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April 1, 2016

EPA-CASAC-16-001

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Subject: CASAC Review of the EPA's Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur

Dear Administrator McCarthy:

The Clean Air Scientific Advisory Committee (CASAC) Secondary NAAQS Review Panel for Oxides of Nitrogen and Sulfur held a public teleconference on December 1, 2015, to peer review the EPA's Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards (NAAQS) for Oxides of Nitrogen and Oxides of Sulfur, hereafter referred to as the draft IRP. The Panel then discussed their draft peer review report and the Chartered CASAC discussed the disposition of the panel's report during a public teleconference on February 29, 2016. The CASAC's consensus responses to the agency's charge questions and the individual review comments from the CASAC Secondary NAAQS Review Panel for Oxides of Nitrogen and Oxides of Sulfur are enclosed.

In brief the CASAC finds that the draft IRP reads well but lacks detail and perspective that limited its scientific soundness from being effectively evaluated. Several recommendations for strengthening the content and improving the clarity of the document are highlighted below and detailed in the consensus responses.

- Lack of Specificity in the Plan: The CASAC is concerned that providing just preliminary ideas in the draft IRP does not constitute a plan that could be put into action.

- Context in Relation to 2008 Review: Details on the work and outcomes of the 2008 CASAC Secondary NO_X and SO_X NAAQS Review Panel, which are critical to framing the work of this current CASAC review panel, should be included.

- Chemically Reduced Nitrogen: Chemically reduced nitrogen compounds should be considered, in addition to NOx. Consideration of other reactive nitrogen compounds (Nr; i.e., any N compound

other than N_2)—which would/could include ammonia (NH_3), ammonium (NH_4^+), organic nitrogen, and other chemically reduced nitrogen compounds—needs to be included. These N-species were discussed in great detail in the previous 2008 CASAC review, yet they are only briefly mentioned in the draft IRP. How EPA might address these pollutants in a standard based on oxides of nitrogen and sulfur was an important consideration then and remains an important consideration now.

- Uncertainty: A more in-depth consideration of uncertainty is needed, including uncertainties associated with metrics to relate ambient concentrations of Nr and SOx to aquatic impacts. The discussion of uncertainty and variability in the draft IRP is too brief, given that a new secondary standard was not proposed/adopted in the previous 2008 review process primarily because of uncertainty. This is noted particularly in discussion of the Aquatic Acidification Index (AAI).

    - The CASAC recommends that a more thorough discussion of the previous development of the AAI be included in the draft IRP, even if an AAI-like metric may or may not be evaluated in this current review. The AAI was developed to address the need to relate the ecological effect of interest (aquatic acidification) to an ambient air concentration (level), integrated N- and S-deposition impacts (joint pollutant standard including the role of chemically reduced N deposition), and as an index measure that would allow the use of ecological and atmospheric models in determining attainment with the standard.

    - While the EPA did not adopt the AAI approach, citing concerns with the magnitude of uncertainty associated with the development and application of this index, the CASAC recommends that these uncertainties be critically evaluated. The discussion of the four-tiered approach put forth by the World Health Organization (WHO), which the agency plans to use to characterize uncertainty, also needs to be greatly expanded.

- Defining 'Form': In the past, "level" has been restricted to an ambient air concentration. Such a restriction limits the applicability of the various approaches to the form of a standard which in turn may reduce the ability of standards to achieve their goals. An important question to address in framing this review process is: according to the Clean Air Act, can a secondary standard be based on atmospheric deposition rather than on ambient air concentration?

- Models and Tools: Potential tools and models for risk and exposure assessment are presented, but more specifics on the models are needed to assess how these tools will actually be used, and whether these tools will be successful or scientifically valid for their intended use. Presenting results from multiple models can help inform the degree of uncertainty on the impacts of acidic deposition on ecosystem service provision and how it could be addressed in development and implementation of the proposed standard(s).

- Climate Change and Pollutant Interactions: Climate change can interact with atmospheric deposition and alter the effects on ecosystems that can promote or inhibit achievement of policy goals. Interactions of nitrogen and sulfur with other air pollutants can also result in similar complexities. The draft IRP should address these issues, particularly in developing the risk and exposure assessment.

- Other Endpoints: The draft IRP excludes depositional effects on manufactured structures, cultural objects, and atmospheric visibility. These effects should be included in the assessment.

- Valuation: The CASAC encourages the agency to think broadly about the best way to present the results of the NAAQS review to the Administrator and the public. Although the EPA may be inclined to present results as succinct monetized values, alternative means for presenting results should be identified and implemented. Since valuation of ecosystem effects is hard to quantify and may greatly underestimate the benefit associated with meeting a given set of standards, the agency should consider presenting model outputs both as monetized values and biophysical impacts.

With the recommended revisions, the draft IRP should serve its intended purpose in presenting the review plan, schedule, and process, as well as the key policy-relevant science issues that will guide the review of the Secondary NAAQS for Oxides of Nitrogen and Oxides of Sulfur. In addition to the main points identified above, a number of individual comments provided by panel members are enclosed for your consideration. The CASAC appreciates the opportunity to provide advice on the Draft IRP and looks forward to the EPA's response.

Sincerely,

/Signed/

Dr. Ana V. Diez Roux, Chair
Clean Air Scientific Advisory Committee

/Signed/

Dr. Ivan J. Fernandez, Chair
Secondary NAAQS Review Panel for Oxides of Nitrogen and Sulfur

Enclosures

NOTICE

This report has been written as part of the activities of the EPA's Clean Air Scientific Advisory Committee (CASAC), a federal advisory committee independently chartered to provide extramural scientific information and advice to the Administrator and other officials of the EPA. CASAC provides balanced, expert assessment of scientific matters related to issues and problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not represent the views and policies of the EPA, nor of other agencies within the Executive Branch of the federal government. In addition, any mention of trade names or commercial products does not constitute a recommendation for use. CASAC reports are posted on the EPA website at: http://www.epa.gov/casac.

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Clean Air Scientific Advisory Committee
CASAC

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U.S. Environmental Protection Agency
Clean Air Scientific Advisory Committee
Secondary NAAQS Review Panel for Oxides of Nitrogen and Sulfur

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Consensus Responses to Charge Questions on
EPA's Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur

As part of the ongoing review of the secondary national ambient air quality standards (NAAQS) for Oxides of Nitrogen (NOx) and Oxides of Sulfur (SOx), EPA's National Center for Environmental Assessment and the Office of Air Quality Planning and Standards prepared a *Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur* (draft IRP). The draft IRP summarizes the NAAQS review process and anticipated schedule, the general approach and policy-relevant issues for the current review, the plan for both the science assessment phase and the quantitative risk and exposure assessment phases of the current review, and summarizes the policy assessment and rulemaking phase.

The Clean Air Scientific Advisory Committee (CASAC) Secondary NAAQS Review Panel for Oxides of Nitrogen and Oxides of Sulfur was assembled to review EPA's draft IRP. Panel members provided individual comments prior to the public teleconference held on December 1, 2015, to receive a briefing on the EPA's draft IRP and to hear public comments and deliberate on responses to the EPA charge questions. The draft consensus responses to the charge questions were developed based on comments and suggestions proposed by panel members on the major issues identified in the draft IRP and then vetted by the panel. The panel met on February 29, 2016, to discuss its draft consensus responses and the chartered CASAC then conducted a quality review and approved the report with minor revisions.

The EPA charge questions to the CASAC with a summary response for each are presented below and the individual review comments from the CASAC Secondary NAAQS Review Panel for Oxides of Nitrogen and Oxides of Sulfur are included in an appendix.

OVERALL ORGANIZATION AND CLARITY

Charge Question #1: *To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_X and SO_X NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?*

This charge question focuses on the content of Chapter 1 of the draft Integrated Review Plan (IRP) of October 2015. Chapter 1 provides an overview of the process to be undertaken by the EPA and the CASAC to review the Secondary National Ambient Air Quality Standards (NAAQS) for NO_X and SO_X. Chapter 1 summarizes legislative requirements, articulates the step-wise process of the secondary NAAQS review, provides a brief history of air quality public welfare criteria and secondary NAAQS for oxides of nitrogen (NO_X) and sulfur (SO_X), and ends by proposing a schedule for the current review.

The CASAC finds that the introductory chapter was generally well written and serves its primary purpose of setting out the tasks to be undertaken. This includes the legislative impetus behind the current review, a conceptual model that clearly communicates the process to be undertaken by the entire secondary NAAQS review (as well as the role and function of CASAC within that process) and historical context for the review. The CASAC notes that the chapter was clear in conveying its

message; however, there were several areas that either required further clarification, were not explained in the context of the previous 2008 CASAC secondary NAAQS NO_X and SO_X review (USEPA, 2008), or were lacking entirely.

To directly address the charge questions:

- *To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_X and SO_X NAAQS and the key scientific and policy issues that will guide the review?*
  The CASAC agrees that the IRP clearly defines the four components of the NAAQS (i.e., indicator, form, level and averaging time), appropriately communicates the review process and broadly defines key issues for this review.

- *To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?*
  Whereas Chapter 1 provided excellent historical context for actions undertaken in response to the Clean Air Act and its sections that require the EPA Administrator to take appropriate actions, a more detailed and clearer rationale for not revising the existing secondary standards in the last review is lacking.

Key Findings

1. Although the long-term historical context is well established, there was insufficient discussion in Chapter 1 in this draft IRP of the work undertaken by the 2008 CASAC Secondary NO_X and SO_X NAAQS Review Panel, including findings and recommendations. This is an omission that spans other issues as well (see below).

2. More clarity is needed on the 'form' of the secondary NAAQS (i.e., the 'form' of a standard defines the air quality metric that is compared to the level of the standard in determining whether an area attains the standard). Although the chapter clearly defines the four basic elements (i.e., indicator, averaging time, form, and level), it neither explains how the aquatic acidification index (AAI) standard was derived in the previous review cycle, for example, nor whether this 'form' is meaningful/applicable to the current review as a starting point.

3. Related to issues 1 and 2 above, consideration of other reactive nitrogen compounds (N_r, i.e., any N compound other than N_2), which would/could include ammonia (NH_3), ammonium (NH_4^+), organic nitrogen, and other chemically reduced N compounds need to be given greater consideration including changing proportionalities among compounds. This was discussed in great detail in the previous 2008 CASAC review, yet is only briefly mentioned. For example, chemically reduced nitrogen (NH_3 and NH_4^+) was included in the AAI form of the standard; however, the current draft IRP does not clearly articulate how the role of the chemically reduced nitrogen compounds would be addressed.

4. Chapter 1 clearly describes the chronology leading up to previous decisions by the EPA Administrator not to propose or adopt changes in primary and secondary NAAQS as recommended by the CASAC. The CASAC recommends that the IRP provide more information regarding how and why EPA's decisions were made, including the role of various uncertainties associated with adopting the requisite form of the standard. The draft IRP should also address how various uncertainties such as

those identified in the 2008 review (uncertainties in models, limited ecological and atmospheric data) will be addressed and resolved in this effort. As an example, the draft IRP should describe how the five-year pilot field study or smaller efforts that were undertaken may have been able to eliminate or reduce some of the uncertainties identified in the previous review.

Key Policy Relevant Issues (Chapter 2)

Charge Question #2*: Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?*

Chapter 2 identified and characterized some of the policy-relevant questions that are important to the review in the secondary NAAQS for NO_X and SO_X, although the range of issues/questions identified and their characterization was limited. The range of issues and depth of coverage should be expanded, particularly given the outcome of the last review. While the CASAC understands that this is a new, separate and independent review process, greater details are needed regarding the recommendations of CASAC in the last review, the proposed final rule, and the Administrator's response to the last review, including the rationale for her decision. Specifically, are there scientific and policy-relevant questions from that decision that should be considered by the current CASAC? The issue of uncertainty is of importance; specific attention to the uncertainties identified by the Administrator will be important. What specific issues of uncertainty did the Administrator cite in the prior review, and if those uncertainties have been addressed, how were they addressed? The current section in the draft IRP consists of only two paragraphs and is not sufficient for this purpose. A more robust description of the concerns, including the uncertainties identified in the last review, is needed in order to properly address them.

A critical policy-relevant issue of immediate importance is what type of standard is allowable under the Clean Air Act (CAA). The four components of the standard - form, level, averaging time, and indicator(s) - are independently and jointly important. In particular, "level", in the past, has referred to an ambient air concentration. If that is still the case, this limits the applicability of the various alternative approaches to the form of a standard considerably and also impacts the potential choice of averaging times and indicators. Given that it is difficult, if not impossible, to measure dry deposition directly, especially in a large network, atmospheric models will have to be used to determine attainment with the NAAQS. An important question to address in framing this review process is: According to the CAA, can the secondary standard be based on deposition rather than on ambient air concentration?

The current document says that depositional effects on manufactured structures (and, one should add, cultural objects), as well as atmospheric visibility, will not be included in this review. The current reasoning for not including those endpoints is not well supported. Absent a more reasoned and stronger justification (e.g., exclusion is mandated by statute), both of those endpoints should be included as part of this review. The CASAC notes that reduction in atmospheric visibility and acid deposition were linked in past policy discussions. In the 1987 PM NAAQS review, a secondary PM NAAQS was considered but ultimately rejected because of the close association of atmospheric visibility and acid deposition, and a preference was stated for addressing both issues together, rather than separately.

Adding to the lack of clarity in the IRP is inconsistent usage of the term "ecosystem services." This would likely lead to further confusion in subsequent documents. Ecosystem services should therefore be defined for the purposes of this document, and used consistently throughout. For example, one definition provided is: "Ecosystem services can be generally defined as the **net benefits** individuals and organizations obtain from ecosystems." This can be confusing because the definition of "benefits" is vague. Are benefits to be estimated as welfare measures (e.g., the monetized value of the goods and services an ecosystem provides) or biotic measures that households, communities, and businesses understand as being valuable (e.g., lakes that are clean enough for swimming and fishing)? Also, contrast the above language to language in Chapter 4: The EPA has defined ecological goods and services as the "*outputs* of ecological functions or processes that directly or indirectly contribute to social welfare or have the potential to do so in the future." This definition of ecological goods and services seems to be referring not to benefits, but to biophysical outputs. The CASAC recommends that the EPA not rely on the Millennium Ecosystem Assessment definition and classification of ecosystem services, which – while broadly used – perpetuates this terminological confusion. Its "supporting" and "regulating" services describe valuable ecosystem *functions*, its "provisioning" services describe quantifiable goods (food and fiber), and its "cultural" services include a mix of *activities* that benefit from natural resources and their qualities (recreation) and *social values* associated with ecosystems (existence, spiritual). Ecosystem services valuation (monetized or not) should also be defined clearly. It would be helpful to use a standard definition and terminology when referring to ecosystem services. One option would be to use the standardization outlined in an EPA document by Landers and Nahlik (2013).

Additionally, and as noted for Charge Question #1, the integral role of chemically reduced N, and organic S, in depositional effects needs to be better described. How the EPA might address those pollutants, in a standard based on oxides of nitrogen and oxides of sulfur, is an important question of policy relevance that needs to be addressed here. Furthermore, another important issue to consider is how the relationship between emissions and deposition may change in the future in response to changes in the relative abundance of key species owing to current emissions requirements and in response to climate change.

Many of the above concerns can be addressed by providing a more thorough discussion of the development of the AAI in the previous review, even if an AAI-like metric may or may not be considered in this review. The AAI was developed to address the need to relate a specific effect of interest (i.e., aquatic acidification) to an ambient air concentration (level), integrating N- and S-deposition impacts (joint pollutant standard and the role of chemically reduced N deposition), and the AAI proposed the use of ecological and atmospheric models in determining attainment. These still remain as important science and policy relevant issues, and many of the uncertainty concerns noted by the Administrator are generally associated with the development and application of this index.

Science Assessment (Chapter 3)

Charge Question #3: *Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.*

In general, the CASAC is supportive of the approach outlined for the Integrated Science Assessment (ISA) in Chapter 3 and has a series of broad suggestions for improving its clarity and transparency. As noted for Chapters 1 and 2, a vital issue identified by the CASAC is the need to provide a detailed

review of the current scientific understanding of the emissions, transformations, deposition and ecological effects of chemically reduced nitrogen compounds (both inorganic and organic). The *Atmospheric Sciences* section in this chapter appears to be an appropriate place for this discussion. The IRP provides detailed descriptions of the emissions, transformation, deposition and spatial and temporal patterns of sulfur and nitrogen oxides in the atmosphere. Comparable descriptions of chemically reduced nitrogen compounds need to be provided at the same level of detail. Chapter 3 should therefore include descriptions of the limitations of emission estimates and measurements, monitoring and model projections, spatial and temporal scales associated with the impacts of chemically reduced nitrogen, as well as, the spatial distribution of wet and dry deposition of chemically reduced nitrogen compounds, how these patterns have changed in recent decades, and how such patterns are projected to change under future emissions (e.g., decreasing NOx from mobile sources and SO_2 from power plants) and climate change scenarios.

The CASAC notes that there have been decreases in atmospheric sulfate and nitrate deposition in the eastern parts of the United States and increases in the deposition of chemically reduced nitrogen compounds in some areas over the past few decades. The ISA should describe and take advantage of these observations to document how/whether ecosystem function and structure have responded to these changes in atmospheric deposition. This type of analysis could be incorporated into the chapter sections on terrestrial nitrogen effects, aquatic (freshwater and marine) nitrogen effects, terrestrial acidification effects and aquatic acidification effects and possibly wetland nitrogen effects.

While the CASAC recognizes the need to organize the chapter into cohesive subsections, such as atmospheric sciences, terrestrial nitrogen effects, aquatic acidification effects and so on, this approach fails to address the linkages among ecosystem components and ecosystems. Water draining upland terrestrial ecosystems flows into wetlands and low order streams and ultimately to coastal waters. Important linkages such as these are not captured in the IRP currently but should be addressed in the document.

An AAI was proposed as an approach in the 2008 CASAC review for the NO_X and SO_X Secondary Standard. The Administrator ultimately rejected this approach due to a number of uncertainties, including uncertainties in observations and data required to implement the AAI. The CASAC recommends that these uncertainties be critically evaluated as part of the ISA.

Quantitative Risk and Exposure Assessment (Chapter 4)

Charge Question #4: *Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review.*

As stated in the introduction to the chapter, the Risk and Exposure Assessment (REA) is intended to address several questions described in Chapter 3, including:

1) What is the nature and magnitude of negative ecosystem responses to NO_X and SO_X (including atmospheric concentrations and deposition)?
2) What is the variability in responses across ecosystem types, climatic conditions, environmental effects and interactions with other environmental factors and pollutants?
3) How does NO_X and SO_X (including atmospheric concentrations and deposition) interact with other pollutants and are there joint impacts on ecosystems or are the impacts additive?

4) Are there specific levels of atmospheric concentrations and deposition associated with adverse effects of concern? In other words, can thresholds be identified?

Charge Question 4 (a): *To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review?*

Since the REA has not yet been developed and the amount of progress that will be made in understanding and quantifying the ecological responses to the changes in sulfur and nitrogen exposures in the many effect areas identified in Chapter 3 is not currently known, the exact approaches that will be employed in the REA plan (Chapter 4) are also not entirely known at this time. The intended scope, issues to be considered, and planned organization of the ISA, which is the scientific basis for development of the REA, are described in a very preliminary way. Although Chapter 4 was understandable, the CASAC is concerned that providing preliminary ideas does not constitute a plan that could, if approved, be put into action. The CASAC notes that the scope of the REA needs to be broadened to include emissions as well as concentrations, deposition, and impacts.

The IRP proposes using an integrated assessment approach (section 4.2.1) combining analytical and modeling tools to assess ecological impacts, and an ecosystem services framework (section 4.2.2) as a tool for framing the discussion of the ecological effects of NO_X and SO_X on public welfare. A combination of national and case study assessments (section 4.2.3) is also proposed. The CASAC finds that these collective approaches are reasonable. However, the specific methods to be used are poorly defined at this time making it not possible to adequately evaluate these methods for scientific soundness.

Numerous potential tools and models for risk and exposure assessment are reviewed in Section 4.3 of the IRP. These include the use of atmospheric transport models and monitoring data for characterizing air quality, critical loads models, and various models for looking at environmental /ecosystem effects. This section of the IRP, although understandable, is full of inconsistencies (e.g., inconsistent use of references and the level of detail with which modeling approaches are described), and has many editing errors. Many useful editorial suggestions were made in individual comments by panel members. It is difficult to assess how the tools that are reviewed in Section 4.3 of the IRP will be used, and whether these tools will be successful or scientifically valid for quantifying specific levels of atmospheric concentrations and deposition associated with adverse effects of concern across gradients of environmental conditions.

