Comments to CASAC on "Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Urban Visibility Impact Assessment"

Anne E. Smith, Ph.D.
CRA International
1201 F Street NW, Suite 700
Washington, DC 20004

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In February 2009, the U.S. Environmental Protection Agency (EPA) released its *Scope and Methods Plan for Urban Visibility Impact Assessment*, which describes the data and approach that EPA intends to use to assess urban visibility. This is also called the Urban Visibility Assessment Plan (hereafter called the "UVA Plan"). Following is a summary of my main comments on UVA Plan. The UVA Plan includes two core elements that I address in the following order: (1) assessment of urban VAQ preferences, and (2) assessment of urban visibility outcomes under various alternative scenarios of air quality.

(1) Comments on EPA's Plans for Assessing Urban VAQ Preferences

- **The UVA Plan is founded on the use of VAQ preference studies, but this methodology is not scientifically valid or reliable.**
  Although EPA feels that the previous CASAC review panel gave "general support for the use of this type of approach,"[1] new evidence has been developed and entered into the record since that last review. The comments that I submitted on the First External Review Draft of the PM Integrated Science Assessment (PM ISA) introduce evidence that this method of assessing VAQ preferences does not produce a reliable indicator of public attitudes towards different levels of VAQ.[2] This is because the VAQ "standard" that one would infer from such a study is highly dependent on the particular range of VAQ shown to the survey participants. The new VAQ preference study pilot found that a given deciview level might be deemed highly unacceptable, or highly acceptable, depending on what other deciview conditions participants are also asked to evaluate. Tthese studies are not producing results that can be considered valid or appropriate for setting a standard, even for a single city.

- **If EPA performs new VAQ preference studies, it should construct a survey design that will be able to demonstrate that its results are invariant with respect to the particular range of VAQ used in the survey.**
  It appears that EPA is or soon will be conducting new VAQ preference studies for use in this UVA, rather than rely on the existing set for Denver, Phoenix, Lower Fraser Valley, and

[1] UVA Plan, p. 1-9, line 5.
[2] A synopsis of CRA's new research results is provided in my written comments regarding PM ISA Section 9.3.5, submitted with UARG comments on the First External Review Draft of the PM ISA, March 13, 2009, pp. 3-7. The full report on CRA's study will be finalized in early April 2009.

Washington DC. If the VAQ preference study methodology were appropriate to use at all, EPA's plans for performing new studies for this UVA would be commendable. However, EPA should take into consideration the new evidence in my written comments described in the bullet above before conducting any new studies. If EPA is to perform new VAQ preference studies, it should construct its survey design so that it will be possible after the fact to ensure the results are invariant with respect to the particular range of VAQ used. (It may prove impossible to identify a VAQ cutoff that is invariant to the photos shown, but this method simply should not be used at all to inform a visibility standard if that is the case.)

- **The UVA Plan for new preference studies would have the upper end of the light extinction range shown in the survey correspond to the visibility at the current secondary NAAQS (*i.e.*, at 35 µg/m^3).[3] This guarantees that the current standard will be deemed "unacceptable," and therefore must be eliminated.**
  CRA's new research demonstrates that this will result in a very biased result: EPA's new surveys, if designed this way, will be *guaranteed to find that visibility at the current standard is unacceptable.* This is because CRA's tests showed that the vast majority of any sample of people participating in a preference study will always deem the photograph showing the highest degree of visibility degradation to be "unacceptable," no matter what that lowest-deciview level may be.[4] This part of EPA's plan should be eliminated. As noted above, EPA should in fact abandon the use of VAQ preference studies altogether, except if EPA can demonstrate that it has developed a new design that eliminates the problems CRA has identified.

- **The UVA Plan should eliminate its emphasis on assessing preferences using the most sensitive of vistas.**
  The UVA Plan strives to minimize the complexities mentioned in the bullet above by choosing vistas for preference studies that would *maximize* people's ability to observe differences in visibility. For example, the UVA Plan states: "In general, long-distance views are more sensitive to changes in perceived haze level…[therefore] it will be important to try to select other urban scenes that have a long sight path…In situations where there are no distant scenic elements…the presence of white clouds may be among the most sensitive indicators of visibility."[5] And so, EPA says it expects to use photos with clouds "if we determine that they are sufficiently sensitive"[6] from a perceptual standpoint. This is an approach guaranteed to produce a biased inference about the public's preferences for visibility in their daily lives. The fact is that most of peoples' day to day activities do not expose them to such "sensitive" scenes. An assessment of "residential use" visibility preferences ought to account for the variety and relative frequency of peoples' activities, and how well they perceive changes in visibility conditions over that entire pattern of typical activities. EPA's emphasis on assessing preferences using the most sensitive of vistas should be stopped.

