The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Subject: Review of the *Policy Assessment for the Review of the Secondary National Ambient Air Quality Standard for NOx and SOx: Second Draft*

Dear Administrator Jackson:

The Clean Air Scientific Advisory Committee (CASAC or Committee) Oxides of Nitrogen (NO_x) and Sulfur Oxides (SO_x) Secondary National Ambient Air Quality Standards (NAAQS) Review Panel met on October 6-7, 2010 and held a public teleconference on November 9, 2010 to review EPA's *Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for NOx and SOx: Second Draft*. **(To be inserted pending review/approval by CASAC: "**The Chartered CASAC held a public teleconference on XXXX to review and approve the report.") This letter provides CASAC's overall comments and evaluation. We highlight the most important issues that need to be addressed as the second draft Policy Assessment (PA) is revised in Enclosure A. The CASAC and Panel membership is listed in Enclosure B. The Panel's responses to EPA's charge questions are presented in Enclosure C. Finally, Enclosure D is a compilation of individual panel member comments.

EPA staff has demonstrated through the Integrated Science Assessment (ISA), Risk and Exposure Characterization (REA), and the draft *Policy Assessment* that ambient NO_x and SO_x can have, and are having, adverse environmental impacts. The Panel views that the current NO_x and SO_x secondary standards (for NO_x, an annual arithmetic standard of 53 ppb, identical to the primary standard with no short-term standard; for SO_x, a separate secondary 3-hour standard of 0.5 ppm, not to be exceeded more than once per year, with no short-term standard) should be retained to protect against direct adverse impacts to vegetation from gas phase exposures of these two families of air pollutants. Further, the ISA, REA, and draft *Policy Assessment* demonstrate that adverse impacts are also occurring due to deposition of NO_x and SO_x even at the level of the current standards. Those impacts include ecosystem acidification and undesirable levels of nutrient enrichment in some ecosystems. The levels of the current NO_x and SO_x secondary NAAQSs are not sufficient, nor the forms of those standards appropriate, to protect against adverse depositional effects; thus a revised NAAQS is warranted. It is recognized that such a NAAQS would potentially need to be formulated very differently from the existing NAAQS to provide requisite protection in sensitive areas, while not more providing protection more stringent than necessary for this purpose.

We compliment EPA staff on the progress that has been made since the Panel reviewed the first draft *Policy Assessment*, and appreciate their responsiveness to CASAC's initial comments. There are significant scientific challenges in developing a multipollutant, ecologically relevant secondary standard. To meet this challenge, EPA has developed a new index. The Atmospheric Acidification Protection Index (AAPI) integrates the impacts of NO_x and SO_x deposition on aquatic acidification, while considering the effects of underlying ecosystem characteristics and current reduced nitrogen deposition. The AAPI approach is responsive to recent recommendations by the National Research Council for multi-pollutant air quality management (*Air Quality Management in the United States*, 2004). However, because the AAPI considers depositional effects of multiple pollutants within diverse and complex ecological systems, it also introduces a number of analytical complexities. Despite these complexities, it is not apparent how one would construct an equally appropriate, and significantly simpler, approach to capture the many important processes that influence the relationship between observable atmospheric concentrations and aquatic acidification. The proposed approach would appropriately integrate the combined effects of NO_x and SO_x deposition, and, based on the analyses EPA Staff have presented so far, would provide protection for sensitive aquatic ecosystems from acidification from NO_x and SO_x deposition at an appropriate scale. In contrast to the science in the ISA, REA, and *Policy Assessment* supporting protection against acidification in aquatic ecosystem from NO_x and SO_x deposition, there is not yet enough confidence in the science that might support new standards specifically protecting against undesirable levels of terrestrial acidification and aquatic nutrient enrichment. Although a standard that focuses on aquatic acidification provides some co- benefits in addressing these other adverse effects, EPA should consider developing a different approach for protecting against adverse terrestrial acidification and aquatic nutrient enrichment..

The Panel's review of this document has been challenging as a result of several factors. Even though the second draft *Policy Assessment* was novel and complex, the Panel received the document only three weeks before the review meeting. As delineated further in Attachment A and in our responses to the Charge Questions, there are critical sections of the *Policy Assessment* that are unclear and/or where further analyses are necessary. In addition, and in contrast to *Policy Assessment*s for other pollutant reviews, EPA did not provide staff recommendations for key elements of the secondary NAAQS for NO_x and SO_x along with supporting rationales. As a result, the Panel was not able to provide specific comments on the EPA Staff recommendation nor was the Panel was not able to use Staff recommendations to help frame CASAC recommendations about the four key elements of the NAAQS. Finally, as is delineated further in Attachment A and in our responses to the Charge Questions, there are critical sections of the *Policy Assessment* that are unclear and/or where further analyses are necessary.

As a result of the issues identified above, the Panel is not prepared to provide a consensus recommendation on elements of the standard. The document requires further revision to adequately inform us, or you, on the specifics of a revised (and in this case novel) NO_x-SO_x NAAQS. However, the panel did agree, in general, that: a3-5 year averaging time is likely appropriate; acid neutralizing capacity (ANC) targets in the range of 20 to 100 ueq/L appear appropriate to consider; and that at least half of the selected water bodies should be protected, though that fraction depends upon how akes are excluded from EPA's analysis.

The Panel recognizes the very tight time lines associated with revising the NO_x and SO_x

secondary NAAQS, but the Panel views that CASAC should have the opportunity to review a more complete draft of the *Policy Assessment* --one that provides staff recommendations, the rationales for the choices made, the direct supporting analyses for those choices, and the ramifications of alternative choices within the ranges of the alternatives. Without this information we cannot provide you the level of advice traditionally provided by CASAC, nor is it apparent how you can make a well informed decision.

Enclosure A identifies critical needs in the further revision of the *Policy Assessment.* While we have identified various needs for additional analyses and added clarity before the final *Policy Assessment* is published, the Panel remains very supportive of this novel approach described in the document. We support EPA staff's continuing work on revising the document to establish a foundation for a revised NO_x-SO_x NAAQS. The Panel would welcome an opportunity to review EPA's revisions and to provide a letter to inform decisions on proposal for new secondary standards.

In closing, the Panel trusts that our comments will be useful in revising the *Policy Assessment* and developing a proposal for the secondary NO_x-SO_x NAAQS. The Panel looks forward to seeing the next revision of the *Policy Assessment* and to providing advice on the proposed rule.

Sincerely,

Enclosure A

Critical Needs in the further revision of the *Policy Assessment for the Review of the Secondary National Ambient Air Quality Standard for NOx and SOx: Second Draft*

1. The Panel requests that staff recommendations of the specific formulation of all of the elements? and the ranges associated with each element?(Too many elements) of the NO_x-SO_x Secondary NAAQS be provided in the next *Policy Assessment* .These recommendations should be well supported. Further, analyses should be conducted that explore the ramifications for alternative choices within the ranges suggested by the staff.