More specifics on the models are needed for the proposed REA approach to be credible. For example, the IRP needs to specify model details, model assumptions, input data requirements, modeling resolution/domain, applicability, and methods for model evaluation. In the IRP, EPA should also describe how these models will be integrated to provide the needed answers regarding risk and exposure. The CASAC suggests using consensus from multiple modeling approaches, and ensemble modeling results, to guide decisions. Some of the proposed models do not perform well in certain areas of the country (e.g., CMAQ model), and uncertainty in model outputs is not fully acknowledged (Foley et al, 2010). EPA should identify known deficiencies and describe how model deficiencies will be dealt with, fully articulating model uncertainties. The CASAC is also concerned about the ability to scientifically quantify ecosystem goods and services and how these quantities change as the environment changes. As of now, many ecosystem service models are not detailed and sophisticated enough to convert changes in NO_X and SO_X deposition into changes in the provision and quality of ecosystem services. The IRP should clarify which models, if any, can convert changes in NO_X and SO_X deposition into changes in the

delivery and quality of ecosystem services. The CASAC also generally finds that it is not necessary to always put monetized values on impacts for this assessment. If biodiversity measures are used as ecological endpoints, it is important to clearly articulate their significance and how they will be measured.

In Section 4.4 of the IRP, the discussion of uncertainty and variability is too brief. Given that a new secondary standard was not proposed by the EPA in the previous 2008 review process primarily due to uncertainty, the IRP needs to cover this topic in greater detail. The four-tiered approach put forth by the World Health Organization (WHO, 2008), which EPA plans to use to characterize uncertainty, should be discussed in greater detail in the IRP.

Key uncertainties, associated with data and model limitations, are summarized in Table 4-1 of the IRP. However, the uncertainties listed in Table 4-1 are not uncertainties used in the customary scientific way, as quantitative ranges of effects; rather, they are listings for each of the ecosystem effect categories, of what might be referred to as "known unknowns". EPA should plan to provide quantitative estimates of the magnitudes of uncertainty.

Charge question 4 (b): *To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?*

The IRP acknowledged many new sources of information and models that will be reviewed by the EPA. In general, the CASAC finds that these are good tools for considering risk and exposure. However, more information is needed to describe how these models will be integrated and used to determine secondary NAAQS for NOx and SOx.

The CASAC suggests that EPA consider using the Watershed Analysis Risk Management Framework (WARMF) model (which is distributed by the EPA) as an important additional analytical tool for evaluating risk and exposure. The model is highly mechanistic and includes the algorithms used in the Integrated Lake-Watershed Acidification Study (ILWAS) model. In addition to being able to mechanistically simulate the response of terrestrial and aquatic watershed components to acidic deposition, WARMF simulates the response of watersheds and fish to atmospheric mercury deposition, including the relationship between mercury methylation and sulfate.

The CASAC also notes the importance of including in the risk and exposure analysis the effects of chemically reduced nitrogen compounds on public welfare. Furthermore, climate change is expected to interact with atmospheric deposition in affecting ecosystems in ways that may confound or alter ecosystem responses to atmospheric deposition. This adds uncertainty to assessments of atmospheric deposition effects and may need to be further integrated into the assessment.

Key Findings:

- Chapter 4 of the IRP does not adequately describe the planning process for quantifying risk exposure and analysis. The chapter is a key part of the IRP and needs substantial improvement. The intended scope of the Integrated Science Assessment (ISA) is described in a very preliminary way making it difficult to evaluate the scientific soundness of the plans for the REA that will be based on results of the ISA. The focus of the chapter as well as the specific plan for what will be done need to be clarified.

- Instead of providing only a general list of models and tools that EPA intends to explore in considering risk exposure and analysis, the IRP needs to specify model details (e.g., model assumptions, input data requirements, modeling resolution/domain, applicability, and methods for model evaluation), and how they will be used, integrated, and lead to new understanding. The IRP should specify what biophysical and welfare conditions need to be measured and modeled. Then the models that can contribute to such an analysis should be identified. Further, a method for integrating models and incorporating uncertainty into the modeling assessment needs to be discussed. Finally, the EPA needs to explain how model inputs and outputs will be used to enhance the understanding of the biophysical and welfare impacts of alternative changes in NO_X, SO_X and/or NH_x emissions. The IRP should allow for using the newest and best version of data and modeling tools. Some of the proposed tools that EPA is considering may not be adequate to accurately quantify parameters, such as the CMAQ model and ecosystem goods and services valuation models. Therefore, the CASAC suggests using consensus from multiple modeling approaches, and ensemble modeling results, to guide decisions.

- The CASAC suggests not emphasizing only a monetized value of ecosystem goods and services. Non-monetized ecosystem services are also important and need to be considered. The CASAC suggests using multiple models and ensemble modeling results in order to appreciate the extent of analytical uncertainty and identify any model consensus. Additionally, the EPA should consider presenting model outputs both as monetized values and biophysical impacts.

- Given that a revised secondary standard was not adopted in the previous review process primarily due to uncertainty, substantially more background information is needed documenting the uncertainty and the WHO tiered approach that will be used to address it. Further, ranges of quantitative uncertainty values need to be added to table 4.1.

- Comments from individual CASAC panelists are very detailed with regard to feedback about Chapter 4, including editorial, technical, and scientific suggestions to improve the IRP. Though major points from the panelists are summarized here, the CASAC encourages EPA to carefully review these comments.

Policy Assessment and Rulemaking (Chapter 5)

Charge Question #5: *Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?*

The plans for the policy assessment and rulemaking procedures in Chapter 5 are clearly summarized in brief and general terms. Since the Policy Assessment (PA) document and associated rulemaking are entirely dependent on the yet-to-be-developed ISA and REA assessments, the CASAC notes that the brevity and lack of details are appropriate.

While there have been advances in the understanding of the welfare effects associated with NO_X and SO_X emissions, concentrations, and deposition since the last NAAQS review, it will be challenging to synthesize the science into policy relevant options that can be clearly communicated to the Administrator and to the public. The PA will need to describe the incremental changes in a wide range

of environmental effects, and potential thresholds, that would be expected to occur with varying degrees of NO_X and SO_X emissions decreases, including increases or decreases in ammonia emissions. The PA would also need to explain why such changes in the environment matter for human welfare and well-being.

Since the development of a multi-pollutant secondary NAAQS is such a new and inherently complex undertaking, dependent on currently unknown results from the ISA and REA, it should be anticipated that the PA will present new or newly synthesized information. For this reason, the CASAC recommends that the Agency plan to allow time for more than one draft of the PA, to assure the most effective feedback from the CASAC and the public.

The CASAC encourages the EPA to think more broadly about the best way to present the results of the NAAQS review to the Administrator and the public. While the Agency may be inclined to present results as succinct monetized values (e.g., the estimated monetized net benefit of a new standard in dollars), the CASAC also encourages the Agency to present results in alternative ways. For example, tradeoff curves could be used to show the tradeoff between economic costs and some biophysical indicator under varying standard levels. This curve would intuitively indicate how much must be given up in monetized terms to secure better functioning ecosystems and increased ecosystem services. The Agency could also use pictures or graphics to describe expected typical states of natural features under various standard levels. The Agency could use narratives to describe alternative hunting, fishing, and hiking experiences in natural landscapes under differing standards. If the impact of greater deposition is not visible to the naked eye or is not made manifest through recreational experiences, then an intuitive explanation may be warranted to explain why stricter standards could be a vital addition to the PA.

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APPENDIX A.

Preliminary Individual Comments
Clean Air Scientific Advisory Committee
Secondary NAAQS Review Panel for Oxides of Nitrogen and Sulfur[1]
December 12, 2015

[1] Dr. Robert W. Howarth is a member of this panel, but did not participate in the review of the IRP.

Dr. Ivan J. Fernandez

General Comments

There are several overarching issues that emerged from the review of the draft IRP and associated deliberations that warrant highlighting.

1. More detail on the history of the review of secondary standards for NOx/SOx, with particular attention to the details of where the last review left off, what transpired, and why. This directly informs the starting point for the work of this panel and must be clearly defined. Issues surrounding uncertainty in the last review were to have focused on a pilot project, but nothing is said about the results of that work. Uncertainty prevented recommendations from the last review from being implemented, but the specifics of that issue are lacking in this IRP.
2. There is compelling evidence that our changing physical climatology influences a broad range of welfare effects. The implications for this changing climatology, and the possible alternative futures that will unfold, has important consequences for N and S pollution concerns and the standards that are appropriate for that future. The climate change factor should be included in the IRP.
3. What are the limitations for this review in light of the historical focus on gas concentrations and oxidized species? The science over the past decade has made increasingly evident the importance of reduced species of N, reactive N and total N dynamics, as well as the importance of linking atmospheric concentrations with deposition and indirect effects. What are the legal limits of the charges before this panel in the development of recommendations?
4. While there may be a sound rationale why other welfare effects (e.g., visibility, the built environment) are not included in this review, those were not evident in the draft IRP. This should be articulated, and there are good reasons to include other welfare effects in this review because those insights could inform our decision-making on appropriate recommendations for the welfare effects that are already included.
5. All of the work of the IRP, ISA and REA leads to the PA that frames recommendations for action by the Administrator. Every effort should be made to assure that time allowed and procedure used supports as thorough a consideration of the PA, or greater, than will have been devoted to earlier stages in the review process.

Specific Comments

Page	**Lines**	**Comment**
1-1	2-6	For the general public, it might be useful to use 'primary' along with 'secondary' to clarify the types of reviews included in this statement.
1-13	22	aspect(s)
2-5	14	After the sentence about the focus of this review, it would seem of value to have a sentence to say why this focus is taken, or point to where the focus on particulate NOx and SOx is covered in other EPA procedures.
2-6	12	"judgements is plural so 'is' should be 'are'

Page	Lines	Comment
2-7	1-2	Recommend changing "Other information that may be helpful to consider…" to "Information that may be particularly useful to consider…" since by saying "Other" it assumes that these approaches would not be part of the consideration of ecological effects noted above.
2-8	Fig 2-1	It is not completely clear why NOx and SOx vs SO2 and NO2 are used rather than a single terminology in this table. Also, 'Nature" in the upper right box should not be capitalized.
2-9	2-3	Something is wrong with the wording of this sentence.
	4-5	Why spell out the words for NOx and SOx here and use symbols below? If there is no reason, these should be consistent. If there is, the reason is not evident.
	20	delete 'incremental'
3-1	11	trivial, but the font size for 'x' is inconsistent for NOx and SOx in this section. Also, 'other their' products does not make sense but it is not clear what this is trying to say.
	12-13	This seems to me an odd mix of disciplines, at various levels of specificity, and includes 'ecosystem services' that seems to be a topic and not a discipline. Would something about disciplines included will range from atmospheric and hydrologic sciences to ecology and biogeochemistry achieve the intended goal?
	20	delete comma
3-3	FIg 3-1	What does 'See Figure III' in top box refer to?
3-5	18	This is a general question regarding this section, and the intent of an evaluation of 'quality'. Earlier a criteria noted was that the studies must be peer reviewed. Is there any consideration of the quality of the outlet? This is specifically asking about metrics like impact factors, and complications of modern 'peer reviewed' journals that include open source options that sometimes have little review as long as the fee is paid.
3-9	14	relationship(s), threshold(s)
	19, 22, 23	Why spell out nitrogen and sulfur and shortly afterwards abbreviate S and N? These should be consistent unless there is meaning implied, and if so, it is not clear to me what that is.
	27	NOy?
3-10	1, 3, 5	NOy?
	15	was' should be 'were'
	17	that' were
	19	Shouldn't this be 'indicated' to convey it is from a past study?
	23	concentration(s)
	33	forest(s)
3-11	12	in (a) few instances
	19	throughout, use the symbol N now rather than go back and forth with format

Page	Lines	Comment
	21	change 'exists' to 'exist'
	24	Since these questions frame the scope of the analysis to be done, it seems undesirable to use 'etc.' which offers little definition. Perhaps just say '…changes in biodiversity to ecosystem form and function.'
	27	delete 'other'
3-12	9	change 'vegetation' to 'forests' since the remainder of this paragraph focuses on forests only. Framing it with the term vegetation could leave the reader wondering why all the other types of ecosystems were not included.
	22	dose-response
3-13	11	delete 'nutrient'
	31	valence on NO3 should be a superscript
3-14	12	spell out laboratory
	17	end with '?'
3-15	5	NOy?
	8	dose-response should be hyphenated throughout.
3-16	7	NOx 'and' SOx
	16-18	I would add 'time' as one of the types of variability, or 'temporal' variability to the list of factors here.
4-1	7	more on format consistency, but it seems the symbols do not need to be reintroduced, but rather introduced once at the beginning of the document and then used consistently.
Table 4-1		-For aquatic acidication, the first box first bullet refers to 'weathering rates for aquatic ecosystems' which likely comes directly from the last REA. However, typically it is the watershed (mineral) weathering rates that are the focus. Is this about sediment weathering rates in the lake, or watershed weathering rates/ -There is a random use of periods at the end of statements in this table. -In aquatic eutrophication, what is the term 'air load'? Prefer 'atmospheric loads'.
4-6	29	subscript in SO2
	31	more' not 'ore'
4-7	8	tools' not 'tolls'
4-11	24	The acronym NADP stands for National Atmospheric Deposition Program, not Network.
	26	This is probably not the number to use as this includes active AND inactive sites. I would use a total for currently active sites. This is possibly off by 25%.
4-12	9, 10	NOx'

Page	Lines	Comment
	12. 13	This appears to be the first use of a reference in support of a scientific statement, despite many statements above referring to science from the previous assessment. Is this one different in some way? If not, I would not include this reference which is presumably sourced in the earlier documents.
	15, 17	omit hyphen
4-14	Fig 4-5 9	caption uses NOy instead of NOx. NOx not NO)
4-15	7	NOx
	4	Again, for the CMAQ section there are multiple references which is a departure in style from other sections. This is probably a global question for the document as to the philosophy behind when citations are included or not, particularly if both instances occur for references noted in the documentation from the earlier assessment.
4-18	22	fix sub- and superscripts on SO4
4-23	25	This seems an outdated description since results are expected in spring 2015 which is soon to be a year in the past.
5-2	15-16	Given the complexity of committees and panels in environmental regulation, any mention of this panel should consistently use the precise title of this panel. I believe that would be 'Secondary NAAQS Review Panel for Oxides of Nitrogen and Sulfur'. Same comment for 3-16, lines 14-15.
5-3	8	What criteria or who decides the length of the comment period since it varies? By way of editorial modification, can insight on that question be incorporated?

Dr. Edith Allen

I reviewed the draft Integrated Review Plan with special attention to Sec. 3.
I agree that there is much new published literature since the last review that are relevant to current standards for NO2 and SO2. In particular, in my area of expertise, there are recent publications on critical loads of N deposition for impacts on plant species richness, species loss, vegetation community shifts, and changes in ecosystem functioning that occur above a critical load. In many of these publications reduced N (NH_3, NH_4^+) is 50% or more of the deposited N. However, only oxidized N is regulated by the EPA.

The Plan includes several references to reduced N as a component of N deposition. Sec. 2. Question IIa. States: What components of total reactive nitrogen deposition need to be considered? This question provides a platform for a discussion on the importance of reduced N to public welfare, and to begin to consider ways that reduced N can also be regulated.
The role of reduced N in ecosystem responses to deposition, and the potential for regulation of reduced N, are important topics that should be included in CASAC discussions.

Additional review comments:

During our panel discussion on December 1, other panel members noted that organic N deposition may also be an important component of total deposition. To assure that no important sources of N emissions are omitted in our discussions, another approach for the IRP would be to include all forms of N deposition in the review questions (oxidized and reduced N, organic and inorganic N). There is considerable information on NHx deposition. Many (most?) studies on ecosystem impacts of N deposition include both oxidized and chemically reduced forms, either as impacts from ambient N deposition or simulated deposition (fertilization), and the effects of oxidized and reduced N cannot be separated in those studies. There is less information (fewer measurements and models) about rates of organic N deposition and impacts, but organic N should nevertheless be considered in our questions and discussions.

For instance,

p. 2-9 Sec. 2.2.1, Policy Relevant Questions, specifically mentions reduced N in two questions (II a, c), but not in all of them. None of them refer to organic N.

For II b. “What types of ecological effects can be quantitatively related to NOx and SOx in ambient air and associated deposition?”, including reduced N (NHx) in the question would be especially important. If, for policy reasons, the main question cannot include reduced N, then perhaps we could add a second question under II b, “What types of ecological effects can be quantitatively related to NHx, or the combination of NHx plus NOx plus organic forms of N in ambient air and associated deposition?”

p. 3-10 lists several questions:

“What new information is available on spatial and temporal trends in ambient NOy and SOx concentration, particularly in vulnerable areas?

What new information is available on NOY and SOX sources, transport, transformation, and deposition processes that impact exposure?

What new information is available on speciation of NOY and SOX components and their 5 impact on deposition?"

For NOy (NOx?) can we substitute "NOx plus NHx"? Or add additional questions to address NHx and organic N?

(Organic forms of S were also mentioned in the review panel discussion, but this is not my area of expertise).

Dr. Praveen Amar

General Comments:

EPA's current effort on potential revisions of secondary NAAQS for SOx and NOx builds on and is a continuation of the previous EPA effort over the years 2008-2012, that resulted in its publication in the Federal Register on April 3, 2012, as a Final Rule on "Secondary National Ambient Air quality Standards for Oxides of Nitrogen and Sulfur".

The goals of the previous effort, similar to the current effort, were to assess the ecological effects and valuation of changes in ecosystem services associated with deposition of total reactive nitrogen (TRN) and sulfur, focusing on four main targeted ecosystem effects on terrestrial and aquatic systems: (1) aquatic acidification; (2) terrestrial acidification; (3) aquatic (nitrogen) nutrient enrichment, including eutrophication; and (4) terrestrial (nitrogen) nutrient enrichment. The previous effort also addressed a number of issues in a qualitative manner including the relationship between sulfur oxides deposition and production of methyl mercury; effects of nitrous oxides and climate; effects of nitrogen on primary productivity and biogenic greenhouse gas fluxes, and phytotoxic effects on plants.

The previous effort for the first time considered multi pollutants (SOx, NOx/NOy, and ammonia and ammonium (NHx) in a combined manner as well as in a multimedia context (air, water, soil/land). For ammonia/ammonium, however, the Final Rule only indirectly "took into account" the role of ammonia without addressing the control of emissions of ammonia. Equally important, EPA for the first time considered secondary standards for environmental/public welfare on their own merits, separately from primary standards for human health effects.

Finally, EPA in 2012 concluded that there was a strong scientific basis for development of a standard to limit acidifying deposition of these pollutants to sensitive aquatic ecosystems around the country. The form of the proposed standard was an "Aquatic Acidification Index" (AAI) that related levels of NOx and SOx in the ambient air to water quality (Acid Neutralizing Capacity or ANC). AAI did take into account the fact that different ecosystems vary in the amount of acid deposition they can tolerate (e.g. regional critical loads) before exhibiting adverse effects.

However, in the final rule, EPA decided not to adopt the AAI form of the standard because of various uncertainties associated with adopting the requisite form of the standard. These uncertainties are described in great detail in the Final Rule.

To lower the level of uncertainties, EPA in 2012 determined that it will undertake a 5-year field study to collect and analyze data "to enhance our understanding of the degree of protectiveness that would likely be afforded by a multi-pollutant standard, specifically to address deposition-related acidification of sensitive aquatic ecosystems."

Information from this pilot study was to be used to inform the current review of the secondary NAAQS for NOx and SOx. Data generated from the field study/studies was also to inform the development of an appropriate monitoring network to support a multi-pollutant standard.

With these general comments as background, here are the responses to the five charge questions.