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[3] UVA Plan, p. 3-5, lines 7-10.
[4] In fact, CRA's research found that 100% of the people sampled would deem the visibility associated with 20 µg/m^3 to be unacceptable, if that were to be the worst-case visibility photograph shown to them. (CRA's "Test 2" had a worst case photograph of 27.1 deciviews, which, using Abt Associates' assumptions about speciation and relative humidity, would be met when $PM_{2.5}$ was 20 µg/m^3.)
[5] UVA Plan, p. 3-4, lines 3-12.
[6] UVA Plan, p. 3-4, line 16.

- **The UVA needs to address the difficulty of separating health concerns from aesthetic concerns in the preference surveys.**
  The UVA Plan offers no indication that EPA will carefully address the most important problem that EPA has identified with both visibility and preference studies, which is the extent to which the responses to such surveys intertwine people's concerns about the healthfulness of the air with their concerns about day to day aesthetic experiences. This is an exceedingly serious concern with the use of visibility preference studies (as well as visibility valuation studies), and ranks second only to the concern CRA's new research has identified about the inherent malleability of the statements of acceptability/unacceptability. EPA must address it explicitly.

- **The UVA Plan dismisses using VAQ valuation studies with a rationale that can also be used to dismiss its planned use of the "acceptable visibility" metric.**
  On p. 1-19 (lines 9-12), the UVA Plan states: "Because the use of a perceptual or visibility valuation metric would require incorporating the effects of urban-specific scene sensitivity and public/scene contextual information for every applicable urban area, we conclude its selection as a metric would be impractical in the context of setting a national standard." This statement appears to be EPA's justification for not using any of the visibility willingness-to-pay (*i.e.*, "valuation") studies. However, the exact same problems apply to the VAQ preference study methodology and cutoff point for "acceptable VAQ" that EPA wishes to infer from preference studies. By EPA's logic, the "acceptable visibility" metric also is impractical in the context of setting a national standard.

- **The UVA Plan states that VAQ preference studies find visual ranges from 40 to 60 km to be acceptable, but the correct range is 21 to 55 km.**
  On p. 1-9 (lines 17-20), the UVA Plan states that the VAQ preference studies find visual ranges from 40 to 60 km to be acceptable, but this is not consistent with the actual results of the four studies cited. The actual range over which a majority of participants report acceptability is 21 to 55 km. The Draft PM ISA reports a range of 30 to 55 km (see Draft PM ISA, p. 9-4), but the lower bound is still incorrect, as the lower bound in the Washington DC pilot is 21 km.[7]

(2) Comments on EPA's Plans for Assessing Urban Visibility Outcomes

- **A visibility standard for a mid-day average, such as noon to 4 pm, does not resolve the large differences in eastern and western conditions.**
  EPA states at page 1-7 that east/west differences in visibility impacts due to differences in average relative humidity are "minimized" by considering only daytime visibility conditions, such as the 12-4 pm time period. The differences in eastern and western light extinction for given $PM_{2.5}$ levels may be at their minimum during those hours, but the remaining differences are *not small*. For example, the average 12-4 pm relative humidity in Tucson is less than 30%, while the average 12-4 pm relative humidity in Washington DC is over 50%.[8] Further,

[7] See written comments by Anne E. Smith regarding PM ISA Section 9.3.5, submitted with UARG comments on the First External Review Draft of the PM ISA, March 13, 2009, pp. 2-3.
[8] Based on relative humidity data from nephelometers at the Washington DC IMPROVE site and at the Children's Park in Tucson AZ (also downloadable from the IMPROVE website). These averages include rainy days, which cannot be screened out from nephelometer data files on their own.

the 98th percentile of the 12-4 pm average relative humidity is very different across the nation, especially if one considers only non-rainy days.[9] The same concentration of 35µg/m^3 $PM_{2.5}$ could result in 20 km visual range in Tucson and 15 km in Washington DC on days at their respective peak relative humidities – a difference in visual range of about 33%.[10] EPA needs to recognize that what matters in their assessment of visibility for a secondary NAAQS is differences in the *peak* 4-hour-average visibility conditions that will occur, and not differences in *average* 4-hour-average visibility conditions (unless EPA will be considering a secondary NAAQS for visibility that only constrains the annual average of the 4-hour-average visibility conditions). It is misleading to assert that a standard for a mid-day 4-hour-average mitigates difficulties of large differences in eastern and western conditions.

- **The UVA Plan to produce an assessment of *hourly* visibility conditions does not have a sufficient plan to analyze and report the inherent attending uncertainties.** The UVA Plan includes a complex sequence of data massaging to produce an assessment of *hourly* visibility conditions, "as is" and also under alternative standards. This is certainly an interesting endeavor for data analysts, but the end product will be highly uncertain due to the many unfounded assumptions on which it will be based. The UVA Plan acknowledges that uncertainties will exist, but does not have a sufficient plan to analyze and report uncertainties of this degree of profundity.[11] EPA also needs to grapple with how the resulting hourly visibility distributions can appropriately inform the Administrator on visibility standard options in light of the lack of understanding about whether visibility preference studies reflect concerns with the VAQ level if it were to occur at any instant, or if it were to occur as a median or average event over the year. As the UVA Plan itself notes, "it is important to realize that visibility is an instantaneous process…However, human valuations of visibility may reflect average visibility over longer periods than an instant."[12] Unless the latter unknown from the preference studies is addressed head-on as well, EPA's UVA Plan risks implying that the degree of visibility degradation under any particular standard is much worse than the public would actually consider it to be. A better approach is to eliminate use of VAQ preference studies altogether (for the reasons explained in the first section of my comments) and to focus on doing a very thorough job of simulating the hourly distributions – *and their uncertainty* – under alternative standards. That analysis may be very informative on its own, and it should not be muddled by attempts to use scientifically-invalid inferences from preference studies to define the "public acceptability" of its outputs.