2. Chapter 5 must be presented more clearly, in general, and the section on spatial categorization approach, in particular, needs justification and clarification. The AAPI is new, novel and complex. Unlike more traditional standards, there is no precedent, and therefore the specifics of how the standard works and the implications of choices that might be made need to be clear.
    a. This chapter needs a section that summarizes and integrates the information contained. It is necessary to provide the reader a better understanding of how all of the elements work together and is the bridge to subsequent following chapters.
    b. EPA should more clearly present the pros and cons of the target fraction of lakes to be protected at a given level of ANC. Further, the approach to excluding lakes from the cumulative distribution function needs to be better supported (see our response to Charge question 7).
    c. EPA should more clearly present the AAPI and the magnitudes and distributions of the elements of the AAPI.
    d. EPA should provide additional information about the distribution of current depositional loads (DLs), and how those DLs would change given specific choices of elements of the standard. The level of NO_x and SO_x emissions reductions required should also be indicated.

3. More thorough and targeted analyses are needed to provide information about levels of uncertainty and how uncertainties might impact determining the appropriate level of the standard. While Chapter 7 on uncertainty is a welcome addition, it is not as informative as necessary.
    a. EPA staff provides a useful analysis on the elasticities of the calculation of the AAPI on each component of the "AAPI equation," and this is helpful, but it still is not clear to what element(s) the AAPI is most sensitive. Further, it is the sensitivities of the allowable concentrations of NO_x and SO_x (or the DLs) that are most critical, and this chapter should be extended to include an analysis of the sensitivities of those quantities to components of the AAPI equation.
    b. A more comprehensive uncertainty assessment is called for, as described in our responses to Charge Questions 14-17 and 21. Staff can examine the study presented by EPRI to assess their approach and levels of uncertainties used.

4. To the extent practicable, EPA should conduct further analyses [of an application of the AAPI using historical data.

5. Based on recent scientific evidence, an assessment of the potential bias introduced from not including sulfur retention in the AAPI equation is warranted.

6. A more focused evaluation of CMAQ and relevant to the AAPI is still needed, with particular attention to the uncertainties in the estimates of the deposition of chemically-reduced nitrogen and the deposition transference ratios.

7. A more thorough discussion of the potential unintended consequences (positive and negative) of a secondary NO_x-SO_x standard to address acidifying deposition would help to identify areas of research and monitoring needs.

Enclosure C: Panel's Responses to EPA's Charge Questions

Chapter 3: Considerations of Adversity to Public Welfare

1. What are the Panel's views on the definitions of adversity that are appropriate to consider in determining what constitutes adversity to public welfare relative to the NOx and SOx secondary standards?

Ecosystem services provide a framework to characterize and describe how changes in ecosystem function affect public welfare, even if they cannot be specifically quantified. The link is well-documented between the selected ecosystem effects indicator, acid neutralizing capacity (ANC), and the public welfare effects of lost value of recreational fishing, biodiversity, and habitat. Fish populations (and in some cases whole species) become unsustainable in lakes and streams with decreased ANC levels caused by elevated inputs of acidic deposition. The text mentions non-use values several times, but it would be helpful to make explicit that this includes values for the preservation of habitat and biodiversity that are independent of human use value. These services generally fall into the category of cultural services). More could be done to explain and characterize the qualitative links between acidic deposition and lost ecosystem services that are known and documented but cannot be specifically quantified for a specific amount of acidic deposition.. While it is clear that the total value of these services is large; what is importantis to convey the degree to which they are diminished at current acidic deposition levels.

Evidence of community, local and state actions to decrease acidification is informative regarding adversity even though such evidence doesn't provide specific estimates of welfare changes. Also including federal actions, such as the Title IV (Clean Air Act Amendments of 1990) program, to address acidification would be appropriate here.

Chapter 4: Addressing the Adequacy of the Current Standards

2. What are the Panel's views on staff's approach to translating the available evidence and risk information and other relevant information into the basis for reaching conclusions on the adequacy of the current standards and on alternative standards for consideration?

a) In light of the Panel's views on the appropriate definitions of adversity to public welfare (see Chapter 3), do you agree that the current levels of NOy and SOx deposition are adverse to public welfare?

Yes, the Panel agrees that current amounts of NO_y and SO_x deposition are adverse to public welfare especially with regard to effects on aquatic ecosystems in acid-sensitive regions in various parts of the United States. The Panel also agrees with EPA's historical interpretation that air-pollution-induced effects on ecosystems should be considered "adverse to public welfare" whenever these effects include "disruptions in ecosystem structure and function" that are considered important to the people of this country.

3. Has staff appropriately applied this approach in reviewing the adequacy of the current standards and potential alternative standards?

Yes, the Panel finds that EPA staff has appropriately reviewed the adequacy of the current standards and potential alternative standards. The current NO_x and SO_x standards were designed to protect vegetation against direct foliar effects from short-term exposures to gaseous $SO_2$and NO_2. Thus, the current standards address only a fraction of the total nitrogen and sulfur compounds that are causing adverse effects on aquatic ecosystems, and these standards are not designed to protect ecosystems from acidic depostion. None of the elements of the current NAAQS standards – indicator, form, averaging time, and level – are suitable for addressing the long-term (multi-annual) cumulative acidification effects of total atmospheric loads of total reactive nitrogen and sulfur on aquatic ecosystems.

The ISA and REA for the current review (as summarized in Chapters 2 and 3) make it clear that current ambient concentrations of airborne nitrogen and sulfur compounds (including not only NO_y and SO_x, as asked in Charge Question 2 but also ambient NH_x as well as organic forms of nitrogen) are now causing significant “disruptions in the structure and function of aquatic ecosystems” in various acid-sensitive regions of the United States.

4. Has staff appropriately acknowledged the potential beneficial effects of nitrogen inputs into nutrient limited ecosystems, while maintaining the focus of the review on preventing adverse effects in nitrogen sensitive ecosystems?

Staff should more appropriately acknowledge the potential beneficial effects of nitrogen inputs into nutrient-limited ecosystems. While these beneficial effects have been acknowledged, the tone and emphasis given is not been appropriately balanced. As an example, the last few lines of page 4-45 in Chapter 4 and especially the first four words, may suggest the potential benefits to be very limited: In certain limited situations, additions of nitrogen <u>can</u> increase rates of growth, and these increases can have short-term benefits in certain managed ecosystems....”

