicate the undefined and uncontrolled shortcomings of historical data that underlie existing epidemiological analyses? Or is it to make an accurate measurement of NO_2?

2. How are concentrations from microscale locations to be linked to available public health statistics for epidemiologic analyses? Data from neighborhood- or urban-scale monitors have demonstrated utility for epidemiology because they are indicative of typical exposures for identifiable populations large enough to generate routine public health statistics. The numbers of residences near microscale monitors will be small, and the vehicle occupants driving by them will be anonymous. Will site-specific panel studies be required to connect the near-road data to health effects?

3. How large a slice of the monitoring pie is ultimately contemplated for near-road monitoring? The Agency deserves great credit for recognizing the need "to support measurement of multiple NAAQS pollutants" in calling this meeting. "Maximum expected hourly concentrations" are likely to occur at different locations (with different vehicle mixes and road characteristics) for different candidate species (e.g. NO_x, CO, black carbon, $PM_{0.1}$, and PM_{10}). And health researchers will view the consequently different pollutant mixes as an important environmental signals for epidemiological analyses. Measuring different species at different sites would clearly be of little value for anything more than a NAAQS-compliance determination. Are we looking at NCORE on steroids, something like 75 x (number of traffic-related species) for the total number of sites?

Dr. Yousheng Zeng
General Comments

Near-road monitoring requirements: The purpose of near-road monitoring is to protect the health of residents living near roadways. There should be a screening criterion: In a particular CBSA, if there are no residents living within the 50-m corridor, near-road monitoring should be exempted. Following a similar line of thinking, if there is only one community within the 50-m corridor, the near-road monitor should be sited at this community, and not necessarily at a location where the impact is highest. In this case, other siting analysis is unnecessary.

The end-point of near-road monitoring: Normally when an ambient monitor shows exceedance of NAAQS, state/local authorities are required to develop a State Implementation Plan (SIP) to bring the area into attainment with NAAQS. The State Implementation Plan will include some control measures to achieve attainment. If a near-road NO_2 monitor shows exceedance of NAAQS, how will a non-attainment area be delineated and what does EPA expect the state/local authority to do? Due to the nature of significant concentration gradient along the roadways, the area with high NO_2 concentrations could be extremely small. What will be the basis for designating an area as non-attainment area? The non-attainment is basically caused by mobile sources. In some areas, it is largely attributable to vehicles passing through the area on the interstate highways. What can the state/local authority do to achieve attainment? If the state/local authority cannot do anything, what is the point of requiring this type of near-road monitoring? EPA could conduct some studies and achieve attainment through regulations on vehicle emission standards.

Charge Question 3.c
In urban areas, the road segments that have high AADT are commonly elevated roadways. Requiring monitoring sites at-grade will either miss the plume from the roadways or significantly limit the choices for the monitoring sites. As far as the vertical location is concerned, the guidance document should consider the two factors – (1) the monitor's probe intake should be in the general vertical area of the plume coming from the roadways; and (2) the residence time for sample to travel from the probe intake to the analyzer will meet the criteria (20 sec.), i.e., no extremely tall probe from the ground that cause a long residence time. As long as these two criteria are met, there is no need to specify whether the monitor needs to be at-grade.

Charge Question 4
In many traffic related air quality impact analyses (e.g., air quality analyses as part of required NEPA process for highway projects), the CALINE3 and CAL3QHC models are used. They are still listed as preferred models on the EPA SCRAM webpage. EPA should evaluate these models along with AERMOD and provide guidelines on which model should be used for siting near-road monitors.

In this guidance document, EPA should explain if and how Ambient Ratio Method (ARM) and Ozone Limiting Method (OLM) can be used in conjunction with AERMOD model to convert freshly emitted NO to NO_2. On June 28, 2010, EPA issued a memo addressing these issues for more general NO_2 modeling (http://www.epa.gov/nsr/documents/20100629no2guidance.pdf). There should be some consistence between these modeling policy memos and this guidance document to be developed. If the guidance document identifies CALINE3 or CAL3QHC as allowed model, it also should explain if and how ARM and OLM can be used.

Also see my response to Charge Question 6 on modeling.