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[9] It is not possible to exclude non-rainy days from the nephelometer data, but within the nephelometer data, about 2% of all the hours between noon and 4pm, rainy or not, exceed 75% in Tucson. In contrast, about 14% of the hours exceed 75% in Washington DC. Transmissometer data do allow rainy or foggy hours to be screened out. The IMPROVE Shenandoah site's transmissometer (SHEN2), which is relatively close to Washington DC, indicates that even when there is no rain or fog, 8 percent of the hours between noon and 4 pm have relative humidity above 75%. Comparable data for the IMPROVE Petrified Forest AZ site (PEFO2) find that only 0.4% of the non-rain, non-fog hours between noon and 4 pm have relative humidity above 75%.

[10] This calculation assumes a peak non-raining relative humidity of 75% in the east and 45% in the west. It also accounts for differences in the speciation of the fine PM in the east and west. It assumed about 57% of the $PM_{2.5}$ is sulfate and nitrate in the east and about 23% in the west. (Specifically, sulfate, nitrate, organic carbon, elemental carbon and fine soil were assumed to be (18, 2, 5, 8, 2) µg/m^3 in the east and (5, 3, 8, 12, 7) µg/m^3 in the west.

[11] See the Plan at p. 2-9, lines 20-24, which includes the statement: "Specific methods to characterize…uncertainty…have not yet been developed."

[12] UVA Plan, p. 1-17, lines 24-27.

- **Model-based Policy Relevant Background (PRB) would give a very misleading impression of how much visibility could be improved through US policy action.**
  The UVA Plan (pp. 2-2 to 2-4) discusses the possibility of using model-based estimates of PRB rather than monitored rural non-sulfate $PM_{2.5}$. Both approaches have their problems, but the model-based approach suffers from a very significant definitional concern. EPA defines PRB as the level of ambient concentration that would occur if anthropogenic emissions of the ambient pollutant (and its precursors) were eliminated. This would not be an unreasonable definition if only US anthropogenic emissions were to be set to zero. However, EPA is defining the background ambient level relevant for US policy decisions as *also* involving the elimination of Mexican and Canadian emissions. Given the established fact that Mexican anthropogenic emissions account for a substantial portion of the visibility degradation in the southwestern parts of the US, the PRB that would result from a model-based approach following the EPA definition of the "background scenario" would give a very misleading impression of just how much visibility could be improved through US policy action.

- **Model-based estimates of *hourly* PRB until model performance at the hourly level has been studied and shown to be reasonable.**
  An additional concern with use of model-based estimates of PRB relates to the desire to have an hourly analysis of $PM_{2.5}$. The CMAQ model that would be used has a very large grid (36 km x 36 km) that does not perform particularly well in the West. While it is reported to perform well in the East and Midwest, that is only for *annual average and ("most") seasonal* concentrations.[13] The quality of the model projections for *hourly* $PM_{2.5}$ is not stated, but is likely to be very poor, given the scale of aggregation of models such as this, and the apparent difficulties even at the seasonal and certain regional levels. It should not be used for define an hourly PRB until model performance at the hourly level has been studied and shown to be reasonable.

- **In simulating "just meeting" current and alternative standards, uncertainties about speciation of the rollback will be large and need to be addressed explicitly.**
  Speciation should matter for the health risk analyses as well, but EPA has long chosen to ignore the important uncertainty of relative potency of PM species in those analyses. Because of that omission, the question of how much each individual PM species would be rolled back when the entire distribution of $PM_{2.5}$ is rolled back has never been addressed. It simply cannot be ignored for a PM-related visibility assessment, because the PM-to-visibility impact formula *does* assign different "potencies" to each PM species. EPA needs to postulate a variety of assumptions about regional attainment strategies – including the attainment strategy for the current primary $PM_{2.5}$ NAAQS – and then to simulate the rollback *by species* for each postulated potential attainment strategy. This may inject substantial uncertainty into the visibility assessment results, but the uncertainty is real and must be addressed explicitly and clearly for the UVA to be useful.

- **In developing diurnal profiles, EPA should give consideration to co-variance structures between relative humidity and PM concentrations.**
  The entire procedure as described on UVA Plan p. 2-4, should be conducted with many different feasible assumptions for hourly speciation factors, diurnal variations, and co-variance relationships.

[13] UVA Plan, p. 2-3, lines 20-25.