A better balanced presentation of these same ideas could read as follows:

> “Most areas in the United Staqtes are nitrogen-limited, so regional decreases in emissions and deposition of airborne nitrogen compounds will lead to some decrease in growth of the vegetation that surrounds the targeted aquatic system. Whether these changes in plant growth are seen as beneficial or adverse will depend on the circumstances. Increased carbon sequestration due to increased growth in N-limited ecosystems may be the most significant category of potential beneficial effects of N deposition.”

Carbon sequestration is not addressed in the *Policy Assessment*. Carbon sequestration is implied, however, by the inclusion of Climate in Table 3-1, and is of more practical relevance than" Climate Control" or "Regulating Climate" as is now shown in the table.

While the *Policy Assessment* and supporting documents acknowledge the possibilities of beneficial effects in passing, they tend to minimize them. While the panel feels that while such unintended effects by no means justify continuing current levels of air pollution, a balanced document should discuss them more thoroughly.

Chapter 5: Conceptual Design of an Ecologically Relevant Multi-pollutant Standard

5. What are the Panel's views on staff's revised conceptual framework for the structure of a multipollutant, ecologically relevant standard for NO_x and SO_x? To what extent does the Panel agree that this suggested structure adequately represents the scientific linkages between ecological responses, water chemistry, atmospheric deposition, and ambient NO_x and SO_x?

The revised conceptual framework and structure of the proposed standard(s) is well-thought out for addressing various components and connections between these components (ecological effects, atmospheric wet and dry deposition, atmospheric concentrations of NO_y and SO_x, and surface-water chemistry), with some exception noted below.

For example, the framework and the structure "take into account" the reduced ambient NH_x and its deposition in designing the AAPI (atmospheric acidification potential index). The revised treatment of ammonia and deposition of reduced nitrogen is an improvement over the first draft in that AAPI will periodically reflect changes in NH_x concentrations. Emissions of ammonia (which is currently an unregulated air pollutant) and resulting ammonia and ammonium concentrations and deposition levels are expected to increase over the next few decades because of increased food production and increased activity in CAFO sources (confined animal feeding operations) in the United States.

The conceptual framework for the proposed multipollutant ecologically relevant standard for NO_x and SO_x is sound with considerable support from the scientific literature on how the generation of strong mobile acids results in the acidification of soils and water. Some of the information, however, is not correct or is incomplete. For example, the discussion of sources of nitrate during snowmelt is incorrect in that it suggests that most of the nitrate is atmospheric. For example, the vast majority of nitrate mobilized during snowmelt is derived from nitrification in the soil itself. Also the assumptions associated with atmospheric sulfur input being equal to drainage water losses are not correct. For example, the soil can serve as a substantial source or sink of sulfur depending upon soil properties and history of atmospheric sulfur sources.

Even though the conceptual framework looks fine in principle, its practical usefulness will depend on its robustness. One way to evaluate robustness of the AAPI framework is by using sensitivity and/or uncertainty analysis, as discussed in our responses to Charge Questions 14 and 21. An additional way the AAPI can be tested is by the use of historical data. Where data are available, one could use the AAPI to get a trajectory of changes in AAPI in response to changes in SO_x and NO_y concentrations. The values of other components of the AAPI (Q, N_{eco},

$[BC]_o$, LNH_x, TNO_y and TSO_x) have already been estimated by EPA or can be determined from measured values. It is critical to do this analysis of historical data at more than one location. The changes in predicted AAPI should more or less match the changes in ANC (may be with some lag).

Notwithstanding these concerns, the proposed structure adequately represents the scientific linkages between ecological effects, surface water chemistry, atmospheric deposition, and ambient levels of NO_y and SO_x.

6. What are the Panel's views on the appropriateness of considering a single national population of waterbodies in establishing standards to protect against aquatic acidification? What are the Panel's views on consideration of alternative subdivisions of the U.S. to identify the spatial boundaries of populations of waterbodies and acid-sensitivity categories, specifically:

a) the use of Ecoregion III areas to aggregate waterbodies ?

b) the use of ANC to further aggregate Ecoregion III areas into different categories of sensitivity?

c) the relative appropriateness of the suggested methods for categorizing spatial boundaries of sensitivity, e.g. one nation, binary sensitive/less-sensitive classes, cluster-analysis based sensitivity classes, and individual ecoregions?

The justification, logic, and necessity of the spatial grouping classifications were not clear to the panel. The ecoregions approach has the conceptual appeal, but the rationale and limitations for classification and aggregation methods must be better articulated for all options described in the *Policy Assessment* before the CASAC Panel can provide meaningful advice.

The first approach (option 1), which considers the whole United States as one unit, has the advantage that it provides for a single deposition metric and is simple and easy to use. However, the single-region approach also has many weaknesses (e.g., over protection for the least sensitive areas and under protection for areas that are most sensitive necessitates having a system with higher spatial resolution) and is probably not a desirable approach. Nonetheless, the panel finds it useful to include discussion of this option for the overall context. On the other hand, the option 2d, which includes 85 ecoregions, would appear to add an unnecessary amount of complexity, but future analyses could provide support for such a choice. The use of clustering is also conceptually appealing, although the optimal number of sensitivity categories and the degrees of protection that would be provided under the different sensitivity categories are not clear. It does appear to strike a more reasonable balance between oversimplification and unnecessary complexity. The use of ANC appears to be a reasonable basis for grouping ecoregions into a relatively small number of categories, each containing surface waters with similar inherent sensitivities to acidification. This approach is consistent with the overall emphasis of the standard to protect sensitive surface waters from further acidification and to decrease acidifying deposition to levels that will allow those water bodies (that have been deleteriously impacted by acidic deposition) to recover as indicated by increasing ANC values.

The Panel recommends that the final *Policy Assessment* include a more detailed descriptions of the clustering approach and other options, along with clear illustrations of the advantages and disadvantages of the recommended options.

7. What are the Panel's views on the appropriateness of the critical loads that form the basis for the population assessment to determine deposition metrics?

Using the concept of critical loads is logical and appropriate for development of a secondary standard for biological effects of NO_y and SO_x. This approach links concentrations of the atmospheric oxidized forms of nitrogen and sulfur with N & S deposition and their acidifying effects on aquatic ecosystems and includes consideration of reduced forms of atmospheric N.

a) What are the views of the Panel on the appropriateness of generalizing the f-factor approach to apply to lakes and streams in the Western U.S. and other portions of the Eastern U.S.

The f-factor approach is a reasonable initial approach to evaluate the response of aquatic ecosystems to changes in atmospheric deposition. However the f-factor approach is based on steady-state calculation but ecosystems are simply not at steady state. Ultimately, it would be useful to apply dynamic models as management tools to evaluate effects of atmospheric deposition on non-steady state ecosystems.