Charge Question 5

A trailer-based transportable monitor will be very useful and practical for near-road monitoring. It will be self contained (a generator, analyzer, zero air, calibrator, retractable met tower, wireless modem, etc.) in a relatively small trailer. It can be pulled by a pick-up truck to a candidate site for a day, a week, or a longer period of monitoring. It will be moved to another candidate site. Once the candidate site screening is completed, the trailer can be stationed in the chosen permanent site, blocked up and tied down to serve as the permanent near-road monitor in that CBSA. The data generated by such a system will have the same quality as fixed monitoring station. Compared to a motor vehicle based monitor, the trailer-based unit offers comparable mobility at much lower cost, and it can used as a fixed monitor at a permanent site for years. In terms of data quality and comparability, the data generated by a FRM or FEM analyzer in the trailer-based monitor has a higher quality and confidence level than the data generated by other screening instruments (passive devices and portable instruments). Presumably there will be no meteorological (met) instruments collocated with passive or portable devices. An analysis of the data gathered by these devices will rely on met data from nearby met stations. For near-road monitoring, the wind conditions will be relevant and extremely localized. The analysis based on met data from some distance could be misleading.

Charge Question 6

Peak CO concentrations are expected in urban street canyons and/or urban cores, especially at intersections where cars are idling in front of traffic light and the impact is coming from more than one street. I am not familiar with typical NO_2 concentrations in this type of situation as compared to NO_2 concentrations near major highway with heavy traffic. I am sure this type of data is available. If NO_2 concentrations in urban street canyons are comparable to the NO_2 concentrations near major highway, using one site to serve the monitoring need for both CO and NO_2 should be encouraged in the guidance document. Otherwise, it would be infeasible to make a compromise between the two needs and the monitoring for CO and NO_2 should be addressed separately.

The CAL3QHC model is design to predict CO concentrations near road intersections. If EPA has validated the model, should the modeling be sufficient for determination of compliance with CO NAAQS and therefore no monitoring is required? In the recent SO_2 NAAQS rule, EPA is changing its long-standing position of using monitoring data for NAAQS attainment determination, and will use modeling for NAAQS attainment determination. For the same rationale, using a modeling analysis to determine NO_2 and CO NAAQS attainment seems reasonable. Similar to (actually even worse than) the case of SO_2, ambient CO and NO_2 concentrations have an extremely high spatial variability near road. One monitor showing compliance with NAAQS at one street corner or road segment does not mean that the NAAQS is attained at different street corner or road segment. Modeling can cover a much larger space at a much lower cost. Even at the same street corner or road segment, moving the monitor by one meter could make the difference of attaining or not attaining NAAQS.

Charge Question 11

Before responding to Charge Question 11, I would like to ask if monitoring these pollutants with extremely high spatial variability in a micro-scale is a good idea. See my response to Charge Question 6. If the answer is no, there is no need to spending resources to develop definition of "urban street canyons" and "urban core" and associated guidance for monitoring.

In case EPA wants to pursue monitoring at street locations with high traffic volume and high spatial concentration variability, the following elements should be considered in defining urban street canyons:

- Traffic information similar to the one for near-road monitoring (e.g., AADT, posted speed limit, traffic light cycle)
- Street geometry
  - Ratio of street side building height to the width of the street (H/W ratio). Need to develop an approach to the treatment of (1) different heights of buildings on the two sides of the street and (2) tiered buildings.
  - One-way vs. two-way street (more plug flow in one-way and more turbulent in two-way street).
  - Is the street lined with trees on the sidewalk? Tree canopy may have an effect of umbrella and trap portion of pollutants at the street level.
  - Some way to normalize the H/W ratio with respect to number of traffic lanes on the street. This factor may not be important because the effect may have been incorporated by the combination of H/W ratio and the traffic volume (e.g., AADT).
- Meteorological factors: the angle between the street and prevailing wind direction (higher concentrations are expected if the angle is 90 degree).

In the context of ambient air quality monitoring rule, perhaps a set of cut-off values reflecting the above mentioned elements can be used to define urban street canyons.

Charge Question 14.c.

The impact of mobile sources to ambient air quality is governed by two types of factors, vehicle emissions and dispersion conditions. For compliance monitoring, the monitors should be placed near the highest impact area, which means both emissions and dispersion conditions are equally important. For the pilot study, however, factors associated with dispersion (e.g., terrain, roadway design, extremely micro-scale meteorological conditions) should be given more attention than factors related to the level of vehicle emissions (e.g., AADT, fleet mix) because the emission rates can be characterized well using current tools (e.g., MOVES), AND the emission rates are the only parameter that impact ambient concentration in a linear or near linear fashion. If the pilot study can provide better understanding of the dispersion, the impact of a higher emission scenario can be anticipated or predicted by simply substituting the emission rates. The information derived from a more dispersion focused pilot study will be more useful than an emission focused pilot study.