Charge Question #1- Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

The overall organization of draft IRP is acceptable. However, the IRP does not clearly describe how this review will extend the work accomplished in the previous review. For example, the form of the standard (AAI) is mentioned here but it does not mention or explain the four components (F1, F2, F3, and F4) of AAI and how they were arrived at and whether the form of AAI is meaningful and applicable in the current review. Same comments apply to the role of reactive reduced nitrogen (ammonia and ammonium) that was discussed in great detail in the previous review. It is not clear how the role of ammonia would be addressed in this review (emissions, chemistry, deposition, ecological effects, etc.). For example, would the issue of reactive reduced nitrogen be addressed at more/less/ same level based on current understanding of the role of ammonia?

In the area of uncertainties (Section 4.4: Characterizing Uncertainty and Variability), please note that the Final 2012 Rule described various uncertainties (in data, in air quality and ecological models, in representativeness of selected Eco regions, etc.), These uncertainties then became the basis for not proposing the AAI standard, and a field program was proposed to lower the level of uncertainties. The draft IRP's description in Section 4.4 on how these issues would be addressed needs to be more detailed and should more thoroughly articulate how the uncertainties in the previous review would be addressed. For example, have the results from the field program resulted in lowering the uncertainty of some data/model results? If some of the uncertainties still remain/will remain, they should be noted and how they will be addressed in ISA and REA.

Charge Question #2- Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

Chapter 2 does address key policy relevant issues satisfactorily. However, please do see my earlier comment about AAI and why its four components should have been described here. Also, Section 2.1.2 ("Key areas of Uncertainty") needs to not only list areas of uncertainty, but how they will be addressed in this review. It is not clear to me how this will be done.

Charge Question #3- Science Assessment (Chapter 3): Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

Chapter 3 is well-written and clearly outlines how EPA will evaluate various new studies and how they would be incorporated in current review.

Please note that Section 3.4 on atmospheric sciences (page 3-9) should be extended to ambient concentrations of ammonia in addition to SOx and NOx. Unless new evidence is to the contrary, the findings of the previous review on role of ammonia should be a starting point for this review. For example, this review should treat ammonia (its emissions, atmospheric processes, deposition, etc.) with the same rigor as it treats SOx and NOx. Thus, this review should try to assemble ammonia emission inventory at the same spatial resolution as SOx and NOx (12km by 12 km resolution). If this review has access to 2013 NEI, it should be used in place of 2011 NEI.

Charge Question #4- Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

The first question (page 4-1, Line 14) should be modified to say "what is the nature and magnitude of negative ecosystem responses to total reactive nitrogen (TRN) and SOx…", so as to include NHx into total reactive (oxidized and reduced) nitrogen load.

Page 4-2, Line 25-Line 27: Eutrophication Index is not defined here or in the List the Key Terms. On page 4-4, there is reference to "bad to poor" eutrophication index. What does it mean? What is meant by "existing benchmarks" for ecological effects in the coastal sage scrub communities?

Page 4-3, Figure 4-1: Please modify the Figure to show the second supplemental area, "Little Rock Lake, Wisconsin" on the map

Page 4-3, Line 10: Please note that the previous REA showed that that the effects of ammonia sources were found to be on scales beyond just "local sources." In many cases, the scale of NH3 effects was of the same regional scale as the scales of emissions of NOx and SOx. Ammonia emissions have the same regional impact as emissions of SOx and NOx.

Page 4-3, Lines 17-18: This REA should update the data to present-day conditions (years 2010-2015?), if available, on percentage of modeled lakes that exceed ANC levels of zero to 100.

Page 4-4, Lines 11-18: The description of "key uncertainties" here and in rest of the IRP is inadequate (please see earlier comment).

Page 4-5, Table 4-1 ("Key Uncertainties identified in the Previous Review"): As I note in other comments on "key uncertainties," this Table needs to be more precise in description of key uncertainties. As it is written now, the uncertainties in the previous review are described in very general terms (for example, the words such as "lack of information", "limited information," "limited ability" are widely used in the Table) and it is not clear what the current review would undertake to improve on the previous review's uncertainties.

Page 4-14, Emissions: This draft IRP should outline its approach to improve on the current emission inventory for ammonia including sources related to CAFO and fertilizer applications.

Page 4-20, Section 4.3.2.3; Water Quality Models and Sources: Please note that the description of the models here (SPARROW, SWAT, HAWQS, NPDAT) is very sketchy and it is not clear how these models will be used in REA in the current review.

Page 4-21: Ecosystem Services: I think the Title of this section should be changed to "Ecosystem Services Valuation" to reflect the purpose of this effort. Also, this ecosystem services valuation should reflect the specific recommendations made in a recent NRC Committee's report "Sustainability Concepts in Decision-Making: Tools and Approaches for the U.S. EPA" (September 2014). One example is a recommendation for EPA to characterize, quantify, and monetize the types of ecosystem services that have been difficult to valuate in the past (for example, nutrient cycling and biodiversity). In particular, ISA and REA should focus on the development and use of ecological production functions that can estimate how effects on the structure and functions of ecosystems will affect the provision of ecosystem services that are directly relevant and useful to the public. Where ecological functions do not exist, this current review should seek to improve and strengthen the current methods on the basis of ecological indicators.

It is not clear how the FEGS/NESCS approach described here would apply to more complex services provided by ecosystems beyond "commercial fishing." If the InVEST approach as well as "Ecosystem Valuation Toolkit" (as well as ARIES, NSRE, FHWAR) are to be used in the current review, they need to be explained more fully.

Charge Question #5- Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

Chapter 5 summarizes the policy assessment and rulemaking process quite clearly.

Dr. James Boyd

Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

No comments.

Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

- In reference to the following: "Because oxides of nitrogen and sulfur are deposited from ambient sources into ecosystems where they affect changes to organisms, populations and ecosystems, the concept of adversity to public welfare as related to impacts on the public from alterations in structure and function of ecosystems would seem appropriate for this review."

While assessment of impacts to ecosystem "structure and function" are *necessary* to assessment of welfare impacts, would EPA consider structure and function impacts *sufficient* to make a welfare assessment?

- The section refers to "habitat provision and biodiversity" as critical ecosystem functions. Should "biodiversity" be considered a "function"? As opposed to biodiversity being an outcome of ecosystem functions, or a service provided by those functions.

- Would it be useful to distinguish more clearly between:
  - ecosystem processes and functions
  - biotic outcomes of those processes and functions
  - the subset of biotic outcomes that capture/reflect welfare-relevant ecosystem services

- A terminological point: "ecosystem services" is a generic term that can introduce confusion. For example the definition provided "Ecosystem services can be generally defined as the benefits individuals and organizations obtain from ecosystems" can be confusing because the definition of "benefits" is vague. Are benefits a welfare measure (e.g., the monetized value of the feature or resource quality) or biotic measures that household, communities, businesses understand as being valuable?

Also, contrast above language to language in Chapter 4: The EPA has defined ecological goods and services as the "*outputs* of ecological functions or processes that directly or indirectly contribute to social welfare or have the potential to do so in the future.

- A related point is that the MEA definition and classification, while broadly used, perpetuates, or indeed is the cause of, this confusion. Its "supporting" and "regulating" services describe valuable ecosystem *functions*, its "provisioning" services describe quantifiable goods (food and fiber), and its "cultural" services include a mishmash of *activities* that benefit from natural resources and their

qualities (recreation) and *social values* associated with ecosystems (existence, spiritual). All of these "services" are categorically different kinds of things/concepts.

To be clear, though, properly defined, I am in total agreement that "ecosystem services may aid in assessing the magnitude and significance to the public of a resource and in considering how oxides of nitrogen and sulfur concentrations and deposition may impact the public welfare through effects on that resource."

- The policy questions conclude as follows: "Are these risks/exposures of sufficient magnitude such that the welfare effects might reasonably be judged?"

Should another question be added beyond the "might reasonably be judged" question, relating to whether or not impacts to public welfare benefits justify the policy option's costs? Or has the language been left deliberately looser (i.e., the burden of proof at this stage is simply "might reasonably be judged to be important?")

to be important to the public welfare?

Science Assessment (Chapter 3): Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

- No comments, except see above discussion of how ecosystem services are defined.

Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

- Possible discussion of intermediate versus final ecosystem goods and services, and emphasis on point that some ecological outcomes can be both intermediate and final.

- Possible discussion of the statement that "Although a wealth of economic data and research are available to quantify the total value of many ecosystem services, less information is available for incremental analysis."

- Appreciation of the statement that "Even without completing the pathway to economic valuation, valuable conclusions can be drawn from the analyses of impacts on components of public welfare as defined in the CAA."

- Discuss biophysical data inputs necessary to linkage with ecosystem service modeling frameworks (NESCS, INVEST, ARIES, etc)?

Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

No preliminary comments.

Dr. Elizabeth W. Boyer

Charge Question #4- Quantitative Risk and Exposure Assessment (Chapter 4).

Chapter 4 provides a summary of previous risk exposure and assessment which is useful, and discusses the planned approach to considering the potential for additional analyses in the current review. As stated in the introduction to the chapter, the risk and exposure assessment is intended to address several questions described in Chapter 3, including:

5) What is the nature and magnitude of negative ecosystem responses to NO_X and SO_X (including atmospheric concentrations and deposition)?
6) What is the variability associated with those responses, including across ecosystem types, climatic conditions, environmental effects and interactions with other environmental factors and pollutants?
7) Are there specific levels of atmospheric concentrations and deposition associated with adverse effects of concern?

Charge question 4a). To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review?

Given that how the Risk and Exposure Assessment (REA) will be developed is to be worked out; and that it's not currently known much progress will be made in understanding and quantifying the ecological responses to changes in S+N exposures in all of the many effects areas identified in Chapter 3, the exact approaches that will be employed in the risk and exposure assessment are not entirely knowable at this time. The intended scope, issues to be considered and planned organization of the ISA are clearly described in a very preliminary way that was acknowledged. There was worry expressed among reviewers that providing just some "preliminary ideas" hardly seems like a plan that could, if approved, be put into action and that is quite difficult to evaluate for scientific soundness.

The report proposes using an integrated assessment approach (section 4.2.1) combining analytical and modeling tools to assess ecological impacts, and an ecosystem services framework (section 4.2.2) as a tool for framing the discussion of the ecological effects of N&S on public welfare. A combination of national and case study assessments (section 4.2.3) is also proposed. Many view the collective approaches as reasonable or even excellent, yet the exact methods to be used are so ill-defined at this time, that they are hard to evaluate. And, many concerns were raised with the current scientific ability to quantify ecosystem goods and services.

Key uncertainties that were recognized, associated with data and model limitations, are summarized in Table 4-1. However, as panelist Schwarz pointed out in his written comments, the uncertainties listed in Table 4-1 are not uncertainties used in the customary scientific way, as quantifiable ranges of quantifiable effects, but rather are listings, for each of the ecosystem effect categories, of broad categories of what might be categorized as known unknowns. He

also points out that it seems important to give some understanding of quantitative estimates of the magnitudes of uncertainty, and I agree.

Numerous potential tools and models for risk and exposure assessment are reviewed (section 4.3). These include use of atmospheric transport models and monitoring data for characterizing air quality, critical loads models, and various models for looking at environmental / ecosystem effects. This section, though quite understandable, is full of inconsistencies (such as the use of references, the detail with which modeling approaches are described, etc), and has many editing errors that made it seem like a first draft, leading to many useful editorial suggestions by the panelists. It seems to be wide open as to what tools could be used, seemingly just encouraging us to trust that EPA will be thorough in using these tools. However, it is difficult to assess whether these tools will be successful or scientifically valid, e.g., with regard to quantifying specific levels of atmospheric concentrations and deposition associated with adverse effects of concern across gradients of environmental conditions.

Charge question 4b). To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

The review acknowledged many new sources of information and models that will be reviewed by EPA which were thought to be sufficient. One panelist suggested use of the model WARMF for considering risk and exposure, and pointed out new sources of data. Several panelists commented that additional issue of the importance of reduced N-species to public welfare should be included in the risk and exposure analysis.

Dr. Douglas Burns

Response to Charge Question #2

In my view, the key challenge in the NOx/SOx NAAQS is how to proceed from an objective evaluation of the scientific evidence on ecosystem effects of NOx and SOx to recommendations of the required elements of the secondary standard itself, the indicator, averaging time, level, and form. This can be seen clearly in the draft IRP by examining the science questions on Page 2-9 and the succeeding questions pertinent to the secondary standard on Page 2-10. It is not at all clear to me how we get from the policy-relevant science questions to providing definitive answers to the necessary secondary standard questions. An attempt was made as a result of the last review in 2005 to develop a metric that could transcend the gap between air concentrations and an ecosystem effects indicator. This attempt was unsuccessful and I would posit that this did not result necessarily from quantitative uncertainty, but rather because the metric was perhaps not completely clear and straightforward from the policy practioner perspective. And the challenge that faced the last assessment remains---how to get from the science to an appropriate policy that is consistent with the best and latest scientific information available and yet follows the dictates and structure of the Clean Air Act.

As I look at these two sets of questions, there are some areas that seem a little unclear to me. First, the science questions discuss “total reactive nitrogen deposition”, which clearly includes ammonia and ammonium. But the secondary standard questions necessarily refer only to NO_2. The effects of reduced nitrogen deposition are inextricably linked with those of nitrogen oxides. Yet it appears that these effects would have to be disentangled in order to proceed to the secondary standards. Second, Chapter 2 discusses critical deposition loads as an appropriate assessment metric to review. I agree with this view, and this is an area where much progress has been made in the US since 2005. However, I still see a real hurdle, if not a major roadblock, in translating from a critical loads assessment, to the specific questions that must be answered regarding indicator, averaging time, level, and form. I think that the CASAC can try to make some headway on this challenge. But at the end of the day, this will remain a difficult bridge to cross.

Ms. Lauraine Chestnut

Overall, the Draft Integrated Review Plan is clear, logical and lays out a reasonable and comprehensive plan for conducting the review of the secondary NAAQS for NOx and SOx.

Chapter 1: Introduction

The IRP needs to give a more thorough explanation of why other known welfare effects of NOx and SOx are being excluded from this review. Most relevant and feasible to include seems to be visibility. I can understand that factors determining a requisite standard to protect against deposition-related welfare effects may be different than those for visibility-related welfare effects; the fact remains that they are caused by the same pollutants. Although control costs are not a factor in determining a requisite standard, they certainly may be a factor in determining an ultimate regulatory approach and control strategies. Strategies that maximize the reduction in all adverse effect caused by these pollutants would seem preferable to those that consider each effect in isolation. It is a matter of gaining the most benefits for the pollution-control dollars to be spent. Somewhere in the process such "co-benefits" need to be considered.

Chapters 4 and 5: Risk and Exposure Assessment and Policy Assessment

The risk and exposure assessment needs to set the stage for the policy assessment by drawing upon the scientific evidence to make the linkages between changes in the amount of pollutants in the environment and endpoints of relevance to public welfare. Endpoints in this case may be related to ecosystem functions or services.

The IRP describes the need for information to allow the Administrator to assess whether the proposed standards would be effective in remedying any adverse welfare effects. This does not require that the effect be monetized. It is helpful information to make all the linkages quantitative including monetization when feasible, but it is not necessary. There is a danger that the focusing on what can be monetized may give insufficient attention to effects that are significant and well understood but cannot be monetized.

Information necessary to help the Administrator make a determination with regard to how a proposed standard could protect the public from adverse effects includes:

1. The incremental change in the ecosystem expected to result from a reduction in pollution from current conditions to meeting proposed standards needs to be explained. This could be descriptive rather than fully quantitative, although some sense of magnitude is needed. The total value of the resource or ecosystem service involved is not very helpful unless some measure of the magnitude of the change the standards would obtain can be determined.

2. Why the change in the resource or ecosystem service matters. This can be descriptive and can include preservation values that may not be linked to direct human uses. Especially in relatively "natural" areas, people care about preservation of habitat and ecosystem functions and services regardless of direct human usage.

Throughout the assessment process, it will be important to address variability in sensitivity to these pollutants. It was very challenging in the last review to bring variability in sensitivity into the equation when linking it all back to changes in ambient concentrations and to a uniform national standard. Are there any new approaches being considered to address this? Is it feasible for the standard to apply to only those areas with sensitive resources?

Dr. Charles T. Driscoll, Jr.

In general I found the Chapter 3 Integrated Review Plan for the Integrated Science Assessment for the Secondary National Ambient Air Quality Standard Review of Oxides of Nitrogen and Oxides of Sulfur to be appropriate and to build on the ISA that was conducted in the previous review in 2008. Although the subtopics to be addressed in the IRP seem appropriate (e.g., atmospheric sciences, terrestrial nitrogen enrichment, aquatic acidification), I have concerns that this segmented approach fails to identify important linkages among the different effects. For example, atmospheric nitrogen deposition to terrestrial upland ecosystem could become mobilized to downstream wetland, freshwater and coastal ecosystems and have effects. There can be linkages between nitrogen enrichment and acidification. These are just a couple of examples. The coupling across ecosystem types and across effects should be addressed in the ISA. The EPA proposed an Aquatic Acidification Index as an approach in the last CASAC review for the NO_x- SO_2 Secondary Standard. The Administrator ultimately rejected this approach due to uncertainties in observations and data required to implement the AAI. These uncertainties should be be critically evaluated as part of the ISA.

However I have a number of specific comments and suggestions.

1. Page 3-3 I am disappointed in the conceptual model developed for the ISA which is illustrated in Figure 3.1. The figure depicts that process for evaluation of health effects. I believe the review process is fundamentally different for secondary ecosystem effects than health effects. I would hope that a conceptual diagram could be developed that would be specific for ecosystem effects that would be relevant to the diverse nature and indirect nature of air pollution effects on ecosystems.
2. Page 3-9, section 3-4. Shouldn't "new" effects that were not addressed in the 2008 ISA be addressed? I believe that recent science may have shown effects that were not previously identified in the 2008 ISA.
3. Page 3-9, atmospheric sciences. There be a detailed description of reduced nitrogen emissions, chemistry and deposition. The previous assessment considered both oxidized and reduced nitrogen, even though reduced nitrogen is not part of a potential standard. It would seem a description of the state of the science of reduced nitrogen (inorganic and organic) emissions, chemistry and deposition would be a critical component of the ISA.
4. Page 3-10, atmospheric sciences. I would like to see changes in the relative contribution of dry to wet deposition in response to decreases in emissions addressed in this section.
5. Page 3-11, terrestrial nitrogen enrichment. Address how have terrestrial ecosystems have responded to increases or decreases in atmospheric nitrogen deposition.
6. Page 3-12, terrestrial acidification. There is some recent literature linking changes in acid deposition to changes in water use efficiency. This issue might be addressed in the ISA.
7. Page 3-12, terrestrial acidification. The response of dissolved organic matter and total phosphorus from terrestrial ecosystem to decreases in acid deposition might be addressed in the ISA.
8. Page 3-12, terrestrial acidification. It would be useful to document how terrestrial ecosystems have responded to decreases in acid deposition.
9. Page 3-13, aquatic nutrient enrichment. It would be useful to document how freshwater and coastal marine ecosystems impacted by elevated nitrogen deposition have responded to recent decreases in nitrogen loading and what is the contribution of decreases in atmospheric nitrogen deposition.

10. Page 3-13, aquatic acidification. Might consider including responses of dissolved organic matter to decreases in acidification and these effects targets for goals of acidification recovery in the ISA.
11. Page 3-14, aquatic acidification. Should consider how acid impacted aquatic ecosystems have responded to decreases in acid deposition.
12. Page 3-14, aquatic acidification. Isn't the third question redundant with the eutrophication effects section? Might it be moved?
13. Page 3-15, sulfur driven mercury methylation. There was a scientific assessment conducted for the Mercury and Air Toxics Standard. Shouldn't that be incorporated in this section?
14. Page 3-16, sulfur driven mercury methylation. Do there need to be questions / information concerning effects of methylmercury?

Dr. Mark Fenn

Charge Question #4- Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review.

(1) To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review?

In section 4.3.1 (Air Quality) the use of chemical transport models (CTMs) for characterizing ambient air quality is described. Here it states that occult deposition is not modeled explicitly but "it is generally assumed to be incorporated in models through mass conservation principles". This may often be true but in California forests, where dry deposition and in many cases occult or fog deposition are major input pathways, CMAQ often doesn't perform well. And in many cases where cloudwater deposition of pollutants is important, the CTMs are likely to underestimate atmospheric deposition by a large degree, considering the extremely high concentrations of nitrogen and sulfur pollutants that can in fog or cloudwater in areas affected by anthropogenic emissions.