Differences between the use of MAGIC and the SSWC methods to determine background concentrations of base cations are not adequately described in the PA, and the proposed procedures and differences between the two approaches need to be described more clearly

b) What are the views of the Panel on the filtering criteria used to remove lakes and streams that are naturally acidic or not sensitive to atmospheric deposition?

It is logical to exclude in advance water bodies impacted by mine drainage. It is not clear, however, why water bodies with low background ANC and high concentrations of naturally occurring organic acide are, likewise, excluded from further consideration since these are often the highly sensitive water bodies. The rationale for this approach needs to be better explained with examples given, with some discussion of the implications for eliminating these water bodies. The panel needs this information before it can fully and meaningfully respond to the question.

8. What are the Panel's views on the suggested methods for determining appropriate values of reduced nitrogen deposition in establishing NO_x/SO_x tradeoff curves?

The proposed approach makes sense and utilizes the best available knowledge on levels and distribution of reduced N based on the CMAQ outputs. Potentially the NADP chemistry and PRISM precipitation results could also be utilized. Due to its high NH_3 deposition velocity, steep concentration gradients near the NH_3 source areas can be expected. Therefore averaging N_{red} concentrations over larger areas may lead to missing smaller areas where NH_3 concentrations may be seriously elevated with potentially high ecological effects. Consequently, option "2" is preferable since it allows for additional spatial refinement of sensitive areas to reflect the heterogeneity of NH_x deposition. A better understanding of spatial and temporal distribution of reduced N, especially NH_3, in the United States is critical. Realizing that estimates of chemically -reduced N deposition are viewed as highly uncertain, efforts should be continued to assure the nationwide monitoring of N_{red}, especially in remote areas.

9. What are the Panel's views on the revised characterization of the deposition transference ratios (T_{NOy} and T_{SOx})?

A major concern with TNO_y and TSO_x is that although they are the critical links between NO_y and SO_x ambient concentrations and their deposition, they are derived using a model that has not been thoroughly evaluated for its ability to accurately simulate N and S deposition because of lack of measurements of the required concentration and deposition components. It is recommended that EPA evaluate the stability of these ratios using different models, emissions and meteorological conditions. It is recommended to calculate these ratios for the following model simulations (in addition to what has already been done):

- CMAQ and CAMx models (it is acceptable, in fact preferable, to use different emissions and meteorological conditions)
- Different chemical mechanisms
- Different model grid resolutions (36-km v/s 12-km or even 4-km, if available)

The CMAQ T_{SOx} calculation could also be evaluated using a combination of measured wet deposition data from NADP and the measured concentrations and estimated dry deposition of SO_2 and pSO_4 from CASTNET.

The PAD notes the possibility of large amount of sulfur and nitrogen deposition in the forest ecosystems in the coarser particle mode and further notes that CMAQ may not adequately account for coarse particle sulfate deposition. At the same time, most currently available measurement programs do not specifically quantify coarse mode sulfate or nitrate concentrations or deposition, so there are no data to evaluate CMAQ estimates. It is not clear how big this issue is and how it should/would be addressed. The panel requests more clarification on this issue.

On a related topic, the Panel suggests that the Agency consider the feasibility of calculating an alternative deposition transfer ratio for oxidized nitrogen, using a combination of (or perhaps the sum of) nitric acid and particulate nitrate, as an alternative to using NO_y. A possible advantage of this approach is that nitric acid is the component of NO_y that deposits most efficiently, and correlates best with total oxidized N deposition, so the resulting total deposition estimate would be less dependent on CMAQ model performance. A second possible advantage is that this calculation (as well as the TSO_x calculation) could be made using currently available and relatively low-cost CASTNET filter pack measurements, and so it would not be dependent on the establishment of a large new network of continuous NO_y and SO_2. A disadvantage of this approach is that while CASTNET measurements of total (gas + particle) nitrate are considered reliable, the CASTNET measurements of the separate HNO_3 and $p\text{-}NO_3$ components are subject to large sampling artifacts.

Estimates of total oxidized N deposition calculated using the original T_{NOY} method and the suggested alternative approach could be evaluated against both CMAQ estimates of total deposition as well as wet deposition measurements from the NADP plus dry deposition estimates from the CASTNETnetwork. It would also be important to consider whether the alternative approach would perform as well as the original TNOY when calculated over broad spatial scales, and over long time periods when NOx emissions and NO_Y species compositions may change.

As an alternative approach, EPA should attempt to further evaluate the stability of the TNOy and TSOx ratios over time and space recognizing that these ratios are a function of both air concentrations and deposition velocities. One possibility would be to use information from other sources (e.g., CASTNET) to make some comparisons among concentrations among those chemical species with respect to their modeled deposition velocities and resultant estimated deposition where such data are available. The Panel recognizes that the suite of chemical species that can be used in this analysis is less extensive than that modeled in CMAQ. If these ratios obtained from other data sources show substantial variation over time or space it would be useful to evaluate that the relationship between meteorological and/or emissions sources be also be provided.

10. What are the Panel's views on staff's conclusion that an averaging time of 3 to 5 years is appropriate given the AAPI form of the standard?

The EPA staff makes a good case for using the averaging time of three years and the panel agrees with that recommendation.

11. What are the Panel's views on the preliminary staff conclusions regarding alternative target ANC levels that are appropriate for consideration and the rationale upon which those conclusions are based?

Based on the available scientific data, the range of target ANC values considered in the *Policy Assessment* is appropriate, i.e., 0, 20, 50 and 100 µeq/L as target levels. These values encompass the range of sensitive ANC classes for surface waters in the literature, and there is a range of biological responses corresponding to this range of ANC levels. There will likely be biological effects of acidification at higher ANC values within this range, and there are relatively insensitive organisms that are not impacted at ANC values at the low end of this range. Adverse effects of acidification on aquatic biota are fairly certain at the low end of this range of ANC and incremental benefits of shifting waters to higher ANC become more uncertain at higher ANC levels. There is substantial confidence that ANC levels between 50 to 100 µeq/L offer protection against aquatic acidification, with higher levels in this range being more protective. Levels higher than 50 µeq/L, such as between 50 µeq/L to 100 µeq/L, would provide additional protection but with the panel has less confidence in the incremental benefits as the level increases. As indicated in the PA, there are clear and marked biological effects at ANC values near 0 µeq/L, so this is probably not an appropriate target value for the AAPI. At a target value of 20 µeq/L, aquatic biota experience acidification effects. Moreover, at this level of ANC many surface waters experience episodic acidification and associated biological effects. As a result, target ANC values of 20 to 100 μeq/L are in the range of appropriate values, while recognizing there is additional protection at 50 to 100 μeq/L.

a) In light of the Panel's views on the appropriate definitions of adversity to public welfare (see Chapter 3), what are the Panel's views on the appropriateness of the information related to adversity considered by staff in evaluating alternative target ANC levels?