I agree with the argument made in this section regarding the usefulness and need to use CTMs for evaluating atmospheric exposure and inputs, but I'm concerned that the uncertainty in model output isn't fully acknowledged. In our work in California, CTMs such as CMAQ and Tdep (also CASTNET dry deposition values) grossly underestimate N deposition in sites with moderate or high N deposition-----the very sites that are being most impacted by air pollution. So we use empirical throughfall data to adjust the CMAQ simulated deposition---a hybrid approach. Thus, ground truthing of modelled deposition is needed because of the uncertainty in modeled deposition, which is expected considering the high degree of complexity in modelling atmospheric chemistry, transport and deposition processes. Uncertainty is greatest for dry deposition processes, which also suggests that in the more arid parts of the country where dry deposition often dominates atmospheric inputs, uncertainty in modeled deposition is expected to be greatest. Adding to the uncertainty is the fact that deposition often varies by many-fold over short distances in forested areas (i.e., steep deposition gradients) when dry deposition dominates, because of high rates of deposition to the high canopy surface area of forest vegetation.

Climate change is expected to interact with atmospheric deposition in affecting ecosystems in ways that may sometimes confound or alter ecosystem responses to atmospheric deposition. This adds uncertainty to assessments of atmospheric deposition effects. This may need to be integrated more into the plan.

In section 4.3.2.1, Critical Loads Databases, several reports of studies on terrestrial plant biodiversity that are in preparation are mentioned (page 4-18, lines 13-15); others may also become available. If the national epiphytic lichen critical load work, based on US Forest Service Forest Inventory and Analysis (FIA) lichen survey data, is published in time for use in the REA then this is likely to provide broader national coverage than any other single ecosystem condition indicator, and this is based on work in which the same methodologies are applied across the entire network. This point is also highly applicable to section 4.2.3 in the discussion of 'National and Case Study Assessments'.

The increasing emphasis on linkages between atmospheric deposition and ecosystem services is a good idea considering the recent increase in research on such linkages.

Regarding uncertainty in accounting for deposition of nitrogen in chemically reduced forms (NHx), see below:

(2) To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

It has become apparent in recent years that reduced forms of N (NHx) are becoming proportionally more important as oxidized forms of N (NOx) emissions decrease. Elevated emissions of NHx are generally thought to be primarily due to agricultural activities, although three-way catalytic converters on light duty vehicles are known to over reduce a fraction of the NOx emissions and contribute to NH3 emissions. Increasingly data from networks of passive samplers for NH3 and nitrogen deposition networks demonstrate that even in urban sites and sites downwind of urban areas high levels of reduced N are common. This suggests that the relatively high NHx:NOx ratios found in the NADP/NTN data and from other studies are not due solely to decreasing NOx emissions and that the importance of NHx emissions and deposition to ecosystems in some regions is likely underappreciated when only modeled deposition data are relied upon. This issue is partially being addressed by the application of empirical NH3 data from the AMon network in the TDEP modeling, although NH3 data from a much greater number of sites is needed. In summary, uncertainties in NH4 deposition needs to be acknowledged when considering the acidification or eutrophication effects of N deposition.

For section 4.3.2 I would just mention that the possibility now exists to more fully address responses of some high elevation lakes from the western U.S. to acidic and eutrophying deposition. The SSWC model described in section 4.3.2.2 has been applied to lakes of the Sierra Nevada in California and this work has been published in a peer-reviewed journal. A number of additional studies have been published on historical responses of diatom communities to changes in water chemistry in high elevation lakes of the West. Most or all of these are from Class I areas.

Dr. James Galloway

Thank you for the opportunity to provide initial comments on Chapter 3 of the draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur. In my view, the chapter does a good job of describing the scope and specific issues to be considered. The one issue that I think is not sufficiently addressed concerns the impacts of total N deposition on receiving ecosystems, in the context of the CAA which only addresses NOx. I realize that this is not a new issue (as it was noted in the last review), but it is one that is of growing importance given the decrease in NOx emissions, and the opposing increase in NH3 emissions. In this regard, perhaps the attached Finding from the 2011 report of the EPA Science Advisory Board on *Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options*, might be of some use.

A Report of the EPA Science Advisory Board
Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options

EPA-SAB-11-013 | August 2011 | www.epa.gov/sab

Finding 8: Scientific uncertainty about the origins, transport, chemistry, sinks, and export of Nr remains high, but evidence is strong that atmospheric deposition of Nr to the earth's surface as well as emissions from the surface to the atmosphere contribute substantially to environmental and health problems. Nitrogen dioxide, NO 2, is often a small component of NO y, the total of oxidized nitrogen in the atmosphere. The current NAAQS for NO 2, as an indicator of the criteria pollutant "oxides of nitrogen," is inadequate to protect health and welfare. NO y should be considered seriously as a supplement or replacement for the NO 2 standard and in monitoring. Atmospheric emissions and concentrations of Nr from agricultural practices (primarily in the form of NH 3) have not been well monitored, but NH 4+ ion concentration and wet deposition (as determined by NADP and NTN) appear to be increasing, suggesting that NH 3 emissions are increasing. Both wet and dry deposition contribute substantially to NH x removal from the atmosphere, but only wet deposition is known with much scientific certainty. Thus consideration should be given to adding these chemically reduced and organic forms of Nr to the list of Criteria Pollutants.

Recommendation 8a: *EPA should reexamine the criteria pollutant "oxides of nitrogen" and the indicator species NO2 and consider adding chemically reactive nitrogen as a criteria pollutant, and NHx and NOy as indicators to supplement the NO2 National Ambient Air Quality Standard.*

Recommendation 8b: *Monitoring of NHx and NOy should begin as soon as possible to supplement the existing network of NO2 compliance monitors.*

Recommendation 8c: *EPA should pursue the longer term goal of monitoring individual components of Nr, such as NO2 (with specificity), NO and PAN, and HNO3, and other inorganic and reduced forms, as well as support the development of new measurement and monitoring methods.*

Recommendation 8d: *The scope and spatial coverage of the Nr concentration and flux monitoring networks (such as the National Atmospheric Deposition Program and the Clean Air Status and Trends Network) should be increased and an oversight review panel for these two networks should be appointed.*

Recommendation 8e: *EPA in coordination with other federal agencies should pursue research goals including:*

• *Measurements of deposition directly both at the CASTNET sites and in nearby locations with nonuniform surfaces such as forest edges.*

• *Improved measurements and models of convective venting of the planetary boundary layer and of long range transport.*

• *Improved analytical techniques and observations of atmospheric organic N compounds in vapor, particulate, and aqueous phases.*

• *Increased quality and spatial coverage of measurements of the NH3 flux to the atmosphere from major sources especially agricultural practices.*

• *Improved measurement techniques for, and numerical models of NOy and NHx species (especially with regard to chemical transformations, surface deposition and offshore export, and linked oceanland-atmosphere models of Nr).*

Dr. Frank Gilliam

This charge—overall organization and clarity—is tasked primarily with considering the content of Chapter 1 of the draft Integrated Review Plan (IRP) of October 2015 as provided for the members of the Clean Air Scientific Advisory Committee (CASAC). This chapter essentially provides an overview of the entire process to be undertaken by the CASAC. It summarizes legislative requirements, articulates the step-wise process of the national ambient air quality standards (NAAQS) review, provides a brief history of the air quality public welfare criteria and standards for oxides of nitrogen (N) and sulfur (S), and ends by proposing a schedule for the current review.

Specifically, this particular change addresses the following: to what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_X and SO_X NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

As part of my charge comments, I would like to synopsize parts of Chapter 1, both to provide CASAC members a brief summary and to help me, a relative neophyte in this process, to better understand its content. As part of its function, the United States Environmental Protection Agency (EPA) is reviewing the existing air quality criteria for oxides of N and S (NO_X and SO_X, respectively) and secondary (welfare-based) NAAQS for NO_2 and SO_2. The IRP is keen to not use NO_X/SO_X and NO_2/SO_2 interchangeably, wherein NO_X/SO_X reflects a collective group of oxidized N and S compounds and NO_2/SO_2 refers to specific chemical species.

Legislative

The impetus behind the current review lies in two sections of the Clean Air Act (CAA), namely Sections 108 and 109. Section 108 compels the EPA Administrator to identify and list "air pollutants" which "in his judgment, may reasonably be anticipated to endanger public health and welfare," including the "presence . . . in the ambient air results from numerous or diverse mobile or stationary sources" and to issue air quality criteria for those that are listed. Air quality criteria are intended to "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of identifiable effects on public health or welfare which may be expected from the presence of [a] pollutant in ambient air . . ." Section 109 directs the Administrator to propose and disseminate "primary" and "secondary" NAAQS for pollutants listed under section 108.

The current process for reviewing the NAAQS includes four major phases: (1) planning, (2) science assessment, (3) risk/exposure assessment, and (4) policy assessment and rulemaking. For many of the member of CASAC, these phases were outlined at a panel workshop at EPA in Research Triangle, NC, in March 2014. We are currently in the second box of Figure 1.1 (IRP):

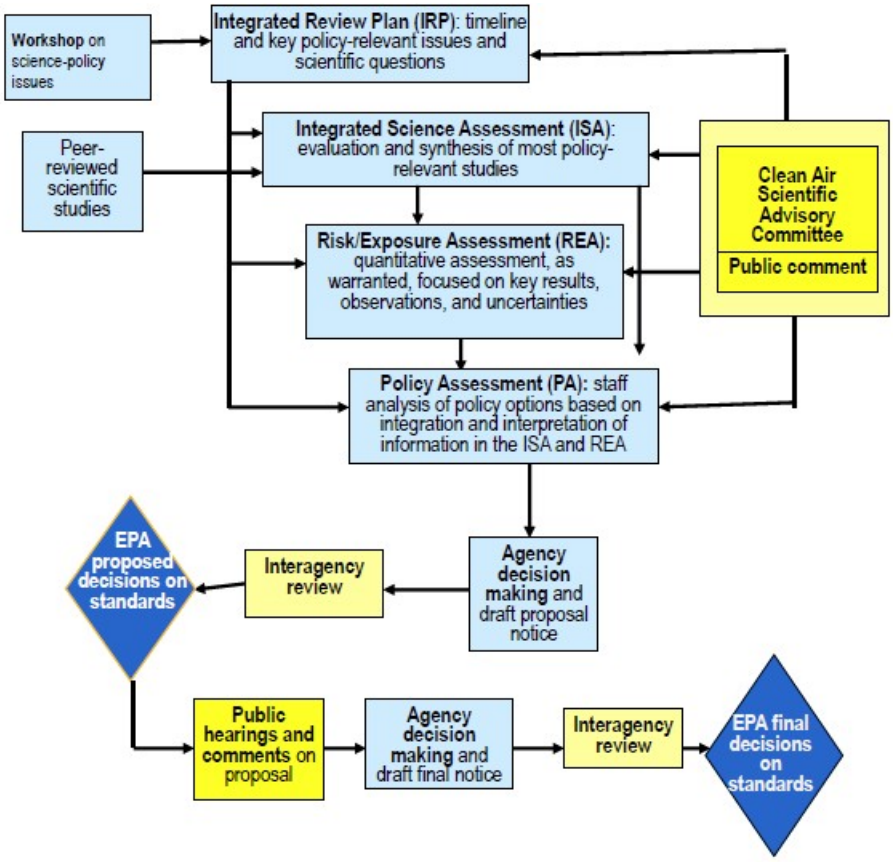

Figure 1-1. Overview of the NAAQS review process.

History

Virtually all ecologists/environmental scientists are generally familiar with the history of setting air quality standards, beginning with the provisions of the CAA and indeed with the establishment of the EPA in 1970, and arising from the National Environmental Protection Act of 1969. From the outset, separate standards for NO and SO were established.

NO_2 NAAQS

For NO_X, the first air quality criteria and standards were issued in 1971, with both the primary and secondary standards were set at 0.053 parts per million (ppm), as an annual arithmetic mean. In 1982, EPA updated the scientific criteria upon which the initial standards were based and proposed to retain these standards in 1984, eventually publishing the final decision to retain the existing standards in 1985. Subsequent efforts for revision were rejected by the Administrator.

SO_2 NAAQS

Also in 1971, the secondary standards for SO_X were set at 0.02 ppm, as an annual arithmetic mean and 0.5 ppm, as a maximum 3-hr, not to be exceeded more than once per year. EPA published a combined air quality criteria document for SO_X and particulate matter for CASAC review in 1980, after which the CASAC pointed out the scientific complexity of acid deposition. That is, the unique challenge in documenting acid deposition it arises from numerous atmospheric pollutants, such as NO_X and SO_X and the fine particulate fraction of suspended particles. In 1990, amendments to the CAA specifically targeted emissions of SO_2 and NO_X.

Charge

1. To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_X and SO_X NAAQS and the key scientific and policy issues that will guide the review? As one new to this review process and who primarily writes to a scientific audience to convey results of original research, I initially found the writing of this chapter (and others that I read) to be rather dense, requiring numerous re-readings. However, I ascribe more of this impression to my 'neophyte' status than to any flaws in the writing of the preparers of the IRP. In short, upon further readings, and even the composition of these charge comments, I find them to be a clear communication of the complexity and process involved in the review.

2. To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated? My comments here would echo what I stated in #1. I learned a great deal in this chapter, not only regarding the process, but also its historical context.

Dr. Robert A. Goldstein

Overall Manuscript: All chapters are clear; however there are few specific editing errors and some specific items that could be clarified. There is an alphabetizing error in Key Terms where Ecologically Relevant Indicators is out of order.

Section 1. This section is basically clear. No comments.

Section 2. This section is basically clear. A few comments follow.

Page 2-1. Line 22. "Biodiversity" is a poorly defined and ambiguous term. Note there is no definition given under Key Terms. People frequently talk about protecting biodiversity but cannot clearly define it or state how it should be measured. Essentially, "good biodiversity" is frequently being used in a qualitative sense as a synonym for "ecosystem health". Assuming you propose well-defined quantitative metric for biodiversity, biodiversity will vary among ecosystems; hence, absolute biodiversity would be meaningless for assessment. For assessment, one would be interested in changes in biodiversity, but what would incremental changes signify? What species do you include in your biodiversity metric? Do you include exotic and nuisance species? The application of biological criteria for waterbodies has received considerable attention. The only waterbody type for which there is general acceptance is a small wadeable stream. Even here you have problems, since it is not clear how to interpret incremental changes. As noted in the recent teleconference, addition of nutrient to a waterbody can lead to increases in biodiversity. In summary, I feel that the best measures for effects assessment are changes in the physical and chemical environment, and changes in individual species populations and functions (e.g., reproduction and growth). Biodiversity is used most often in Section 4 and hence these comments are probably more relevant to that Section.

Page 2-3, line 7. With respect to "sensitive aquatic ecosystems", does this term refer to ecosystems for which a portion of their waterbodies are sensitive or does it refer to the sensitive waterbodies? In other words, does the presence of sensitive components within an ecosystem result in the characterization of the ecosystem as sensitive?

Page 2-3, line 22. "Terrestrial eutrophication" should be defined in Key Terms. Note this term is only used once in the entire manuscript.

Page 2-3, line 23. How is "ecoregion" defined?

Page 2-3. Lines 24-5. I do not understand uncertainty two. What is meant by relationship between effect category and ecosystem services?

Section 3. This section is basically clear. A few comments follow.

I find it confusing to say there is a causal relationship between x and y at the start of a discussion, and then to follow with a description of other factors that mediate the relationship. I think it would be clearer to state in the lead sentence all factors that influence y and then go on to explain relationships in greater detail.

Page 3-1, lines 10-12. There is a problem with the last phrase in the sentence.

Page 3-1, line 13. Why "ecosystem services" and not "ecosystem science". The definition of "ecosystem services" in the Key Terms section includes "biodiversity maintenance". Why is biodiversity maintenance an ecosystem service? "Ecosystem services" is a highly ambiguous term and means different things to different people. To some people ecosystem services means the quantification of ecosystem properties and functions in terms of dollars, to others there is no specification of metric. I agree with other teleconference participants who called for a clearer description of ecosystem services and how EPA plans to apply ecosystem services.

Section 3.3.2. Additional questions: Has this experiment ever been repeated or have the results been replicated in other studies? Have all environmental factors that mediate endpoint results been measured and reported?

Page 3-5, line 7. Add definition of "reactive nitrogen" to Key Terms.

Page 3-9, Atmospheric Sciences subsection. Text switches suddenly from NOx to NOy with no explanation. "NOx" and "NOy" should be added to Key Terms.

Page 3-11, line 6. "Species richness" should be added to Key Terms.

Page 3-13. Lines 1-10. "A causal relationship was also inferred between N deposition at current levels and species richness, species composition, and biodiversity in freshwater aquatic and coastal marine systems." This is a very general statement. The rest of the paragraph correctly indicates that this statement is system dependent. In addition, depending on how you define biodiversity, the sentence may contain a redundancy since "biodiversity" is sometimes defined as "species richness".

Page 3-15, lines 30-31. Increased sulfate results in increased production of methylmercury only when sulfate is limiting.

Mercury Methylation subsection. Se-S interactions should be recognized and new information should be collected.

Section 4. This section is basically clear; although, it is the least clear and contains the most editing errors of all sections in the report. A few comments follow.

Biodiversity. "Biodiversity" is a poorly defined and ambiguous term. Note there is no definition given under Key Terms. People frequently talk about protecting biodiversity but cannot clearly define it or state how it should be measured. Essentially, "good biodiversity" is frequently being used in a qualitative sense as a synonym for "ecosystem health". Assuming you propose well-defined quantitative metric for biodiversity, biodiversity will vary among ecosystems; hence, absolute biodiversity would be meaningless for assessment. For assessment, one would be interested in changes in biodiversity, but what would incremental changes signify? What species do you include in your biodiversity metric? Do you include exotic and nuisance species? The application of biological criteria for waterbodies has received considerable attention. The only waterbody type for which there is general acceptance is a small wadeable stream. Even here you have problems, since it is not clear how to interpret incremental changes. As noted in the recent teleconference, addition of nutrient to a waterbody can lead to increases in biodiversity. In summary, I feel that the best measures for effects assessment are changes in the physical and chemical environment, and changes in individual species populations and functions (e.g., reproduction and growth).

Page 4-1. Lines 27-28. "… ecosystem effects, and, to the extent possible associated ecosystem services." Other parts of this Section contradict this statement by implying that ecosystem services are the key or only ecosystem end points.

Figures. Why doesn't Fig. 4-1 include the second Supplemental Area? Figure 4-2 is referred to and appears later in the text then Figures 4-4. 4-5 and Figures 4-6? There is no Figure 4-3. When most of the figures in Section 4 are referred to in the text, the figure numbers given are for Section 5.

Page 4-6, Line 31. There is a typo.

Page 4-7. Line 25. Add "species richness" to Key Terms.

Subsection 4-2-3. Second paragraph. It is important to note that within an ecosystem type, sensitivity can vary with varying physical, chemical, hydrologic and biological properties.

Page 4-14. Line 5. Are there more recent emissions data than in the 2011 National Emission Inventory?

Page 4-17. Second paragraph. I do not think the empirical approach is a good way to develop critical loads. If data are not available, how do you determine sites are similar? The discussion of simple mass balances models is not clear.

Section 4.3.2.2. First paragraph. The last sentence is not clear.

Page 4-18, Line 29. Sources and sinks for what?

Page 4-19, Line 2. The term groundwater appears in the title; although, there is no mention of groundwater in the following text.

WARMF. I recommend that as an analytical tool, USEPA consider the biogeochemical cycling model WARMF. This model is distributed by USEPA (http://pubweb.epa.gov/athens/wwqtsc/html/warmf.html). The model is highly mechanistic and includes the algorithms used in the Integrated Lake-Watershed Acidification Study (ILWAS) Model (The ILWAS model: formulation and application. S.A. Gherini, L. Mok, R.J.M. Hudson, G.F. Davis, C.W. Chen, and R.A. Goldstein. Water, Air, and Soil Pollution 26, 425-459 (1985)). In addition to being able to mechanistically simulate the response of terrestrial and aquatic watershed components to acidic deposition, WARMF also simulates the response of watersheds and fish to mercury atmospheric deposition, including the relationship between mercury methylation and sulfate.

Subsection 4.4. Uncertainty in the results of a model application is a function of the uncertainty in the algorithms and data. More complex algorithms may be more accurate but they will require more data to apply; hence, as uncertainty of an algorithm decreases, uncertainty in data requirements frequently increase. At some point uncertainty associated with the data is likely to exceed uncertainty associated with the algorithm, and uncertainty in the results will reach a minimum, after which any increases in algorithm complexity will increase results uncertainty. I make this comment with respect to atmospheric models which in my opinion include chemical reactions in greater detail than can be accurately, quantitatively specified. In biogeochemical cycling models, no one would ever attempt to specify individual reactions for each of the myriad organic acids that can be identified to exist in the system. One would instead assume a few hypothetical acids that would mimic the combined behavior of the actual acids.

Section 5. This section is clear. No comments.

Dr. Daven Henze

Charge Question #1- Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

Lead discussants are: *Drs. Frank Gilliam, Praveen Amar, and William McDowell*

- The review plan is clear overall, in terms of describing the timing and components of the review process, defining the key scientific and policy issues, and summarizing the outcome of the last review. That being said, I was expecting more of these issues to be explained a bit more in Ch1, as outlined below:
    - Section 1.2: The distinction between the scope of the REA and the ISA is not very clear in this summary; the basis of the REA only really becomes clear after readying Ch 5. That the term "assessment" in REA implies that EPA staff will actually be performing their own modeling (rather than assessing / evaluating results in the literature) could be stated more directly. The same goes for later (e.g., p2-5, line 10) with the phrase "quantitative analysis"; it would be useful to clarify this is not just quantitative analysis of synthesized results from the literature, but generation of new estimates using air quality, ecosystem, and integrated modeling tools.
    - p1-12, line 16 – 21: The administrators decision to not set any new secondary standards at the time of the last review seems like an essential component of the history of the review process. Here the rational for this decision gets short shrift (although it is explained in more detail in 2.1.1). It may be of value to include another paragraph here summarizing the rational. At the very least, the text should point the reader to the Section 2.1.1 if such detail is not provided at this point.
    - I would suggest summarizing the key policy and scientific questions in Section 1.4.

- For primary NAAQS, a Regulatory Impact Analysis (RIA) is part of the review process. Is that not part of the process for a secondary standard, or does that only become part of the process after a unique secondary standard is promulgated?

- p1-13, line 23: Suggest rewording this, as it possibly comes across as nitrogen or sulfur oxides being emitted in particulate form.

- p1-14, lines 1-4: These seem redundant with lines 31-33 of the previous page. Or, if the point was to make the distinction between nitrogen and sulfur as compared to their oxides, the text in the previous bullet could probably just be adjusted to be inclusive of both.

Charge Question #2- Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately

characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

Lead discussants are: *Drs. Armistead (Ted) Russell, James Boyd, Douglas Burns, and Kathleen Weathers.*

- p2-5, line 15: What was the basis for setting the scope to not include the effects of acid deposition on man-made materials and structures?
- p2-9, line 4: "scientific support" possibly sounds as if science is subjective. I suggest "scientific evidence".
- To what extent would it be important / permissible to also evaluate if other attainment of other standards, e.g., primary NAAQS for O_3 or particulates, would partially or entirely achieve welfare protection goals for nitrogen and sulfur deposition?
- Along the lines of the above point, it seems that consideration of future conditions warrants inclusion the list of policy relevant questions, in terms of future emissions trends (owing to existing domestic standards or otherwise) or changes in climate impacting atmospheric SOx and NOx concentrations and subsequent deposition.
- If the evidence does suggest revision is necessary, will there be additional measurement / monitoring needs? Should this be added to the list on p2-10?

Charge Question #3- Science Assessment (Chapter 3): Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

Lead discussants are: *Drs. Charles Driscoll, Edith Allen, James Galloway, Robert Howarth, and Hans Paerl.*

- The science focus as written is on NOx and SOx concentrations, and their relation to deposition. However, for NOx there are many other species (i.e., NOy, which is only mentioned briefly) that contribute to the welfare impacts. To refer almost exclusively to atmospheric concentrations of NOx may neglect key species (PAN, HNO3, etc.). Granted, emissions controls will be implemented for SOx and NOx, but here there is also a step that seems to be missing in the discussion, which is the relationship between changes to emissions of SOx and NOx and the resulting changes in atmospheric concentrations of sulfur and nitrogen in gas and aerosol phases.
- Since the abundance of NH3 impacts the relationship between NOx emissions and oxidized nitrogen concentrations (extending the atmospheric lifetime of oxidized nitrogen through promotion of ammonium nitrate), this section should include a bullet on new information available on NH3 sources, transport and transformation. In addition, knowing the sources and fates of NH3 will be important for answering questions identified in subsequent sections that seek to separate the impacts of NHx from oxidized nitrogen on terrestrial, wetland, and aquatic nitrogen enrichment.
- In terms of the schedule, it seems potentially a drawback that input from the CASAC doesn't seem to occur in time to inform the set of studies to be included as relevant for the ISA. Will the EPA be open to any suggestions from the CASAC during the review stage of studies not included in the

original selection of relevant studies?

- Given the outcome of the previous review, it seems that explicit quantification of uncertainty is of utmost importance. Section 3.4 (p3-9) mentions the importance of understanding if uncertainties have been reduced since the last review; it might be worth taking this one step further and including uncertainty quantification as a bullet in each of the subsequent science issues (pages 3-9 – 3-16).
- Should there be explicit consideration of the impacts of climate change on atmospheric transport and deposition processes, as well as welfare impacts?
- I would have found this chapter easier to read if the key policy-relevant questions were described prior to the process, i.e., put the current section 3.4 as section 3.2.

Charge Question #4- Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

Lead discussants are: *Drs. Elizabeth Boyer, Mark Fenn, Robert Goldstein, Daven Henze, Donna Kenski, and Stephen Schwartz.*

- The scope of the both the previous (p4-1, line 26) as well as the current (e.g., p4-8, line 30; p4-9, line 17;) REA plan spans from atmospheric concentrations or deposition to ecosystem services. I would think a more comprehensive and useful entry point of an integrated assessment would be emissions, rather than atmospheric concentrations or deposition. That does seem to be the point of entry in the modeling steps actually described (e.g., 4-7, line 18); summary text should be aligned accordingly.
- The ISA identified (p3-10, 3-11) questions related to the impacts of nitrogen on N2O emissions as well as the carbon cycle. However, none of the modeling tools discussed in the REA seem equipped to evaluate these processes, are at least they are not mentioned. I didn't see a separate terrestrial soil model described, and am not aware that the terrestrial soil component of CMAQ account for the response of N2O and CO2 emissions to nitrogen deposition. Does the scope of the modeling work for the REA need to be expanded to include these factors?
- Even more broadly, does the scope of the REA need to be expanded to consider the impacts of climate change?
- Table 4-1 lists as a key uncertainty in the previous REA the limited resolution of the modeled air quality data. It then seems reasonable to propose higher resolution nested modeling domains (e.g., 4x4 km^2) for the CMAQ model simulations over regions selected for case studies, rather than 12 x 12 km^2 for the entire domain.
- Section 4.3.1: Monitoring Networks. It seemed odd not to mention data from the IMPROVE network.

- p4-14, line 6: I understand the rational for starting with the NEI2011 inventory, but it should be recognized that recent air quality modeling studies indicate potentially significant large positive biases in the NOx emissions from this inventory when evaluated with air quality models and observations from the SEACRS and SOAS campaigns during the late summer of 2013.

- p4-14, line 12: I'm not sure what is meant here by "generally accounted for". Yes, these are often included in air quality modeling, but they still remain a source of uncertainty and should not be taken for granted.
- p4-15: inclusion of the bidirectional exchange of NH3 in version 5 of CMAQ is worth mentioning. It would also be recommended to include recent updates to the diurnal variability of NH3 emissions from livestock (Bash et al., in prep.).
- p4-14, line 13: Some organic nitrogen species, such as PAN or isoprene nitrates, are formed secondarily in the atmosphere. It is thus a bit strange to state that they aren't accounted for in emissions inventories.
- p4-16: The version of GEOS-Chem cited here is quite outdated (v8-03-2, compared to the most recent public release, v10-01) and would have several issues specifically of concern for this application, notably excessive concentrations of HNO3 and particulate nitrate, lack of diurnally variable NH3 emissions, lack of bidirectional exchange of NH3, and out-of-date treatment of isoprene nitrates, … I would thus recommend using a more recent version for generating boundary conditions.
- p4-15: I understand the historical motivation for using CMAQ as the air quality model, but when considering issues of uncertainty and variability as discussed in Section 4.4, a multi-model approach seems worth considering with tools such as WRF-Chem, CAMx, or even GEOS-Chem (which now runs at the ~25km scale).
- p4-25: It would be appreciated if additional details of this tiered approach to uncertainty could be provided.

Charge Question #5- Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

Lead discussants are: *Mr. Richard Poirot, Ms. Lauraine Chestnut, and Dr. Erik Nelson.*

- No comment.

Technical Corrections

Throughout: subscripts on SO2, NO2, SOx and NOx need checking.

p1-9, line 20: not defined → not be defined

p1-11, lines 11, 14, 15: EPA → the EPA

p2-6, line 13: “manmade” here but “man-made” on the previous page

p2-9, line 2: For the of the → For the

p3-6, line 7: (Nr)and → (Nr) and

p3-6, line 23: situations, and → situations and

p3-9, line 18: ; → ,

p3-10, line 23: gases and → gases, and

p4-6, line 31: im ore → in more

p4-7, line 8: tolls → tools

p4-16, lines 12, 13: CHEM → Chem

p4-18, line 23: SO42- → SO_4^{2-}

Fig 4-2: There several acronyms in this figure (NAICS, NAPCS, NESCS-D, NESCS-S) that are not defined in the text or glossary.

Dr. Donna Kenski

Charge Question #1- Overall organization and clarity: *To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?*

Given the breadth and depth of the task, this document was surprisingly succinct; perhaps almost too much so. The path forward was laid out clearly, at least as far as the review process is concerned. The authors could/should have expounded much more on the decisions made during the last review (Section 1.3.3), particularly since the proposed metric was ultimately judged too uncertain and abandoned. Some discussion about the difficulties EPA encountered in attempting to move away from an indicator that was not strictly a single concentration of SO2 or NOx would be appropriate here as useful historical context that sets the stage for the coming review discussions. The actual metric is never named, nor the concept of having a standard that would vary by ecologic region. Section 2.1.1 gives a tiny bit more detail, but still doesn't come close to describing what was proposed and ultimately found wanting. Another important issue that arose in the last review was whether EPA had the legal authority to set a standard that was not an ambient concentration, so a review of the legal issues on this topic would be helpful.

Charge Question #2- Key Policy Relevant Issues (Chapter 2): *Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?*

The questions developed are excellent, but total reactive nitrogen is only mentioned once. It is not clear how this review will consider the very significant presence of ammonia in large swaths of the country and its role in acidification. This was a huge issue of discussion/contention in the last review so to see it get so little attention in this planning document at the start of this review is distressing. Even though the standard is for SOx/NOx, the impacts of these 2 species can't be assessed without considering the presence of reduced nitrogen. As SOx and NOx emissions have declined, the role of NHx on chemical processes in the atmosphere becomes more influential. In addition, NHx deposition has grown dramatically in much of the country and is not expected to decrease anytime soon. Please address this more directly in the next draft of the IRP.

Charge Question #3- Science Assessment (Chapter 3): *Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.*

As noted above for Charge Questions 1 & 2, the plan devotes most of its attention to summarizing the previous documents. It would be helpful if it was more explicit about the shortcomings of the last review cycle and the needs identified in that process; again, particularly with respect to the need for including reduced nitrogen and differentiating among the relative impacts of oxidized and reduced nitrogen. The questions at the ends of the Terrestrial, Aquatic, and Wetland Nitrogen Enrichment sections are a good start.

Charge Question #4- Quantitative Risk and Exposure Assessment (Chapter 4): *Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?*

The many models that are being evaluated were summarized very briefly. The IRP needs more information on the outputs of these models and how they might lead to choices for a standard; i.e., how would they be used to develop a new indicator, level, etc. Some kind of wrap up would be helpful, especially if it were to include, for example, a discussion of the previous review's attempt to use AAI as the basis for the standard.

Section 4.3.1 on Air Quality states EPA's intent to use the 2011 NEI emissions for Risk and Exposure Assessment. That may be the only practical choice at the moment, but EPA should consider adjusting that inventory with more current estimates, especially in light of recent evidence of significant differences when NEI NOx is compared with NOx from satellite data. Some states and RPOs have updated or more specific data that would be preferable, especially if future years are forecast.

I agree with Rich Poirot's suggestion that this is an opportunity to look at future scenarios of changes in NHx as well as SOx and NOx, since these species and their effects are so inextricably linked. It would be shortsighted to only examine scenarios that hold NHx constant. An examination of ecosystem impacts should include their sensitivity to NHx.

Section 4.4 on uncertainty and variability was exceedingly brief. Given the protracted discussions on this topic during the last review and the fact that ultimately it was uncertainty that torpedoed the proposed secondary standard, the Planning Document needs to cover this topic in additional detail.

Charge Question #5- Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

This section seems fine, but as noted in the committee discussions, this is the point in the process at which a lot of new information gets presented, typically without a lot of time for discussion, review, or additional drafts. Because this review process is likely to lead to a new indicator and form of the standard, it would be prudent to build in enough time for adequate review and a second draft before finalizing the PA document.

Dr. William McDowell

Response to Charge Question 1: Overall organization and clarity:

Overall, the organizational structure and the approach that have been outlined are clear and appropriate. The draft IRP clearly communicates the plan for the current review of the secondary NOx and SOx NAAQS as well as the key scientific and policy issues that will guide the review. The process by which scientific data will be incorporated into formulation of policy options is clearly articulated. The schedule for completion of the assessment is clear and feasible. The draft IRP clearly articulates the recommendations made in the last review, and the rationales for those recommendations. It could do a better job explaining which were accepted by the Administrator, and which were rejected.

Response to Charge Question #3- Science Assessment:

Despite the overall clarity of approach as described, some streamlining and unification would facilitate the assessment and make it more responsive to the current state of scientific knowledge regarding ecosystem function.

Page 2-3 line 20 clearly summarizes the five main effects categories considered: *Additional areas of uncertainty were also identified as they related to the five main effects categories: (1) aquatic acidification; (2) terrestrial acidification; (3) aquatic eutrophication; (4) terrestrial eutrophication; and (5) mercury methylation.*

In the ISA, a somewhat different organization and nomenclature is used, specifically by changing from "Eutrophication" to "Nitrogen Enrichment" for both aquatic and terrestrial systems, and addition of a new category "Wetland Nitrogen Enrichment." This broadening of inquiry beyond "eutrophication" is an excellent idea, as is the inclusion of wetlands, a major physical feature in the landscape. But the changes in nomenclature and approach should be consistent throughout the Assessment.

The organization and scientific basis of the ISA would be improved by taking a more holistic approach to assessing impacts in terrestrial and aquatic systems, with an effort made to assess a given impact across terrestrial, wetland, and aquatic systems within the context of the entire landscape. For example, the assessment of wetlands includes a useful focus on drivers of N2O and CH4 production and their response to nitrogen enrichment. It broadens the focus beyond eutrophication, expanding to include heterotrophic processes driven by the availability of dissolved organic carbon (DOC) as well as autotrophic processes such as algal net primary production. The questions posed in the wetlands section about drivers of N2O and CH4 are also briefly addressed in the terrestrial section, but they are completely absent from the aquatic assessment. This imbalance – consideration of a fundamental response variable in only a few of the elements of a landscape - is an oversight that should be addressed.

Since publication of the 2008 assessment, a number of papers have addressed the role of aquatic systems in landscape-scale carbon and nitrogen dynamics (Cole et al. 2007; Peter et al. 2014) and emissions of N2O (e.g. Beaulieu 2011). These studies show that the role of aquatic systems can be significant in overall landscape fluxes, and that the molar production of N2O vs N2 by denitrification, for example, varies as a function of where denitrification occurs in the hydrologic flow path (soils, wetlands, in-

stream), the extent to which dissolved organic carbon (DOC) regulates denitrification (e.g. Flint and McDowell 2015) and by extension, how much nitrate is delivered along the flow path from initial atmospheric deposition to coastal ecosystems that are nitrogen-sensitive.

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Dr. Erik Nelson

Charge question 1:

- A table that summarized current primary and secondary standards for SO_2, NO_2, SO_x, and NO_X would be very helpful.
- In the introduction the meaning of the secondary standards for SO_2 and NO_2 is at first just given by a parenthetical – "(welfare-based)". On page 1-3, footnote 8 gives some context to term welfare-based. I think a more thorough definition of what a welfare-based standard is needed in the text at the beginning. Its explanation should not be relegated to a footnote.
- The regulatory history of the secondary NAAQS for SO_2 and NO_2 described on pages 1-7 through 1-11 is a chore to plow through. I understand that a concise narrative of the regulatory history is necessary and should be included in the document. However, a timeline figure that summarized the history would be helpful.
- It would be helpful to have a bit more information on why the Administrator felt that data limitations and scientific uncertainty regarding SO_x and NO_x's effect on the environment was too great to set new secondary standards in 2012. What data or resolved uncertainty would have led to tighter standards?
- The jumping back and forth from SO_x to SO_2 and NO_x to NO_2 is confusing. For example, the title of section 1.3.3 refers to a NO_X and SO_X NAAQS review. Yet most of the section is devoted to a discussion of the SO_2 and NO_2 secondary standard. As the document says earlier SO_2 and SO_X and NO_2 and NO_X are not interchangeable. I am not sure how to reduce SO_x / SO_2 and NO_x / NO_2 confusion but being a bit more clear on which pollutants are relevant in each section would be helpful. Further, do SO_x and NO_X regulations have any impact on SO_2 and NO_2 and vice-versa? Are the SO_2 and NO_2 regulations nested within SO_x and NO_X regulations? More background information on this would be helpful.

Charge question 2:

- Line 23 on page 2-2: Has the acronym AAI been defined?
- Line 16 on page 2-4: The reader would benefit from a re-statement on what each acronym means.
- Lines 30-31 of page 2-4 and lines 1 -4 of page 2-5: I understand that cost cannot be a factor in the Administrator's judgment. However, is the EPA still required to estimate the benefit and costs of any new welfare standard? If not, I am sure academics will try, before and after implementation of any new standard. Given independent cost estimates will be generated, how can the EPA assist these efforts so that they are accurate as possible? I have been involved in several retrospective benefit-cost analyses of federal rules and standards and the quality of these efforts can be greatly affected by data made available by the regulating agencies. As we move forward with this assessment we should structure it such that data needs for future analyses of this rule-making can be easily fufilled.
- Line 4, page 2-6: Shouldn't the review only include impacted ecosystems? Or all places in the nation impacted by NO_X and SO_X deposition?
- Policy relevant questions:
  - Question I is badly written and vague. Could we use: "To what extent has new research and data changed the science on the impact of oxides of nitrogen and oxides of sulfur exposure on human well-being and ecosystem function?"
  - Slight change in wording of question IIb: "What metrics (e.g. measures of particular ecosystems services) are available that can describe incremental changes in ecological function and in the public

welfare derived from these functions due to changes in NO_x and SO_x in the atmosphere and associated deposition?"

- At this point there should be a question related to the uncertainty of any estimates of the ecological and human well-being impacts from NO_x and SO_x in the atmosphere and associated deposition. Something to the effect of "What is the uncertainty in the estimates of impacts?" Ecosystem service valuation and analysis is riddled with uncertainty, incomplete information, and qualifications. Further, how will EPA quantify uncertainty in the scientific literature? How will EPA make a decision on the standards when there will be some uncertainty as to whether the decision is the "best" one?

I see that there is an uncertainty question in the next set of questions. But those are questions to be considered after it has been decided that enough evidence exists to go forward with a serious consideration of new standards. I think there needs to be an uncertainty question in the first set of questions as well. How certain are we that a serious consideration of new standards is needed? What weight of evidence do we need?