The information on adversity to public welfare associated with the effects of aquatic organisms and ecosystems at different levels of ANC is appropriate given the available literature. There is relatively little information on the temporal biological response of acid-impacted aquatic ecosystems to marked decreases in acidic deposition. Most of the information on biological response to acidification is developed from spatial data. It may be useful to emphasize that it is unclear if the biological patterns observed for spatial data of varying ANC will similarly occur temporally in surface waters following increases in ANC due to any future decreases in acidic deposition.

12. What are the Panel's views on the approaches considered by staff for assessing alternative target percentages of water bodies for protection at alternative ANC levels?

This question is difficult to address without specifying the filtering criteria for the watersheds at specific ANC thresholds. As noted in our response to Charge Question 7b, the rationale for the filtering criteria should be better explained. It would be helpful to see an analysis of the implications of different choices of the filtering criteria for the target percentages. It is difficult to suggest target percentages without more information on subdivisions of the United States to be used and the distribution of ANC values in these subdivisions. Since effects at current deposition levels are adverse, the target should be a higher percentage than is currently adversely affected in sensitive areas.

The DL factors, which clearly are numerical indices of some kind should either be formally defined in the form of equations or it should be made clear how the numerical values for them presented in Tables 5-12 and 5-13 were derived.

Chapter 6: Co-protection for Other Effects Using Standards to Protect Against Aquatic Acidification

13. What are the Panel's views on the utility of the additional analyses of co-protection benefits to inform consideration of alternative levels of the standard?

The analyses and conclusions in Chapter 6 are important because the decision to focus on the effects of acidification on aquatic ecosystems means that in the current standard setting process, other important effects on ecosystems (documented in the ISA), are not being explicitly taken into account. To the extent that standards set to protect against effects of acidification on aquatic ecosystems result in decreased levels of N and S deposition there may be additional beneficial and detrimental effects to other ecosystems. It is important to acknowledge these even if they are not quantified.

The analyses reported in Chapter 6 are adequate for this purpose, but the interpretation of the conclusions could be broadened. One analysis suggests that sensitive terrestrial systems located in the same watersheds with sensitive aquatic systems would be protected by the deposition levels that would be needed to protect the aquatic systems. A relevant question then is what share of sensitive terrestrial ecosystems are co-located with sensitive aquatic systems throughout the country. The discussion would benefit from a deeper consideration of the differences in time lag between acidification of the soil as opposed to acidification of soil solution and resultant drainage waters as a mechanism by which atmospheric deposition can cause the acidification of surface waters. This means that aquatic systems are likely to recover more quickly than terrestrial systems when deposition is decreased.

Similarly, even though the standard would not decrease N deposition to the level required for to meet the target share of the TMDL in the Chesapeake watershed, the discussion could say more about what percentage of the target TMDL might be achieved.

The discussion in this chapter should acknowledge that the level of protection from undesirable effects of N deposition in terrestrial ecosystems is not addressed in this analysis and remains uncertain, especially in the arid and semi-arid ecosystems of the Southwest. Negative effects of N deposition on lichen communities are observed in some locations at very low levels of N deposition.

Introduction of mobile sulfate or nitrate anions into acidic soils (whether naturally acid or acidified by pollution) can result in near instantaneous acidification of waters, whereas acidification of soils is a long-term process occurring over decades or longer. Similarly, recovery of surface waters from acidification could happen relatively quickly if mobile sulfate and nitrate are removed, but recovery of acidic soils is highly questionable as soils in humid systems naturally acidify but do not spontaneously become less acid. The rate of acidification of soils should decrease with reduced inputs, however.

Chapter 7: Evaluation of Uncertainty and Variability in the Context of an AAPI standard, including Model Evaluation, Sensitivity Analyses, and Assessment of Information Gaps

14. What are the Panel's views on the following:

a. The degree to which the chapter appropriately characterizes the potential role of information on uncertainty, sensitivity, and variability in informing the standards?

The new Chapter 7 is a major advance toward consolidating and documenting the uncertainty, sensitivity and variability in the proposed indices. The Panel's major comments on this chapter include:

1. Summarize the general framework applied for uncertainty analysis, e.g. the WHO framework used in other NAAQS assessments.
2. Extend the uncertainty analysis beyond the components and examine the propagation of the uncertainties though the entire AAPI. Include the constrains from observations.

3. Aggressively pursue the identification and reduction of biases in the CMAQ model that are relevant to the AAPI.

It is recognized that it is difficult to quantify the uncertainties and sensitivities associated with the AAPI. Nevertheless, more complete uncertainty analysis should be pursued focusing on the overall, end-to-end uncertainty estimation including the possible application of Monte Carlo techniques.

While there is significant uncertainty associated with model calculations both in CMAQ and the MAGIC/SSWC, there is a considerable amount of empirical observations that provide constraints on the magnitude of these uncertainties. The combined use of uncertainty propagation and the observational constrains should be pursued.

b. The appropriateness and completeness of the evaluation of CMAQ model performance and sensitivity to critical inputs?

The inclusion of comparisons of CMAQ and CASTNET results and the related discussion on the CMAQ limitations in Chapter 7 is very helpful. It should be useful for future improvements of CMAQ. As indicated, the “sensitivity of CMAQ derived deposition transformation ratios to changes in emissions and treatment of chemistry” is not yet completed. This should be a high priority for EPA.

The performance evaluation of the CMAQ model can be further improved, and a more complete evaluation with measurements is needed to improve confidence in the calculations of the AAPI. The overestimation of the SO_2 is a significant systematic error that may lead to a bias. and may have a major impact on the estimated deposition and the AAPI overall. A figure like Fig 7-5 for CMAQ-CASTNET comparison for SO_2 could be very revealing. Additional available datasets beyond CASTNET should be utilized if practicable. EPA should also describe the uncertainties and limitations of CMAQ simulation of deposition of reactive nitrogen more completely,

c. The utility of the analyses of temporal and spatial variability in the deposition transference ratios (TNOy and TSOx)?

The figures in the *Policy Assessment* showing the spatial pattern of **T_{NOy} and T_{SOx}** are insufficient to provide the reader with an adequate level of understanding in the spatial variation of the transfer ratios and how they are linked to acid-sensitive ecosystems. The meaning and implications of the box-and-whisker plots are not obvious. The terms “stiff” and “stiffness” are not explained. The T_{NOy} and T_{SOx} are critically important to the APPI calculations, are entirely dependent on CMAQ simulations, and are impossible to fully evaluate with currently available measurements. It is therefore important to demonstrate that their spatial patterns appear reasonable, that the resultant deposition calculations are consistent with (limited) available measurements, and that these ratios remain consistent as emissions, concentrations and deposition rates are changed over time.