Charge question 3:

- Pages 3-4 and 3-5, lines 30 and 1-2: "Studies and reports that have undergone scientific peer review and have been published or accepted for publication are considered for inclusion in the ISA." Given some of the recent peer-review publication scandals should only papers from a journal with a certain impact factor or higher be considered for inclusion?
- Page 3-7, Lines 25-28: Isn't experimental or quasi-experimental design a key consideration in drawing conclusions about causality as well?
- Page 3-11, lines 17-18: What ecosystem services in particular are going to be affected by N enrichment other than carbon cycling? I can think of a few: the quality of fresh water, crop growth, soil fertility, the health of forests and the value of recreation and timber we derive from these forests.
- Overall I am worried about our ability to translate biochemical changes in ecosystems due to NO_x and SO_x deposition into changes in ecosystem services and the value of this change. An ecosystem function is a service if the function provides value to people (theoretically they would be willing to pay something for the service the ecosystem is providing). What is the value of slightly less N in a lake? Theoretically we know how to calculate that, practically it is tough to do. We need to continually remind ourselves that placing some sort of value (monetary or not) on changes in chemical balances in an ecosystem may not be possible given data and scientific limitations and uncertainties.

Charge question 4:

- Page 4-7, lines 27-28: "In the final steps, these end products are linked to changes in direct uses (e.g., recreation) and direct users (households), which affect public welfare." How do we plan to do this? Take recreation for example. First, we need to show that aquatic acidification has made the environment worse off in such a way that recreationalists notice the change. Second, we have to be able to observe a contemporaneous change in recreational behavior. Finally we have to use statistical methods to show that it is likely that changes in recreational behavior was due to aquatic acidification. This analysis will require rich datasets.
- "Although a wealth of economic data and research are available to quantify the total value of many ecosystem services, less information is available for incremental analysis." I do not agree with this statement. It is easier to conduct incremental analysis because you can plausibly say that "all else remains equal." For example, what is the impact of reducing N deposition in a particular watershed? If we assume that nothing else changes outside of this particular watershed we can use current market prices in an economic analysis and treat most other relevant variables as exogenous to our problem.

- I agree whole-heartedly with the point of view expressed in lines 15-21 of page 4-8. There is no need to always reduce changes in ecosystems to dollar values. In many cases presenting the public easily understandable information (e.g., charts, representative images, etc.) on the impacts of a pollutant on the environment, as expressed in relevant biophysical terms, is better at expressing the relevant tradeoffs (our well-being with and without a regulation) then a table of dollar values.

Charge question 5:

- Does the Administrator make his/her decision based on the recommendations made in the PA? Or is the Administrator's decision on the standards know before the PA is written, making the PA a document that justifies the Administrator's decision?

Summary:

- To link changes in ecosystem acidification to changes in human welfare we need to either 1) show that the creatures and natural features we care about are damaged somehow by acidification or 2) that we change our behavior in response to greater acidification and this change makes us worse off all else equal.
- While it would be ideal to translate these damages into dollars it is not necessary to accurately convey the choices we face as a society. In the end our task is to present the public with a set of expected tradeoffs: what do we expect our environment and economy to look like and how do we expect it to function with a standard versus a future without one. These expected tradeoffs can be expressed with pictures, graphs and charts in biophysical units, narratives, and traditional benefit-cost analysis. We should use a "dashboard" of indicators to summarize the tradeoffs.
- EPA should use a suite of ecosystem service tools in the analysis. Relying on just one or two tools to make a judgment on the standard risks making the decision a function of the biases in the selected tools. Using 5 or 6 tools will generate a more robust result.

Dr. Hans Paerl

My comments specifically address Section 3:

Since the last review was completed there have been a substantial number of new studies and manuscripts published stressing the importance of considering all bioreactive forms of N with regard to ecological effects in aquatic ecosystems. While oxidized forms of inorganic N (NO_2/NO_2) have long been recognized as quantitatively significant sources of externally supplied N supporting "new" production, reduced forms, including NH_3/NH_4 as well as some organic N compounds, also significantly and in some cases, unique, impact the composition activities of algal and higher plant communities supporting food webs, biogeochemical cycling and overall ecosystem function in these systems. For example, NH_3/NH_4 inputs have been shown to selectively favor harmful algal bloom (HAB) species, including toxic cyanobacteria and dinoflagellates . We will supply references to support this in a more thorough review of the document, but it is important at this time to mention that there may be ecological and human health effects that are uniquely attributable to these N sources.

In this regard, I echo Edith Allen's comment, "The Plan includes several references to reduced N as a component of N deposition. Sec. 2. Question IIa. States: What components of total reactive nitrogen deposition need to be considered? This question provides a platform for a discussion on the importance of reduced N to public welfare, and to begin to consider ways that reduced N can also be regulated." I'm not sure if this is the appropriate venue to do so, but it should at least be mentioned in the document.

Secondly, it is important to stress in the document that "aquatic ecosystems" that are impacted by atmospheric N sources (both reduced and oxidized) include both freshwater and marine (including estuarine) ecosystems. We have long recognized that marine systems are particularly sensitive to external N inputs because they are by and large N-limited. However, there is increasing evidence that freshwater lakes, reservoirs and rives can also exhibit N limitation and N&P co-limitation (Sterner 2008; Elser et al. 2009; Conley et al., 2009; Lewis et al., 2011; Paerl et al., 2014a, b), and therefore must be considered "N-sensitive". In fact, N-limitation appears to be on the upswing in freshwater ecosystems, probably because their nutrient dynamics are being altered significantly by growing agricultural and urban P inputs (Finlay et al., 2013; Grantz et al., 2013; Paerl et al., 2014b). This topic warrants some discussion by the panel and inclusion in the document.

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Mr. Richard L. Poirot

Overall organization and clarity: **To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?**

The draft IRP clearly communicates the plan for the current NAAQS review and identifies a number of important scientific and policy issues that are likely to influence the course of the review. The general approach and decisions made in the previous NAAQS review, as well as the rationale for those decisions are also clearly articulated.

Key Policy Relevant Issues (Chapter 2): **Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?**

Chapter 2 indicates the intent to build upon the substantial accomplishments from the last review and presents a general approach for expanding on that previous work. It identifies an excellent series of policy-relevant questions that follow logically from that planned approach.

One important issue that could be raised here relates to the question of "How will welfare benefits of attaining alternative secondary SOx/NOx standards be evaluated?" In the last review cycle, the newness, complexity and time limits did not allow did not allow for a comprehensive risk and exposure assessment that went beyond identifying several case study areas where alternative ecological indicators would be exceeded (for example critical ANC limits of 0, 20, 50, 100 ueq/l) for aquatic acidification. Ideally, it would be instructive to take this kind of analysis a few more steps and address questions like:

1. What would the air quality indicator(s) need to be reduced to in locations where the eco-indicators are exceeded in order to attain the level(s) of the desired eco-indicator(s)?
2. What are the alternative pollutant-specific ways in which multi-pollutant air quality indicators might be brought into attainment (in different regions of the country)?

These kinds of questions seem especially important as different kinds of ecological (or other) welfare effects can occur with different mixes of SOx+NOx for different effects or in different regions and at relatively great and varying distances from different kinds of sources. It seems possible that the "integrated assessment approach" (section 4.2.1) planned for the REA may address these questions through a combination of focused case studies and regional or national scale emissions rollback scenarios.

Another general policy-relevant issue that might be highlighted up front relates to the expected ecological (or other welfare effects) responses and associated welfare benefits that might be expected from changes in SOx+NOx concentrations or deposition. Related questions include:

1. (How) have eco-indicators (or other welfare effects) responded to recent historical reductions in SOx+NOx concentrations or deposition?
2. How (and over what time frames) are eco-indicators (or other welfare effects) expected to respond to future reductions in SOx+NOx concentrations or deposition?

While I agree that the decision to focus entirely on the deposition-related ecological effects of SOx/NOx

was justified in the last review given the newness and complexity of the approach at that time, I don't agree that other SOx/NOx welfare effects such as impairment of visibility and damage to building materials and cultural works of art need to be completely neglected in the current review. The emphasis of this review could continue to be on ecological effects, which remain less clearly quantified and more poorly monetized or otherwise valued. But it would not require much work to include a brief SOx+NOx visibility section in the ISA. In the REA, if you conduct any modeling of changed S+N emissions, concentrations & deposition, the S+N visibility change is a readily accessible output from CMAQ. Whether visibility effects of S+N aerosols (and gaseous NO_2) are also considered in an upcoming PM NAAQS review is irrelevant. Past efforts to set a visibility-related secondary PM NAAQS have been unsuccessful (since 1971), and in the 1987 PM NAAQS review, a secondary PM NAAQS was considered but ultimately rejected because of the close association of visibility and acid deposition, and a stated preference for addressing both issues together, rather than separately. There's no reason visibility can't be considered separately under both SOx/NOx and PM reviews. Decide which approach works best, after carefully considering the merits of each approach, not before…

Science Assessment (Chapter 3): **Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.**

The intended scope, issues to be considered and planned organization of the ISA are clearly described. One of the policy-relevant questions in the atmospheric sciences section addresses new monitoring or modeling methods that may improve understanding and predictive capabilities. An important related question that could be addressed up front in the ISA (rather than at the end of the process in the PA) relates to the capability of existing measurement methods and networks – in combination with modeling tools – to adequately capture the spatial, temporal patterns and critical S&N species, not only to support our understanding of associated effects, but also in terms of their potential use to determine compliance with any potential new secondary NAAQS.

The relative absence of, or uncertainties in, an adequate network to measure SO_2, SO_4 and NOy (and NH_3), along with uncertainties in the CMAQ conversions of measured air concentrations to total deposition were cited as reasons for not going forward with a secondary NAAQS last time. Similarly, the absence of (unwillingness to fund) a measurement network to measure hourly PM light extinction was cited as a major obstacle for moving forward with a secondary PM NAAQS in the last review. In both cases, EPA staff and CASAC review panels recommended establishing small pilot networks (neither of which were adequately implemented). The ability to measure any new NAAQS indicator in a compliance determination mode is a key science & policy question that should be considered throughout the NAAQS review process (not just at the end). Conceivably, a combination of modeled and measured data – such as the NADP (Schwede & Lear, 2014) TDep maps might be used to determine compliance – and if so should be emphasized and evaluated as part of the ISA.

Several sections of the chapter emphasize identification of critical limits or loads, thresholds of toxicity and/or definitions of adversity. While all of the above "bright lines" are helpful and important to identify – to the extent feasible, I think it is also important to recognize that there are few absolute thresholds for ecological effects, and that it is equally import to understand and quantify the gradients of effects (shifts in distributions, etc.) that are likely to result from changes in S+N concentrations and deposition.

On page 3-13, the last bullet emphasizes the importance of understanding effects of oxidized N

deposition "(apart from NHx)". I would think we would want to know about effects "apart from and in combination with NHx". To the extent that there are differential effects of NOx and NHx, I would think these would be important to understand as well.

As indicated earlier, I really see no reason why secondary SOx+NOx effects on visibility should be intentionally excluded from this review. Such effects unquestionably occur, have very clearly defined CR functions, can be readily quantified with high temporal and spatial resolution with both measurement networks and models, and will exhibit an instant and accurately quantifiable response to change in S or N emissions. Visibility impairment is also an economically important welfare effect, with annual Clean Air Act benefits estimated at $67 billion in EPA's assessment of the Benefits of the Clean Air Act from 1990 to 2020. This is comparable to estimated benefits of $68 billion from avoided PM morbidity, is greater than the estimated $57 billion from avoided ozone mortality and morbidity combined, and is 6 times greater than the $11,118 benefits from all other welfare effects (monetized in that study) added together.

It would not require substantial staff resources to add a brief section in the ISA that describes the visibility effects of sulfate and nitrate aerosols, to show the relative importance of S+N to total visibility impairment in both urban and rural areas, and to show how well you can reproduce the spatial and temporal S+N visibility effects with CMAQ. Subsequently, it would be relatively easy to include CMAQ estimates of visibility changes in the REA for any modeled future change in S+N emissions or concentrations which are considered to protect against ecological effects. There will be always be readily quantifiable visibility effects as well.

Quantitative Risk and Exposure Assessment (Chapter 4): **Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?**

The intended scope, issues to be considered and planned organization of the ISA are clearly described – to a reasonable extent. Since the scope of the REA and the issues it addresses (and how it addresses them) are partly dependent on the final content of the ISA, and since it's not clear how much progress will be made in understanding and quantifying the ecological responses to changes in S+N exposures in all of the many effects areas identified in Chapter 3, the exact approaches that will be employed in the REA (or even whether an REA will be conducted) are not entirely knowable. I like the "integrated assessment approach" outlined in section 4.2.1, even if it lacks details. The proposed ecosystem services framework also sounds like an excellent approach. The combination of national and case study assessments seems very appropriate to the regional variability in S+N concentrations, deposition and inherent ecological sensitivities.

I assume the planned integrated approach may include exploration of multiple effects large-scale regional or national rollbacks of SOx and NOx emissions. If resources allow, it might be informative to

consider several different mixes of NOx vs. SOx reductions (50:50, 75:25, 25:75). An exploratory rollback of NHx emissions could also be informative (see below).

Possible additional questions that could be added to the list on page 4-1 might include:

1. Are there beneficial ecological or other welfare effects that would result from decreases in SOx+NOx for effects where pollutants are considered stressful but not "adverse"?
2. What are the expected ecological (or other welfare) responses to future changes in SOx+NOx concentrations and deposition?
3. How might future ecological (or other welfare) effects of SOx+NOx emissions change with increases or decreases in NHx emissions?

The Air Quality section of the REA should include a detailed discussion of any air quality indicators being considered in this review, along with a review of current or planned future measurement network(s), or combinations of measured and modeled data, and an evaluation of the adequacy of spatial, temporal and species coverage to determine NAAQS compliance.

As indicated previously, I think it is a relatively easy calculation to add a visibility change (benefit) to any CMAQ-modeled change in SOx+NOx emissions.

While the nitrogen focus of this NAAQS is limited to oxidized N, it might be informative to include some exploratory analyses related to changes in NHx emissions, concentrations & deposition. Future NHx may change, up or down, and that may alter responses to NOx or SOx. NHx is a key (often limiting) ingredient to NH_4NO_3 formation, and so is critical to understanding (and may be a good way of reducing visibility effects). Aerosol NH_4NO_3 also transports farther than gaseous NH_3 of HNO_3, so NHx-limited nitrate aerosol formation can enhance NOx transport distances. Also, if I recall correctly from the last review, the aquatic acidification index included NHx deposition as an inherent "given" characteristic of the eco-region, but would have allowed that NHx contribution to vary over time – based on measurements or models. So (as I interpret it), an area out of compliance might theoretically come into compliance if nothing changed except NHx. So while not required, NHx decreases might be part of an attainment strategy - and NHx increases could require additional NOX+SOx reductions. So exploring consequences of NHx emissions changes could be useful in the REA.

Policy Assessment and Rulemaking (Chapter 5): **Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?**

This very brief chapter clearly summarizes the intended general process for the Policy Assessment Document (PAD) and rulemaking. Since its details will be dependent on unknown results in the yet to be developed ISA and REA, this brief summary seems adequate.

Experience with several recent NAAQS reviews has shown that there is often a large amount of new, or newly synthesized or interpreted material presented in a PAD. It's usually the first time specific new indicators and combinations of indicator(s) levels and forms are presented. Providing adequate time for CASAC review and allowing for a second draft PAD if the CASAC Panel recommends it could be useful and appropriate.

In comments on previous sections of the IRP, I've suggested several issues or questions where additional emphasis or detail could be helpful, and might subsequently be addressed in the PAD:

- Visibility impairment is an important welfare effect of SOx+NOx and could be added to the ISA and REA with relatively little effort. It need not be the "NAAQS driver", but a "visibility co-benefit" can easily be calculated for any SOx+NOx (or NHx) emissions control measures taken to address any ecological effect being considered.
- The expected ecological (or other welfare effect) responses to changes (historical & future) in alternative proposed air quality indicators should be emphasized in ISA & REA
- The suitability of existing measurement networks, or combinations of measured and modeled data planned for use in NAAQS compliance determination should be carefully considered and evaluated, early in the review process (included in the ISA). While the absence of a comprehensive compliance network should not be provide justification for failure to set a NAAQS, the PAD should include specific recommendations for how existing networks will need to be enhanced to implement the NAAQS.
- In addition to inclusion of regionally focused case studies of specific ecological effects, the REA should also evaluate the effects of large-scale regional or national SOx and NOx emissions rollbacks, mixed in different proportions.
- If resources allow, evaluating different relative mixes of SOx and NOx reductions, and also exploring effects of regional NHx reductions could be informative.
- For any emissions changes, a gradient of varied ecological changes is expected. Its important to quantitatively characterize these gradient shifts, in addition to evaluating changes relative to critical loads and other "bright line" thresholds.

Dr. Armistead (Ted) Russell

In response to the Specific Charge Question Associated with Key Policy Relevant Issues:

Charge: Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

Response: Overall, this chapter effectively communicates the key issues and questions, to the limited degree that they are currently presented, i.e., there are more, rather significant, policy relevant issues not covered here, but are important given the outcome of the last review. At present, I think the chapter reads very similarly to what would be found for other, single pollutant, reviews, and does not go in to enough depth in terms of this being a multipollutant review and that there were additional policy relevant issues that arose in the last review that should be more fully communicated in this chapter. Thus, I think they should consider being more expansive, particularly given the outcome of the last review, the recommendations of CASAC, and the final rule and reasoning in response to the last review, including how the decision did/did not concur with CASAC's recommendation, and why, and how that raises specific policy relevant questions. In particular, it was decided that there were significant uncertainties, thus leading to the decision that "while the current secondary standards were inadequate to protect against adverse effects from deposition of NOx and SOx it was not appropriate under Section 109(b) to set any new secondary standards at this time due to the limitations in the available data and uncertainty as to the amount of protection the metric developed in the review would provide against acidification effects across the country" and "she concluded that the current secondary standards are neither appropriate nor adequate to protect from deposition-related effects such as those associated with acidification of aquatic and terrestrial ecosystems and nutrient enrichment of terrestrial and estuarine ecosystems." Further, this raises a specific issue as to whether any new information has significantly reduced the uncertainties. In particular, did the planned studies proposed to address those studies succeed? If not, what type of scientific studies are required to adequately inform future decision making? Is it reasonable to expect such studies to occur in the near future? CASAC is tasked with providing guidance of issues dealing with the needed research.
It would also be good to define the AAI approach in Chapter 2 (or to describe it in more detail), and how it relates to "indicator(s)". Discuss how (and why) the AAI (an index) differs from an indicator. To better understand the policy relevant issues, particularly in context of the last review, a better understanding of the AAI is needed. What are the legal and policy relevant issues associated with using a combined index? A more comprehensive description of the AAI can add clarity to the potential policy relevant issues involved in developing a multipollutant standard where part of the potential effect is potentially due to another compound that is not included in the index.

There should be more of a discussion of reduced nitrogen and the policy relevant issues that arise due to reduced nitrogen deposition.

This section should be more explicit as to what issues were brought up in the last review that led to the choice of secondary standards that were judged, by EPA and others, to be inadequate. A key policy question that should also be included, given the results of the last review, is what further studies will be required to address the uncertainties identified.

Additional Thoughts-

Chapter 1. Be explicit as to what NOx and SOx include.
2-2-23: Define AAI
2-5-16. Explain why you are not including deposition on man-made materials and structures, including historic monuments.
2-5-26/28. Just Eutrophication in aquatic systems… not diversity issues? This list is not as extensive as covered on 3-10 through 3-16.
Policy relevant questions.
What specific information is needed to address the uncertainties identified in the last review, and what sort of studies have been conducted and/or are needed to reduce those uncertainties?
It would be good to provide the working definition of exposure as applied to this rather more complex set of processes, and how it relates to the various effects of the presence of NOx and SOx in the atmosphere. In this case, the exposure of most direct interest may not be to atmospheric NOx and SOx but products of chemical reactions.
Need to more precisely define "indictor(s)" as used here and be consistent and precise. Discuss the complexity when applied to a joint standard.
Page 2-9 (Policy relevant questions)
Question I.
I, What is meant by "new"? Put in context of prior review. The last review was treading new territory, so it might be that not all the information that was available was fully utilized. Might also add something along the lines of information not fully considered in past reviews, or that could be reassessed.
I. What is meant by "exposure to … in the ambient air? Does the exposure of the specific endpoint of interest (e.g., increased acidification) fall under exposure in ambient air.
Question II.
2-9-11: What about fertilization?
2-9-7: " Improve" since the last review?
2-9-23: Do you mean "atmospheric NOx and SOx, or in any media?
2-9-23: The exposure of concern may not be to NOx and/or SOx directly, but to a species that is the results of NOx or SOx in the ambient air. How is this treated here?
2-9-18: How about what are the characteristics of metrics for exposure and deposition and the resulting effects that make them useful? What are the necessary characteristics?
Page 2-10….
2-10-10: Again, what is "new".
2-10-11: What is meant by different? Different than the AAI? Different than the indicator**s** currently chosen?
2-10-21: Somewhere in this list, an important policy consideration are the legal constraints on a joint standard where the potential ecosystem impacts are most closely related to outcomes due to exposures not occurring in the ambient air in that the scientific advice to the administrator has to be guided by what is allowed within the CAA.
2-10-11: Indicator or indictors?
If it is determined that the standards should be revised, a policy relevant question that should be included is: what are the legal constraints on the form of a revised standard?
Given the potential uncertainties and complexities, are there alternative forms and averaging times of a revised standard that would provide the requisite protection to the environment? What are their benefits and limitations?

2-3-24 The phrase “long-term exposure of elevated deposition levels;” Change “of” to “to”? Still not sure this is the correct use of “exposure.” Probably leave exposure out.
2-9-23 Why just exposure metrics? Is the AAI an exposure metric? (Might be good to define exposure as used here, e.g., in the list of definitions).
Other:
In your definitions, why does an “Ecologically Relevant Indicator” need to be easily measured? What is “easily”?

Dr. Stephen E. Schwartz

Introduction to these comments

The document under examination is a draft of a plan for an integrated review of the criteria and secondary National Ambient Air Quality Standards for nitrogen and sulfur oxides.
The comments presented here are prepared in my role as a member of the CASAC panel charged with examining the extent to which the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review?

The panel is charged also with ascertaining the extent to which the decisions made in the last review, including the rationales for those decisions, have been clearly articulated? Evidently the "last review" referred to here is the 2008 Integrated Science Assessment (ISA) referred to on page 1-11. That charge would thus seem to require examination of the 2008 ISA, specifically the decisions made in that review and the rationales therefor. I have not undertaken such an examination. However in the document under review there is little if any presentation of the decisions made in the last review or of the rationales therefor.

Presented here are my comments on the draft plan that was provided to the Panel. I present issues and concerns, grouped into several categories. It may be that some of the concerns that I note are dealt with elsewhere in the document and I missed them, or that they result from mis-reading or misunderstanding on my part. In any event I would hope that the issues and concerns that I present here will be responded to more or less as a punch list, either by modification of the document where it is considered appropriate, or by response, such as "This is dealt with at such and such page and line" or the like.

These comments cover the entire document, but with emphasis on Section 4, which the author is specifically charged to review as part of the CASAC review.

Title of the Document

I find that the title of the document requires careful parsing.

Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur

It is a draft of a plan to conduct an integrated review of the air quality criteria for nitrogen and sulfur oxides and of the secondary (welfare-based) national ambient air quality standards these substances.

The purpose of this Integrated Review Plan (IRP) document is to communicate the plan for the joint review of the criteria and secondary NAAQS for these pollutants.

Organization of the Report

I suggest a brief overview of the document near the beginning. The brief chapter descriptions presented in the charge to the present CASAC Panel would seem like a good place to start:

Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review.
Science Assessment (Chapter 3): Chapter 3 describes the plan for the Integrated Science Assessment.
Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review.
Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process.

Such a brief description of the chapters that follow would seem essential to guide the reader, especially as there are elements of the Plan that are tough to distinguish: Science assessment, Quantitative Risk and exposure assessment; Policy assessment. I am not sure that the above sentences do the best possible job of distinguishing these elements.

Fundamental issues and concerns

1. The operative language of the current standards is as follows [p. 1-1, lines 9-14]

[T]he basic elements of the secondary NAAQS [are] the indicator, averaging time, form, and level. These elements, which serve to define each ambient air quality standard, must be considered collectively in evaluating the welfare protection afforded by the standards. The current secondary standards are a NO2 standard set at a level of 0.053 ppm, annual arithmetic average, and a SO2 standard set at a level of 0.5 ppm, 3-hour average, not to be exceeded more than once per year.

I first question whether the form of the standard, as stated, is appropriate. Essentially it is standard that is based on a maximum local abundance, a mixing ratio not to be exceeded in annual average or in 3-hour average, for NO_2 and SO_2, respectively. But the fundamental question to my thinking, before addressing issues such as magnitude of standard, averaging time, and the like is whether a standard based on local abundance is appropriate to protect public welfare.
For example, consider the issue of acid deposition. The Clean Air Act Amendments for control of acid deposition were formulated to protect sensitive ecosystems from damaging amounts of deposition, reckoned as amount per area per time, or flux density. So the question is whether a local abundance standard is the appropriate means to meet that objective.

Consider a situation in which a facility that leads to a violation of the abundance standard is replaced by a distributed set of facilities having a greater aggregate emissions, but such that none individually leads to a violation of the abundance standard, and further that nowhere does the local abundance resulting from the several facilities exceed the standard. In principle this could lead to much greater emissions than in the original situation of a single facility, without, it seems to me, violating the abundance-based standard. Yet the deposition from the set of sources would be increased in the aggregate, because, over widespread areas of influence, deposition equals emissions (Schwartz, 1989). So on face it would seem that an abundance standard cannot in itself meet the requirement of protecting public welfare.

This issue is synopsized on page 1-10, which essentially states that EPA took it on faith that the "the significant reductions in SO2 emissions, ambient SO2 concentrations and ultimately deposition expected to result from implementation of the title IV program" would suffice to achieve the reduction in acid

deposition necessary to protect public welfare. To my thinking that assumption needs to be revisited.

2. A related issue in an abundance standard is specification of the set of locations at which the standard is to apply. Would it apply at the mouth of a stack or only at the surface; just outside a tailpipe or only at curbside? So it must be clearly specified where such a standard is meant to apply. Page 2-2 line 16 refers to phytotoxic effects "in ambient air." This is some sort of qualification of where the standards are meant to apply. But despite the entire document dealing with ambient air quality standards, I do not see the phrase "ambient air" defined. Note 5 on page 1-1 reads "The “level” defines the allowable concentration of the criteria pollutant in the ambient air," but does not define ambient air. It would seem that such a definition is essential.

3. There seems to be inconsistency in language on page 1-12. Line 23 *ff* states that "the Administrator decided to retain and not revise the current NO2 and SO2 secondary standards", implying existence of then current standards; whereas, line 27 *ff* refers to "The EPA’s decision to not set a secondary NAAQS for NOx and SOx" which implies no such standard. Perhaps the latter meant to state "decision not to revise"? Or perhaps the distinction is between the subscript 2 and the subscript *x*. However line 4 next page refers to court decision re "not setting a secondary standard", so all this needs to be clarified.

4. I question the phrasing of the first overarching question, page 2-1, lines 3-5:

Does the currently available scientific evidence and exposure/risk-based information support or call into question the adequacy of the protection afforded by the current standard(s)?

Setting aside the grammar (plural compound subject requires plural verb), I note that the question as phrased is one-sided, speaking only to the adequacy of the protection and not allowing for the possibility that the current standard(s) are more restrictive than necessary to provide the required protection. Should be neutral. Something like:

Are the current standards either insufficiently tight to protect etc., or alternatively, are they more stringent than required to protect etc.

Commendable example of neutral language: Page 2-4, line 25: establish standards that are neither more nor less stringent than necessary for this purpose.

5. The policy relevant questions on page 2-19 and 2-10 are very important and to great extent set the agenda for the document and for subsequent work.

The first question seems just right:

To what extent has the new information altered the scientific support for the occurrence of effects related to exposure to oxides of nitrogen and oxides of sulfur in the ambient air?

It would seem, however, that it should be qualified to restrict its application to effects other than effects on human health, which are covered under the primary air quality standards.

The second set of questions deals with identified welfare effects: eutrophication, acidification, mercury methylation, and direct vegetative exposures. and with identification of newly available information pertinent to these effects. Better however that the list be exhaustive rather than using the language "including" that suggests that the authors couldn't pin down the full list of identified effects. The questions themselves (a -d) seem on target. Question d seems particularly well stated.

The third set of questions, page 2-10, dealing with potential alternative standards is perhaps even more

important. The questions are introduced with the sentence: "With regard to consideration of potential alternative standards, specific policy-relevant questions include the following:" Here, perhaps, use of the word "including" is appropriate: The list of potential alternative types of standards cannot be exhaustive, so the questions must be exemplary. Thinking of environmental issues beyond those already identified is essential to gain a holistic picture of the environmental consequences of emissions, that must, ultimately, be weighed against costs of emission controls. I also commend the language of the final sentence of the discussion, namely that these questions will frame the assessment of the evidence, development of quantitative analyses, and evaluation of policy options. This sentence seems right on target as the set of objectives of the activity. In contrast I take exception to the sentence in the first paragraph on the page:

[W]e will evaluate how the scientific information and assessments inform decisions regarding the basic elements of the secondary NO2 and SO2 NAAQS....

At issue here is not who is doing the evaluation, but rather that such an evaluation is an essential component of the activity. Nonetheless, an essential part of a plan is in fact who will be doing the activity, so a brief subsection that outlines how the plan will be carried out and who has responsibility for the several components of the activities specified in the plan would seem pertinent and essential.

6. With respect to ***alternative types of secondary standards***, I would recommend that among the options to be considered in the standard setting activity there be consideration of a standard that is based on the concept of critical deposition load, the maximum flux density of deposition (of acids, of active nitrogen) to a sensitive ecosystem without inducing harmful effects to that ecosystem. Such a standard would be a major departure from abundance-based standards (mixing ratio not to exceed ...). It would be holistic taking into account the totality of emissions within an area of influence (say the 1/*e* distance for persistence of material in the atmosphere as governed by transport and deposition). It would determine the maximum emissions within that area of influence, but allow substitution of one source for another as governed by, for example, cost or market forces. It is my view that such an emission-based standard might be an efficient means of protecting sensitive ecosystems and deserves serious consideration and evaluation.

7. As stated on page 3-1, Chapter 3 presents the objective and approach of what is denoted the integrated science assessment, a critical evaluation and integration of the scientific information on the ecological effects associated with ambient air NOx and SOx and their deposition and other their products from the air. This assessment is to be based on review of published literature. I find the chapter to be appropriately focused on that objective. The questions presented in §3.4 seem to be focused and on target. To be sure they focus on new information that is developed since the previous Assessment, but I have confidence that the intent of the activity is that the new information that is developed will be merged with prior understanding to present a picture of total understanding.

8. Chapter 4 seems to be the heart of the document, a presentation of the plan to conduct a Risk and Exposure Assessment in support of setting new secondary air quality studies. The chapter is intended to present the path forward, from the present plan for an integrated review to defining the Assessment on which any revision of the NAAQS would rest. An essential step of the process is development of a Planning Document. Yet the first sentence of that section makes that sound almost like an afterthought:

In addition to this integrated review plan, we will develop a Planning Document that will more specifically outline the scope, methods, and tools that will be used in the Risk and Exposure Assessment.

It seems to me that this section needs to start out with an explicit statement of the path forward.

Something like:

The required examination of the need to revise the NAAQS, and the nature of any such prospective revisions, rest on an Assessment of the state of understanding of cause and effect between sulfur and nitrogen oxides and ecological effects. Preparing the Assessment document thus requires a Plan that details what is required in that document and how those requirements will be met. This section presents....

I stop there because it is not at all clear to me from the material on the top half of page 4-1 what this section is intended to present. "We will develop a Planning Document." Is that the next step after acceptance of the present Integrated Review Plan, as a neutral read of that sentence would suggest? I thought the present document was supposed to *be* that plan. So why the future tense "we will develop a planning document"? Shouldn't it be something like "This section presents the requirements of the Risk and Exposure Assessment and the plan for how to meet those requirements."? Otherwise isn't it just a bunch of Russian dolls nested within each other? A plan to develop a plan....

Finally, the paragraph leads with "we will develop"; it is probably appropriate for a plan to say who it is who will be charged with carrying out a certain activity, but perhaps better to specify the office that will be charged with carrying out this task, instead of the inevitably vague "we".

9. Are the three bullets in the middle of page 4-1 in fact meant to be the requirements of the Assessment? The lead sentence is extraordinarily weak:

In general, the Risk and Exposure Assessment is intended to address several questions described in Chapter 3, including the following:
Why "In general"? Why "is intended"? Why "address"? Why "including"? Better something like:

The Risk and Exposure Assessment must provide answers, at the state of present understanding and with associated uncertainties, to the following questions:

Then it becomes a requirement. Something that the people charged with carrying out the Assessment can be held accountable for. Moreover the list must be exhaustive, these are the questions that must be answered; rather these are the kinds of questions that must be answered, as implied by use of the word "including."

Only after the requirements of the Assessment are presented does it become possible to examine whether the path forward will achieve those requirements.

10. As just stated, the three questions in the middle of page 4-1 as the document is now written would seem to have been meant to be examples of the questions that must be answered by the Assessment process, rather than an exhaustive list. That said I find the several questions poorly constructed;

- What is the nature and magnitude of negative ecosystem responses to NOX and SOX (including atmospheric concentrations and deposition)?
- What is the variability associated with those responses, including across ecosystem types, climatic conditions, environmental effects and interactions with other environmental factors and pollutants?
- Are there specific levels of atmospheric concentrations and deposition associated with adverse effects of concern?

Questions 1 and 3 seem to ignore the possibility of positive responses; perhaps any response, being a departure from the unperturbed state, is considered negative. It is implied that the questions derive from Chapter 3; I did a search on the word "negative" and the present instance seems to be the only occurrence of the word in the entire document. In any event it would seem much more neutral to define a task for the Assessment as
Determine ecosystem responses to NOx and SOx as a function of their atmospheric concentrations and deposition, including variability across ecosystem types, climatic conditions, environmental effects and interactions with other environmental factors and pollutants.

That would seem to condense the three questions into a single task. Finally question 3, as given in the draft document, is a simple yes/no question, whereas the situation would certainly seem to be much more differentiated than can be answered as a yes or no.

That said, I must ask whether the above restatement is the sole task of the Risk and Exposure Assessment. The answer might well be yes; certainly it is a very differentiated task given the many ecosystem types, climatic conditions, environmental effects and interactions with other environmental factors and pollutants that would have to be considered. However the three questions were preceded by "including," implying that the authors had other tasks in mind. If they do have other tasks in mind they should certainly specify them.

11. Page 4-4, line 11 *ff* and table 4-1, Key Uncertainties. It would seem essential to provide quantitative estimates of the magnitudes of uncertainty. Perhaps some sort of triage: 10%, factor of 2, order of magnitude; and to provide justification for such estimates. Without quantitative assessment of magnitudes of uncertainties the table (and indeed the exercise) is fruitless. The exercise must further deal with the path forward in reducing uncertainties. For example is the uncertainty in the critical load flux density, or in the deposition flux density that would result from a given set of emissions (or ambient mixing ratios). Or both. Once these uncertainties are quantified, it would seem essential to provide an assessment of the magnitude of uncertainty that is required to justify any refinement of the AQ standards, and thus of the required reduction in uncertainty. Then a realistic assessment of when such a reduction in uncertainty might be expected, given the expected rate of progress in research that is in turn tied to anticipated staffing and funding. In brief, is it realistic that in the foreseeable future the situation will show an improvement in the capability to refine AQ standards?

12. Table 4.1 lists what are designated as "Key Uncertainties" associated with the five ecosystem effect categories that have been attributed in prior assessments to deposition of nitrogen and sulfur oxides. However these are not uncertainties in the customary scientific usage, namely, quantifiable ranges of quantifiable effects, but rather are listings, for each of the ecosystem effect categories, of broad categories of what might be categorized as known unknowns. Such a listing of known unknowns raises the question of how uncertainty in effects will be quantified in the next Assessment in support of setting secondary air quality standards. What seems to be required would be a statement of how accurately particular cause and effect relations need to be known in order to formulate air quality standards, how accurately these relations are known now, based on prior assessments, and what improvement might be expected from the future assessment, the plan for which is being presented here. None of this seems to be given here.

13. The lead para in §4.2, Approach for the current risk and exposure assessment, Page 4-6, is poorly written and would seem to require justification. The paragraph starts out by stating that "we"

(presumably the authors of the present document) "provide some preliminary ideas regarding the scope of the current Risk and Exposure Assessment." Providing some "preliminary ideas" hardly seems like a plan that could, if approved, be put into action. The several sentences dealing with the anticipated scope of the Assessment lead with what the Assessment will *not* cover. Much better to start with what the Assessment *will* cover; then wrap it up with what will not be covered. If the analyses will focus on ecological effects, lead with that. What the Assessment will focus on is very important. And to my thinking focusing on ecological analyses reflects a decision that ecological cause and effect relationships are in some sense a limiting uncertainty, as distinguished from, say, uncertainty in the local abundance or deposition flux density of pertinent substances that give rise to these ecological effects. But all this needs to be explicitly stated and justified. The two paragraphs immediately under the section head 4.2

use the verb "anticipate" four times. Such vague language hardly lends confidence in the document as a *plan*.

14. The approach that would be employed in the proposed integrated assessment is presented in §4.2.1 and in more detail in §4.3. An example is offered (page 4-7) of how alternative NOx and SOx standards would be assessed. It is stated that changes in emissions associated with varying policy scenarios would be determined by use of emissions inventories (e.g., NEI) that serve as input to air quality models (e.g., CMAQ). Although both tools are given as exemplary ("e.g.") it seems likely that these are the tools that are actually intended to be employed, and perhaps the only tools that will be employed, for these two elements of the assessment. That might perhaps be appropriate, but better an explicit statement; such an explicit statement appears in section 4.3.1: "We intend to use emissions information from the 2011 National Emission Inventory in the Risk and Exposure Assessment." Likewise, "We intend to use the CMAQ modeling platform as a tool for estimating deposition and supporting the development of transference ratios that convert ambient concentrations of NOY and SOx to deposition of nitrogen and sulfur." Even better would be a plan in which multiple inventories and chemical transport models would be employed as a means of assessing uncertainties. The top of Section 4.3 explicitly solicits comments on additional tools that might be appropriate for the analysis (Page 4-11); in this respect the authors might consider running the model WRF-Chem in parallel with CMAQ.

15. The Approach identifies an "Ecosystems Services Framework" (§4.2.2) that in principle would quantify ecosystem services, and the diminution thereof by various incremental levels of emissions of sulfur and nitrogen oxides, presumably to quantify the benefits that would attach to a given reduction in emissions, perhaps as well to support some sort of cost-benefit analysis. The section concludes with a statement that "it may not be possible to fully quantify each of these steps due to data gaps, thus some portions may be qualitative." I think that that statement vastly understates the present inability to quantify ecosystem goods and services and raise the concern that a partial estimate of loss of goods and services provided by natural ecosystems might be taken as a full estimate and thus weighed in the balance with costs of emissions controls, thus tilting the balance in favor of increased emissions.

16. Section 4.3.1, Air Quality, consists of a description of air quality and deposition measurement networks and of the data that are available from these networks, and of a description of chemical transport modeling approaches that would be employed in the Assessment. However how the observations and models would be used in the Assessment does not seem to be explicitly enunciated. In principle one might evaluate model calculations from observations. Likewise one might use observed concentrations to calculate deposition flux densities. But not clear how all this would support the Assessment. In principle one could set an ambient air quality standard simply from a relation of deposition flux density to ambient concentration together with a critical load flux density for a given

ecosystem, thereby determining a critical ambient concentration, with no requirement for a chemical transport model. The chemical transport model would be needed only to transfer the critical concentration to a critical emissions rate. Such an approach would also lead to a path forward in determining uncertainties associated with the chemical transport model. However the approach that would be employed in the Assessment does not seem to be spelled out.

17. Section 4.3.2 deals with critical loads and methods of determining them. The definition of critical load given at page 4-17, lines 16-17, the level of input of a pollutant below which no harmful ecological effects occur over the long term based on the current scientific knowledge" seems appropriate, but I would recommend deleting "based on the current scientific knowledge" from the definition; rather that phrase would apply to the particular estimate of the critical load that is developed by the activity. Several approaches to determining critical loads are described. However the discussion seems to fall short on how the critical loads so determined would be employed in the Assessment. Also, the critical load approach would seem to be binary: yes, it is exceeded; no, it is not, whereas the damage to an ecosystem would seem to be functionally dependent on the load (in excess of the critical load), so some assessment of that functional dependence would seem to be required, especially as input to quantification of loss of ecosystem services, although, as noted above, I have grave misgivings about the utility of that sort of endeavor.