15. What are the Panel's views on the insights provided by the AAPI sensitivity analysis including:

a. The evaluation of elasticities of response?

b. The multivariable ANOVA analysis?

Evaluation of elasticity of response is a good way to get an initial estimate of the AAPI sensitivity to its components. However, it is recommended doing this analysis also for the SOx and NOx response surfaces to meet a particular standard, as those are the quantities for which compliance with the standard would be determined.The sensitivity analyses should include a larger range of perturbations, such as the sensitivity to the 40% SO2 over-estimation in CMAQ.

A summary is needed for the relative sensitivities of the various parameters that make up the AAPI to show the parameters of the AAPI that have the most and least impact and confidence levels. e.g. the role of non-atmospheric inputs, including base cation weathering and runoff rates. Such information should be used in driving research and monitoring efforts by EPA.
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16. What are the Panel's views on the discussion of uncertainty in the critical loads models including MAGIC and SSWC?

There is clearly a fair amount of uncertainty associated with model calculations. However, what has not been acknowledged in the *Policy Assessment* is that there is a considerable amount of empirical field data to support application of this secondary standard. Through monitoring studies there are about 30 years of observations providing a quantitative understanding of the nature and extent of soil and surface water responses to decreases in atmospheric deposition. Through these observations and some field based experiments, there is also a good understanding of the compensatory response of ANC to changes in concentrations of sulfate and nitrate. These empirical data should be used to evaluate the quality of the AAPI calculations and to support the justification and target parameter values for the AAPI.

There has been limited uncertainty analysis of both MAGIC and the SSWC. Some uncertainty analysis for MAGIC is presented in the REA. This activity is important and should be continued.

Beyond uncertainty analysis, efforts should also be made evaluate model structure and compare this to the structure of other models available for use. Efforts should be made to

- test models, although it is difficult to test steady state models
- improve and test the N_{eco} calculation.
- compare results from steady-state with dynamic models to obtain a sense for the time scale to achieve target ANC values.
- evaluate the effects of variation and changes in climate on model calculations.

Some of these evaluations may be feasible within the current NAAQS review cycle, while others will help to refine the standards in future reviews.

17. What are the Panel's views on the areas for future research and data collection outlined in this chapter, on relative priorities for research in these areas, and on any other areas that ought to be identified?

The future research areas outlined in Chapter 7 are appropriate. However there are other areas that should be considered for future research and data collection.

- Key uncertainties identified in the qualitative uncertainty analysis of Chapter 7 including preindustrial base cation levels, dry deposition, and ecological indicators. Any key uncertainty should be an area of future research. .
- There is a need to improve understanding of the sources, atmospheric dynamics ambient concentrations, bi-directional transport and deposition of reduced and organic nitrogen.
- Efforts should be made to develop dynamic models to simulate effects acidic deposition on soil, drainage waters and biota, to test these models and to apply these as tools in determining critical loads. Research should be conducted comparing results from steady-state and dynamic models.
- There is a need for research improving the linkages between atmospheric chemistry and transport models with watershed models. Atmospheric models typically have relatively large spatial scales and simulate over relatively short temporal scales. Watershed models simulating acidification of soil and surface waters, in contrast, have small spatial scales and simulate processes over long temporal scales. It is important to quantify the subgrid scale variability in atmospheric deposition and how this variability can be addressed in simulations of watershed response to changes in atmospheric deposition.
- It is essential that surface water monitoring programs be maintained and soil and biological monitoring programs be strengthened.
- There need to be improvements of tools and models to predict nitrogen retention of nitrogen in watersheds.
- There is a need to better understand the compensatory response of naturally occurring organic acids to decreases in acidic deposition.
- Since the current assessment was unable to address endpoints other than aquatic acidification, there is a need for research regarding endpoints such as terrestrial acidification and aquatic system nutrient enrichment.
- EPA should consider holding a follow-up workshop to further enumerate and prioritize research needs, and make an effort to translate the research needs into research activities. The panel recommends.

Chapter 8: Monitoring

18. What are the Panel's views on using an open inlet to capture all particulate size fractions for the purpose of analyzing for sulfate?
What is your opinion on using existing CASTNET filter packs as a future Federal reference method for sulfate?

As a prefacing comment on these monitoring questions (18-20), this Panel is pleased to learn that the Agency plans to consult with the AAMM Panel to identify the most appropriate monitoring approaches for this NAAQS, and we expect that more informed responses to these and other monitoring questions will be provided in that process. In conducting that monitoring review, we encourage the Agency to emphasize not just compliance determination, but the multiple monitoring objectives outlined in chapter 8 of the *Policy Assessment*, and to consider whether some of those objectives might be most effectively addressed by enhancement of and coordination among existing monitoring programs. In addition, we recommend that the membership of AAMMS be enhanced for that review by adding individuals with expertise in conducting deposition measurements, as well as in assessing the effects of deposited S and N pollutants on aquatic and/or terrestrial ecosystems.

The Panel is not opposed to considering the use of open-faced samplers, and possibly the CASTNET sampler in particular, as a possible federal reference method (FRM) for particulate sulfate, as a component of the multiple pollutant measurements needed to determine compliance with this secondary standard. It should be recognized however, that the inclusion of coarse particle sulfate (excluded in sulfate measurements by more commonly deployed fine particle samplers) will not by itself provide any information on how much of the sulfate is present in coarse mode particles and which would contribute proportionately more to deposition than their fine particle counterparts. It should also be noted that inclusion of coarse particles, which tend to be alkaline, could lead to formation of positive sampling artifacts from reactions with acidic S and N gasses.

Since the open-faced CASTNET samplers also measure particulate nitrate, and since coarse particle nitrate can contribute to nitrogen deposition, especially in areas influenced by marine aerosols, consideration should be given to evaluating the quality of CASTNET filter pack methods for particulate nitrate as well. CASTNET samplers also measure sulfur dioxide and nitric acid, and so if an alternative (to the T_{NOY}) nitrogen deposition transfer ratio could be developed (see response to question 9) based on combined measurements of HNO_3 and pNO_3. As such, all the measurements needed to determine compliance with this standard could be made by the existing CASTNET methods, which could be enhanced by adding new sites in acid and nitrogen sensitive regions, and by adding more detailed measurements like continuous NOy, SO_2, etc. at a subset of those sites to better address important objectives other than compliance. It would be unprecedented to have a compliance network operated by EPA contractor (as CASTNET currently is) rather than by state agencies. And as indicated above, there are also serious concerns with the quality of CASTNET HNO_3 and p-NO_3 data. For these reasons, it would be helpful if the proposed AAMMS review of monitoring methods for implementing this standard includes consideration of both continuous and filter pack measurements of all the relevant S and N species, as well as other approaches like passive samplers and diffusion denuders.