18. Section 4.3 briefly describes some six approaches to quantification of goods and services provided by ecosystems. What seems to be missing is how these approaches would be used. I certainly think it would be instructive to run them all in parallel and see how the results spread among he several approaches. I would anticipate that the differences would be enormous, and even more that there would be considerable differences even in the nature of the goods and services evaluated or not evaluated by the different models. The first question that would have to be addressed would be whether, in view of such differences, the exercise contributes any value to the Assessment.
Section 4.4, Characterizing uncertainty and variability, is brief and not specific; from that section:

We are considering using recent guidance from the World Health Organization (WHO, 2008), which presents a four-tiered approach for characterizing uncertainty. With this four-tiered approach, the WHO framework provides a means for systematically linking the characterization of uncertainty to the sophistication of the underlying risk assessment, where the decision to proceed to the next tier is based on the outcome of the previous tier’s assessment.
One would have expected that by this stage, the planning would have gone beyond the "We are considering" stage.

Technical

1. I question the implied significance of a standard set as "0.053 ppm", the implication of the number of significant figures being that 0.053 would meet the standard but 0.054, a difference of 2% would not. Better "0.05" or "0.06" unless the science justifies a better precision, which I seriously doubt. (Weighing against such a change is the grief that would redound on EPA for either tightening or relaxing the standard.)

2. I take issue with the statement p 1-13, lines 23-24: "Oxides of nitrogen and sulfur are emitted into and occur in the air in both gaseous and particulate form. " To my knowledge and understanding the oxides are exclusively gases.

3. In the glossary heptoxide and thiosulfate are, I believe, meant to be ions, and therefore should be given with charges indicated, as with sulfate. It discredits the document and the EPA if such mistakes in elementary chemistry are present in the document. Ditto SO4 to denote "wet sulfate," whatever is meant by that term. Use of the term "PM2.5fine" to denote particulate matter counters standard usage whereby the term refers to particulate matter of aerodynamic diameter < 2.5 µm. *Cf*. also page 1-10, line 17 "fine particulate matter".
4. Page 1-13, line 29: Ambiguous: "both oxides of nitrogen and also reduced nitrogen"; is it meant to be both of the oxides (NO and NO_2) or both the oxides and the reduced nitrogen?
5. "Concentration." Strictly, the standards that are proposed are mixing ratios, dimension amount (mole) fraction, unit ppm; not concentration, dimension mass or amount per volume, mole m^{-3} or g m^{-3}. However the word concentration is used throughout. Better mixing ratio, throughout, with an explanation at first use. (Schwartz and Warneck, 1993). Alternatively, an explanation at first use of "concentration" that the use of the term to denote abundance expressed as mixing ratio is so firmly entrenched that it is retained here, despite being technically incorrect.
6. "Critical load," Key Terms, page vii: Is defined as "exposure". Is it a concentration? A deposition flux density? A concentration times an exposure time? Any of the above?
7. "Occult deposition," Key Terms, page viii. The term is deprecated. But in any event the definition lacks the necessary other side of the coin, namely "and the deposition to the surface thereby." Similarly, the definition of Wet Deposition would be improved by addition of "and delivery" to surfaces
8. Acid neutralizing capacity, defined in the Key Terms section as "A key indicator of the ability of water to neutralize the acid or acidifying inputs it receives." Water alone doesn't neutralize acidifying inputs. Acids are neutralized by dissolved bases either in the water or in the materials with which the water is in contact that dissolve in the water, prior to or subsequent to the deposition of the acids.
9. Why is the NOx standard sometimes stated as 0.053 ppm; sometimes as 53 ppb? Yes, they are synonymous, but use of different units appears inconsistent and might be confusing.
10. Page 2-5, line 14: Why particulate? The oxides are gases. My inference is that the authors are considering downstream compounds: particulate nitrates and sulfates (also gaseous compounds such as HNO3 and PAN that are not oxides). So the question is whether an ambient air quality standard for gaseous NOx and SOx is the appropriate tool for protecting sensitive ecosystems from the effects of nitrates and sulfates.
11. Page 2-5 line 15: Why exclude effects on man-made materials and structures? It would seem that justification is needed. *Cf*. page 2-6 line 14.
13. Page 4-2, line 19: Acid neutralizing capacity levels: specify units. Also in Glossary.

Specific questions/concerns over language in the document

Title: The document under review is a draft of an "Integrated Review Plan". It does not seem to be made clear anywhere in the document what is being "integrated". Is it an integration of the plans for review of sulfur and nitrogen oxide plans which hitherto have been separate? Some explicit clarification would seem essential.
Page 1-1, line 8. reads "will provide"; better "is intended to provide"; whether it will or will not provide such an integrative assessment remains to be determined.
Page 1-3, line 19. Why "current"?; suggest strike.

The word "key" seems greatly over used in the document. I counted 52 instances. This seems far too

many for all such items to be key.

Linguistic, stylistic

The phrase "***acidic deposition***" should be replaced in all instances by "acid deposition." Both phrases are used throughout the document, apparently interchangeably and with no apparent distinction. In general it is a sign of poor writing to do this. Which to choose? Deposition is a verbal noun, a noun created from transitive verb. As such the noun phrase "acid deposition" denotes the deposition of acid, a process. In contrast the noun phrase "acidic deposition" denotes a substance, deposition, which is acidic. It seems clear that the noun phrase of interest is thus the process, acid deposition, not the substance acidic deposition.

"***Significant***" is a word whose use in technical writing can be ambiguous: Significant in the sense of "important" or "substantial", versus the sense of statistically significant. It is recommended that to avoid such ambiguity, the use here be restricted to statistically significant; that usage to mean substantial be replaced by "substantial." Thus page 1-10, line 4: 21351). In reaching this decision, the EPA took into account the **significant** reductions in SO2 emissions." Better "substantial reductions." Throughout.

First person plural. Should be avoided throughout, as in phrases like "important gaps in **our** understanding" [page 1-4]. Inevitably the reference is ambiguous or shifting. Whose understanding: the authors? The scientific community's? Better simply "important gaps in understanding." Versus page 1-10, line 25: "other parts of **our** nation"; whose nation? the authors'; the scientific community's? Better simply "the nation". Page 2-1, lines 10-11: To inform **our** evaluation of these overarching questions in the current review, **we** have identified key policy-relevant issues. Whose evaluation? The authors? The scientific community's. Not at all clear who is doing the evaluation. EPA? Some set of authors? Chapter 4 clearly uses first person plural "we" to refer to the authors of the document: "we provide some preliminary ideas regarding the scope of the current Risk and Exposure Assessment here. " Possibly appropriate, but would seem to require identification of personal authors; perhaps better: "Some preliminary ideas regarding the scope of the current Risk and Exposure Assessment are provided here;" what is important is the preliminary approaches, not who is doing the providing thereof, so the preliminary approaches would seem better suited to be the subject of the sentence.

In formal writing the phrase "***due to***" is adjectival, not adverbial. Page 1-12, line 18-19. "it was not appropriate under Section 109(b) to set any new secondary standards at this time **due to** the limitations in the available data... Better "because of". Throughout.

The subsidiary conjunction "***while***": in formal writing "while" denotes simultaneity, not contrast; Use "although" or the like to denote simple contrast. Page 1-12, line 16: "The Administrator's decision was that, **while** the current secondary standards were inadequate to protect against adverse effects from deposition of NOx and SOx, it was not appropriate under Section 109(b) to set any new secondary standards at this time ..." Better "although", especially so in this instance given the reference to "time" later in the sentence. Throughout.

The entire document needs a careful edit for grammatical errors such as dangling participles. Page 1-12, line 23: "Thus, taken together, the Administrator decided to retain." Was the Administrator taken together?

Page 1-14, line 5: "A multitude of factors contribute..."; multitude is singular; requires singular verb; if you don't like the way it sounds, then simply write "Many factors contribute.."

Yet another example, page 2-2, line 12: "Taking into account all of this information, the Administrator's decision .. was to retain." I think the individual taking the information into account was the Administrator. Better, "Taking into account all of this information, the Administrator decided to retain."

Page 2-1, "build upon the key issues that were important in previous reviews. " Perhaps better "build

upon the key issues that were identified in previous reviews." If they were key, they were important, no?
Page 2-9, line 2: "For the of the air quality criteria" ; something missing. Page 3-1 "other their products"; something missing
Why sometimes NOx (lower case sub); sometimes NOX (upper case sub); conventional would be lower case italic, as the letter *x* stands for a numerical quantity.
Page 4-6, lines 14-16: "the analyses will focus on ecological effects determined to have a causal or likely causal relationship with NOX and SOX in the Integrated Science Assessment, which may reflect multiple chemical species of nitrogen and sulfur." This would seem to be an important sentence but it is hard to parse. Presumably the phrase "in the Integrated Science Assessment" is meant to modify the verb "determined," not the verb phrase "have a causal...relationship" but it takes a couple of readings to figure that out. And it is not clear what is the antecedent of the "which" clause, what is doing the "reflecting" and indeed whether "reflecting" is the appropriate verb. So any impact of the sentence would seem to be totally muffled.
Page 4-6, line 31: "im ore " seems to have been missed by the spell checker.

References

Schwartz S. E. (1989) Acid deposition: Unraveling a regional phenomenon. *Science* 243, 753-763.
Schwartz, S. E. and Warneck, P. Units for use in atmospheric chemistry. *Pure Appl. Chem*. **67**, 1377-1406 (1995).

Dr. Schwartz (continued)

Addendum to Comments on Draft Integrated Review Plan

Introduction to these comments

These further comments are based on my review of the comments submitted by other members of the Panel, and on the comments and discussion in the Panel teleconference on December 1, 2015.

I was quite favorably impressed with the comments by my fellow Panelists. There are several instances where I found myself thinking that I wished I had thought to say this or that comment made by one or the other Panelists. It is thus my intent in identifying these comments to lend my support to the comment in the hope that this may help influence the authors of the Draft Plan to take consideration of the comment in the revision of the Draft.

Comments

Historical overview. Several panel members provided considerable insight to the document by recounting the history of prior revisions of these secondary standards. I think it would greatly help the document to have a section that places the activity that would be conducted under the Plan, the draft of which is under review here, in the context of prior work. The overview in Praveen Amar's written comments and the perspective in Armistead Russell's written and oral comments were particularly helpful to me as were the oral remarks by Dr. Russell, and thus I feel that the Plan would be greatly improved by such a contextual overview.

As a possible modification of the standards was rejected by the Administrator in the previous re-examination of these standards, it would seem especially important to highlight the concerns noted by the Administrator at that time that might serve as a punch list to see the extent to which subsequent research has removed the stumbling blocks noted by the Administrator. If that is not done, I am concerned that any recommendations that come out of the present Assessment will suffer the same fate as those out of the previous Assessment. It would also seem valuable to synopsize the recommendations of the prior Assessment that were rejected by the Administrator.

Graphical and/or tabular display of standards. I second the suggestions of several Panelists that there be a tabular and/or graphical display of AQ standards (primary or secondary) for SOx and NOx species, with historical evolution.

Form of standard. Although the possibility of a form of standard other than local abundance ("concentration") is explicitly acknowledged in footnote 4 on page 1-1, there was little actual consideration in the Draft Plan of alternative form(s) of standards, such as a deposition flux density standard, units moles m^{-2} yr^{-1}, the value of which could be compared to critical loads for different types of ecosystems. A concentration standard might in principal achieve the same effect, provided the deposition velocity were known, but as several Panelists noted, models for deposition exhibit large uncertainties. I was particularly struck by the comment by Mark Fenn to the effect that deposition flux density can vary many fold over short distances, a consequence of terrain and orographic features. The environmental consequences of such variation in deposition flux density would not seem to be adequately captured in an abundance standard.

Systems at risk other than ecosystems. I second the concerns noted by several Panelists that damage to structural materials and cultural objects seems to be inadequately considered in the Draft. In my oral remarks I called attention also to the issue of agricultural damage, not treated at all in the Draft. I second the remarks of others on the importance of visibility reduction in the context of standards for nitrogen oxides and sulfur dioxide and their oxidation products, nitrates and sulfates. Better that the assessment include these considerations even if they are considered elsewhere as well as they are so strongly coupled to substances of concern here.

Reduced nitrogen and reactive nitrogen. I support the comments of several Panelists regarding the need to take into account the deposition and effects of reduced nitrogen, i.e., NH_3 and NH_4^+. I would add to this organic nitrogen compounds. In one of my oral comments I specifically noted peroxyacetylnitrate (PAN) which is highly phytotoxic. I observe as well that as the deposition of particles to surfaces differs greatly from that of gases, the conversion of gaseous ammonia to particulate ammonium (as sulfate or nitrate) would substantially modify the deposition of reduced nitrogen to the surface; likewise also nitrate. This would not be the case for sulfate, which inevitably is particulate, but the acidity of the particles would be greatly reduced by neutralization by ammonia.

Chemical transport models. Several Panelists noted concerns, which I share, over reliance on chemical transport models to achieve the link between emissions, ambient concentrations, and deposition. On the other hand the availability of multiple models (several were noted in the Comments) is a path forward to assessing present understanding of the represented processes and toward estimating uncertainties in that understanding.

Monetization of effects. I share the concerns raised by several Panelists including Lauraine Chestnut and Richard Poirot over the danger of monetizing environmental effects by in some way placing a dollar value on ecosystem "services". In my judgment this would have the effect of diminishing the consequences of environmental degradation, as monetization would be possible for only a subset, probably a small subset, of such services. Who can place a dollar value on the ability of a vegetated hillside to retain water into soil moisture and ultimately into the water table, water that in the absence of such vegetation that would otherwise run off; likewise the ability of that vegetation to prevent soil erosion.

As was emphasized at the outset of the Committee Meeting, the governing legislation precludes consideration of costs of achieving AQ standards; therefore there is no need to come up with a dollar value for the benefit of one or another standard that might be compared to cost. So I would say monetization is a trap that should be avoided.

Uncertainties. The term "uncertainty" has a specific technical meaning (e.g., measurement uncertainty, uncertainty in model calculations) but also a broader more nebulous meaning (e.g., uncertainty in the mechanisms of damage to a specific organism by a specific antagonist). So some uncertainties can, and should, be quantified. But others inherently cannot be quantified. Still they must be noted and their implications on standard setting identified. This is very important especially as the Administrator cited uncertainties as reason for not adopting any changes in the AQ standards the last time around.

Quantification of uncertainty and locus of uncertainties. A related issue noted by several Panelists is the quantification of uncertainties and identification of the major sources of uncertainty. Daven Henze called attention to uncertainties in NO_X emissions of a factor of 2 as inferred in some studies. It would seem to be especially valuable for the Assessment to try to identify and quantify the major sources of uncertainty in quantitative attribution of local abundances and deposition, for example in emissions, dispersion, reaction, wet or dry deposition. Such identification points the path forward for future research to reduce uncertainties.

Assessment vs. research. I share the concern noted by Daven Henze over the role of the individuals charged with carrying out the Assessment under the Plan that will result from the current activity, namely the extent to which the charge to those individuals is to run chemical transport models versus assess the results of model runs by others. I would think that this should be clarified in the Assessment Plan. Taking a cue from the climate assessment community, the present Assessment activity might be better directed to comparing model runs by others than actually doing model runs as part of the Assessment. The other side of the coin is that if there are no prior model intercomparison exercises, then it might be essential to do such intercomparisons within the Assessment activity. Such intercomparisons would afford the further advantage of providing at least some measure of uncertainty in the modeling, from the spread of multiple models. Here an analogy is the AeroCom exercise that intercompares multiple aerosol models and tries to quantify spread among the elements of the models, in extensive variables (e.g., concentrations, deposition flux densitieis) and intensive variables (e.g., residence times, deposition per emission; Textor, C., et al. "Analysis and quantification of the diversities of aerosol life cycles within AeroCom." *Atmospheric Chemistry and Physics* **6** (2006): 1777-1813.

Dr. Kathleen Weathers

Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the secondary NO_x and SO_x NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

Chapter 1: Overall, I found this chapter to be well written and informative regarding background for the current review. See specific comments, below.

Page 1-2, line 2: suggest adding: "most notably in the cases of acidic deposition,' acidic deposition and nutrient enhancement.

Page 1-3, lines 15 and 16, Figure 1-1, etc: consider noting how this committee (NOx SOx secondary review) functions in relation to the CASC, e.g., "has been performed by the CASAC" who were informed (?) by an independent panel (NOx-SOx, this panel). There are several other places in the first chapter that fail to identify the panel as part of the process, as is the case with Figure 1-1. Perhaps it's by design, but if not, I suggest making clear that an expert panel is part of the process as well.

Note: The entire document should be carefully copy edited—there are several punctuation errors, among others.

Key Policy Relevant Issues (Chapter 2): Building on key considerations and issues addressed in the last review, Chapter 2 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

Chapter 2 characterizes clearly both the scientific and policy issues that are at the forefront for the current NOxSOx review, my comments below notwithstanding.

Page 2-1: A (perhaps rhetorical) question: does the fact that after the last review "the Administrator's decision was that, while the current secondary standards were inadequate to protect against adverse effects…" change the first overarching question? It seems that the 2nd question is the one for which the previous review did not provide a defensible answer and that the first question was answered last round.

Page 2-2
2.1.1: I found the first paragraph rather confusing. Edit for clarity.

Line 29 and on to next page: this sentence is also unclear "…as well as uncertainties that are related to reliance on…" Reword.

Lines 17-19: ditto Uncertainties seem to be conflated here.. I *think* what is meant is that air quality data, especially ammonia, are limited (spatially) and that the sparse data result in uncertainties. There are also many uncertainties associated with dry deposition modeling using air quality data. Since dry deposition is not measured directly, rather it is modeled, these uncertainties should be referred to separately.

Page 2-5, lines 14: should this read “ambient or gaseous” NOx and SOx vs particulate?

The sentence that begins at the end of line 28 could be clarified.

Page 2-6, lines 5 and 6: is this meant to refer to individual impacts of NOx or SOx vs combined S and N effects? Clarify.

Why are man-made (human-made!) and visibility effects excluded from this analysis since they are included in the list of welfare effects? I concur with the statement that “alterations in structure and function of ecosystems would seem appropriate for this review,” and in fact agree that a focus on ecosystem structure and function is crucially important, I’m simply unclear about the justification for excluding other important welfare effects.

Figure 2-1: My comments will invoke a bit of déjà vu all over again (from the last review). I appreciate the goal of Figure 2-1: being able to visualize the process is great. However, modifications would make it more useful. For example:

If the different box shapes are significant, that significance should be outlined in the figure legend. If they are not, please standardize. Also, the figure and the text could/should be more tightly linked.

Since uncertainty was a primary “deal breaker” in the last review, a separate box for uncertainty analyses might be appropriate. In fact, throughout the document, how uncertainty will be dealt with, in general, and specifically, should be explicit.

Also, since deposition will be the focus of the analysis, why doesn’t it show up in the overview?

Should there be a feedback arrow from “Indicators, averaging times, form” back to the “Evidence-based considerations’ row?

Section 2.2.1: See my comments above about uncertainties. I expected to see, first and foremost, something to the effect of: “To what extent have the uncertainties in data and modeling been…”

Throughout Chapter 2: consider reducing the use of or replacing the word “key”.

Science Assessment (Chapter 3): Chapter 3 describes the plan for the Integrated Science Assessment. To what extent does Chapter 3 clearly and adequately describe the scope, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

Community ecology should be included in the list of disciplinary areas to cover as should ecosystem ecology (in addition to ecosystem services)

Interrelated issues of other reactive nitrogen species are missing and absolutely should be addressed, including reduced N and organic N compounds.

Quantitative Risk and Exposure Assessment (Chapter 4): Chapter 4 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 4 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

Table 4-1 lists well the (extensive) uncertainties that were identified in the previous review. It will be very important to understand (via the ISA, presumably) whether the level of uncertainty for any of what is in Table 4-1 has changed since the last review. It is also critical to put these uncertainties in a bigger context (see above), i.e., what should/can we expect in terms of reducing uncertainties? Further, since decisions are made (policy, scientific, life) all the time despite uncertainties, how do make sure that the specter of 'uncertainties,' or an inability to quantify some uncertainties, does not unrealistically hamper decision making?

Policy Assessment and Rulemaking (Chapter 5): Chapter 5 describes the policy assessment and rulemaking process. To what extent does Chapter 5 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

This chapter is short and to-the-point. It does summarize well enough the general process.