19. What are the Panel's views on requiring measurements of ammonia and ammonium to assist implementation of the standard?

Although NH_x deposition estimates could be supplied by CMAQ model output, additional NH_4 and especially NH_3 measurements would be extremely valuable for supporting and implementing the standard both directly - to quantify an unregulated but varying element of the compliance metric - and indirectly, to help evaluate and improve emissions inventories and CMAQ model performance. NH_4 measurements are currently available from the CASTNET and (urban) CSN networks, and could conceivably be added to IMPROVE. NH_3 measurements are currently much sparser and are more critically needed, not only for assessing a key parameter in the AAPI used in the proposed secondary standard but also for better understanding sources and trends of $PM_{2.5}$, regional haze, and sources and effects of N deposition on nutrient enrichment. The passive NH_3 sampling approach currently being deployed in the AMoN Netwok (at a subset of NADP sites) appears promising and would benefit from more dedicated EPA funding support.

20. What are the Panel's views on having a subset (e.g., 3-5 sites) of monitoring stations in different airsheds that measure for the major NO_y species; nitric acid, true NO_2, NO, PAN and p-NO_3?

Appropriate design of a network required to determine attainment with the proposed standard and to inform future reviews will require a major effort, and will require a major effort. An appropriate design will be impacted by the choices made in formulating the standard, including the form, indicator, ecoregion approach and fraction of lakes protected. Insufficient information is available at this time, and we commend EPA staff's desire to involve the AMMS in addressing the monitoring related issues. Some initial thoughts are provided below.

As suggested in the response to question 18, a slight modification to the proposed calculation of the deposition transfer ratio (currently expressed as T_{NOY}) for oxidized nitrogen deposition, might allow the use of a modestly expanded version of the existing CASTNET network to determine compliance with the proposed secondary SO_x/NO_x NAAQS. Disadvantages of this approach include the loss of valuable temporal resolution in the weekly aggregated CASTNET filter pack data, uncertainties in the portioning between nitric acid and particulate nitrate, and the exclusion of important NO_y components like NO, NO_2 and PAN, which better reflect the sources of oxidized nitrogen emissions, which eventually contribute to N deposition downwind, and/or which may represent important components of total deposition at some locations.

For these reasons, it is important for implementing this secondary standard that existing monitoring network be expanded by adding sites in different kinds of sensitive areas, and refined by adding more detailed supplemental measurements at a small subset of these sites. Valuable supplemental measurements would include continuous NOy and trace SO_2, PAN, true NO_2, and possibly continuous nitric acid, p-NO_3, and NH_3. Possibly there will be opportunities to add CASTNET filter packs, passive samplers, denuder analyses, and/or other supplemental measurements to several of the existing or planned rural NCore sites. Such measurements would not only help respond to the multiple objectives for this secondary standard outlined on page 8-1 of the PA, they would also be of great value for improving data analysis and modeling assessments of sources, atmospheric chemistry, transport of and the effectiveness of control strategies for ozone, $PM_{2.5}$ and regional haze.

Chapter 9: Conclusions

21. What are the Panel's views on the overall characterization of uncertainty as it relates to the determination of an ecologically-relevant multi-pollutant standard for NOx and SOx?

EPA has done a good job of qualitatively discussing uncertainties in Chapter 7 and reviewing them in Chapter 9. As noted in response to charge questions 14-16, CASAC believes it is important that there is further progress on quantitative analysis of sensitivity and uncertainty, for key components of the AAPI, for the combined effect of multiple uncertainties on the AAPI, and implications for specification of the trade-off between NOy and SOx allowable concentrations. In Chapter 9, EPA should provide a concise summary of those key uncertainties that are most likely to lead to bias, imprecision, or both, in the AAPI, and the implications of such uncertainties when translating an ANC target into an associated AAPI level. For example, given biases, should the selected AAPI be higher or lower than implied by a specific target ANC? Given imprecision, what range of AAPI might be consistent with a particular target ANC? EPA should conduct a more complete evaluation of the CMAQ simulations used to calculate the deposition transfer coefficients and consider additional processes, such as internal sulfur sources, in the AAPI.

The choice of averaging times and whether only such averages or used, or whether shorter term episodes will be considered, needs to inform the variability and uncertainty analyses of Chapter 7. This is because the range of variability and uncertainty depend on averaging time. Similarly, the geographic scope needs to be taken into account in the analysis of variability and uncertainty. The spatial options for components of the AAPI equation need to be further discussed in terms of implications for variability and uncertainty.

22. What are the Panel's views on the following:

a. The insights that can be gained into potential alternative additional secondary standards (using the AAPI form) by considering:

- *i. Information from studies on the relationship between mortality in aquatic organisms and pH and ANC?*
- *ii. Information from studies on the relationship between fish health and/or biodiversity metrics and pH and ANC?*
- *iii. Information on the relationship between pH, Al, and ANC?*
- *iv. Information on target ANC levels identified by states and regions, as well as other nations?*

Each of the sources of information mentioned in the charge question both separately and taken together provide a compelling case on the relationships between ANC and other water quality metrics that are associated with biotic health of waters, and provide insight regarding target ANC values. Text should be provided on the validity of spatial survey data when applied to infer temporal relationships. Different states and nations have identified different target levels. Some use pH, others use ANC. It will be helpful to explain and compare how these values were developed. Chapter 9 could clearly and briefly summarize possible co-benefits and unintended consequences of various alternatives for the standard. For example, to what extent might a standard focused on aquatic acidification also be protective of terrestrial acidification or aquatic nutrient enrichment? Would higher levels of target ANC provide more protection for these other effects? These points can be made while still placing emphasis on the sufficiency of the scientific evidence supporting the need for a revised standard to protect from aquatic acidification.

b. The appropriate role of qualitative and quantitative characterizations of uncertainty in developing standards using the AAPI form?

Conceptually, the AAPI approach is compelling and appropriate. There are uncertainties associated with the practical use of AAPI that should be more fully evaluated. The sensitivity and uncertainty characterization of the AAPI needs to include not only statistical analyses associated with specific model parameters individually, but also consider their joint effect (taking into account covariance and dependencies) and an evaluation of possible omissions (e.g. reduced nitrogen inputs, contribution of sulfate sources and sinks in soil). To the extent possible, biases and imprecision in values of AAPI associated with a target level of ANC should be quantified, and these uncertainties should be used to inform specification of ranges of AAPI associated with a target ANC that may be more or less protective within the range of scientific uncertainty. This would lead to a family of NO_y-SO_x trade-off curves associated with each target ANC for a given geographic location. A specific standard would be set by choosing an AAPI within the range of scientific uncertainty, which would then be associated with just one NO_y-SO_x trade-off curve per region. EPA staff is encouraged to offer reasonable judgments about the range of uncertainty in AAPI for a given ANC target based on factors difficult to quantify within the time period of the assessment, such as the preindustrial cation weathering, the deposition transfer ratios, unmodeled factors, ancillary benefits, and unintended consequences.

c. The role of considerations regarding the relationship of the standard to:

i. the time trajectory of response, e.g. when specific ANC levels are likely to be realized given a specific level of the AAPI?

Based on recent observations and dynamic model calculations, the time response to recovery from decreases in acidic deposition is very slow. Because of accumulation of sulfur in soils, it is likely that the timescale for recovery of watershed in the Southeast would likely be even longer. Factors such as changes in climate and CO2 concentration in the atmosphere could affect the time trajectory, and the effects may be substantially different between aquatic and terrestrial ecosystems.

ii. the likelihood of damages to aquatic ecosystems due to episodic acidification events given a specific target for chronic ANC?

Based on surface waters studied in the Northeast, decreases in ANC associated with snowmelt is approximately 50 µeq/L. Thus a long term ANC target level of 75 µeq/L would generally guard against effects from episodic acidification down to a level of about 25 µeq/L.

iii. the levels of co-protection for terrestrial ecosystems against acidification effects and the for aquatic and terrestrial ecosystems against effects of excess nutrient enrichment?

There may be co-benefits to terrestrial and coastal ecosystems, and with respect to mercury methylation associated with decreases in sulfur dioxide and nitrogen oxide emissions. Aquatic ecosystems may not be more sensitive to acidic deposition than terrestrial ecosystems. Many soil time series studies suggest ongoing soil acidification while surface waters are recovering from acidic deposition. This may also suggest that soil is more “sensitive” to inputs of acidic deposition than surface waters. Levels of protection provided by the proposed standard against nutritional N effects in terrestrial ecosystems are uncertain, especially in arid and semi-arid zones, and should be evaluated.

23. What are the Panel’s views on Staff’s conclusion that the existing secondary standards for NO_x and SO_x should be retained to provide protection against direct adverse effects to vegetation due to gas phase exposures?

Based on the information presented in the PA, the scientific understanding of effects from direct foliar exposures to gaseous sulfur and nitrogen oxides has not changed appreciably, and the existing secondary standards for SO_2 and NO_2 should be retained. The indicators, averaging times, levels and forms of the current standards are not appropriate for addressing the (indirect) effects of SOx and NOx deposition to acid-sensitive ecosystems. Therefore, the existing secondary standards need to be supplemented with additional secondary standards to protect against adverse effects from acidic deposition.

24. In light of the Panel’s views on what constitutes adverse effects to public welfare (see Chapter 3), what are the Panel’s views on:

a) the degree to which current levels of NO_y and SO_x deposition are adverse to public welfare based on evidence and risk information, and information on adversity provided in Chapters 2,3, and 4?

Current and cumulative levels of NO_y and SO_x deposition have been shown to result in environmental damage to an extent that is adverse to public welfare. The effects include acidification of aquatic and terrestrial ecosystems and nutrient enrichment. However, the panel felt that descriptive information about that adversity and its significance could be better and more comprehensively articulated, and that additional discussion of the possible benefits of S and N deposition would be helpful.

b) target values for ANC that protect against adversity to public welfare in light of the information presented in Chapter 5 concerning levels of ANC and the ecosystem effects associated with those target ANC levels?

ANC is an appropriate environmental indicator. The case is well supported for a target of at least 50, and perhaps even higher (75-100) since a greater degree of protection for aquatic, and some terrestrial ecosystems is likely with higher ANC targets.

c) factors relevant in selecting target percentages of waterbodies to protect at alternative target ANC levels to protect against adverse effects to public welfare, and weights to place on those factors?

The justification, logic and necessity of the spatial grouping classifications was not clear to the panel. It is not clear what is gained by the added complexities of going beyond the two groups of sensitive and not sensitive, although there is inherent appeal to taking into account available information about variations across eco-regions. Because there is large variability in inherent sensitivities of water bodies to acidification effects among different regions and even within regions, protecting a target percentage of lakes from the populations which are potentially susceptible to acidification seems logical, however. It seems that the target should be higher than the current percentages of sensitive water bodies that are below the target ANC.

d) alternative standards for NO_x and SO_x that would protect against adverse effects to public welfare based on the AAPI form, and taking into account

- *consideration of target levels of ANC (chapter 5),*

The panel concurred that ANC levels from 20 to 100 were appropriate to consider, and that a level of about 50 μeq/L is most defensible based on the information presented.

- *target percentage of water bodies to protect (chapter 5),*

The panel felt that this choice was a value judgment and somewhat arbitrary. Insufficient analysis was provided to adequately support a choice at this time. However, the panel felt that protecting only half of sensitive surface waters was probably too low. The panel notes that the target percentage will also be influenced by whether the filters discussed earlier (naturally acidified systems, for example) are applied.

- *consideration of relevant uncertainties in AAPI components (chapter 7),*

The Panel spent considerable time discussing how and what is necessary to characterize relevant uncertainties in AAPI components in order to answer this and other questions about the PA. The current sensitivity and uncertainty analysis should be strengthened. For suggestions on specific AAPI components see the responses to charge questions 5, 9, 14, 15, 16 and 22. The panel would also particularly like to see some assessment of the cumulative uncertainties associated with the complete AAPI calculation. One approach to this might be to employ available measurement data and model calculations to compare levels and changes in AAPI estimates over the past 20 years with concurrent ANC levels in surface waters. In some cases, individual components of the APPI could also be compared with their measured counterparts over the same recent time period. The goal of these syntheses and analyses would be to lend defensibility to the approach, provide broad bounds on uncertainties, or, in some cases to provide reality checks on the components of the AAPI.

- *any other potentially relevant factors, such as levels of co-protection against terrestrial acidification and nutrient enrichment (chapter 6)?*

It seems likely that a standard that reduces acidifying deposition to acid-sensitive ecosystems would provide some co-protection benefits to acid-sensitive terrestrial ecosystems. If attaining such a standard results in regional-scale reductions in nitrogen deposition, there may also be reductions in plant growth rates in aquatic or terrestrial ecosystems or components of those ecosystems. These growth rate changes might be viewed as either benefits or dis-benefits, depending on the specific ecosystem and management objective. It is not currently possible to provide quantitative estimates of co-protection benefits or dis-benefits, but it would be useful to qualitatively discuss these associated effects in the final *Policy Assessment* document.