UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

[Date]

EPA-COUNCIL-10-xxx

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

Subject: Review of Air Quality Modeling for the Second Section 812 Prospective Study of Benefits and Costs of the Clean Air Act

Dear Administrator Jackson:

The Air Quality Modeling Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis (Council) met in February and March of this year to review air quality modeling being conducted to support the Second Section 812 Prospective Study on the Costs and Benefits of the Clean Air Act. The AQMS is charged to review the air quality modeling component, with other parts of the integrated analysis being reviewed by the Council's Health Effects and Ecological Effects Subcommittees and by the full Council.

The Subcommittee reviewed the data sources and modeling methods used to produce future scenarios with and without CAAA programs. The objective of the modeling work is to estimate differences in ambient concentrations of air pollutants for future scenarios, with a focus on ozone and fine particulate matter ($PM_{2.5}$). The projected differences in ambient concentrations are then used to derive estimates of benefits to human health, welfare and the environment.

Overall, the AQMS concluded that the air quality modeling results were appropriate for use in the 812 analysis, pending the further quality assurance checks described in our report. The use of a single, integrated modeling platform (the Community Multiscale Air Quality model, CMAQ) to estimate ambient concentrations of PM and ozone was a significant improvement over the previous 812 study, allowing consistent and efficient estimation of air quality impacts from CAAA programs. CMAQ is a state-of-the-science tool.

The data chosen for the analyses were appropriate and drew upon readily available emissions data from multiple programs. During the review, errors were noted in several components of the $PM_{2.5}$ emissions inventories that had been used to model future air quality. A cover memo should be added to the current modeling report to alert future users of the report to these issues. The Agency proposed an approach to correct these inventories and described a method to adjust CMAQ model outputs using the Modeled Attainment Test Software (MATS) without re-running CMAQ. Based on preliminary results provided to the Subcommittee, the AQMS supports the use of the adjusted $PM_{2.5}$ mass differences between the *with* and *without-CAAA* scenarios in the 2010 and 2020 cases as inputs into estimation of benefits from the CAAA.

The Subcommittee is aware that the Agency may not choose to conduct additional prospective Section 812 reports. Therefore, the primary focus of our advice is on needed enhancements to the present study to fully document the data choices and methodological approaches taken. However, we note the value in conducting comprehensive assessments of the costs and benefits of significant environmental laws such as the CAAA. In our report, we recommend additional refinements that might be incorporated in future assessments, including a broader array of air pollutants and consideration of the impacts of climate change on the analyses.

We appreciate the opportunity to provide our review and advice on the air quality modeling component of the Section 812 Study, and we look forward to your response.

Sincerely,

Dr. James K. Hammitt, Chair	Dr. Armistead Russell, Chair
Advisory Council on Clean Air Compliance Analysis	Air Quality Modeling Subcommittee

NOTICE

U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis
Air Quality Modeling Subcommittee

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1. EXECUTIVE SUMMARY

The Air Quality Modeling Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis reviewed the draft report, *Second Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling*, and other relevant materials at meetings in February and March of 2010. The materials describe the air emissions inventories and other modeling inputs, and ambient air quality results for seven scenarios: a 1990 baseline simulation; and simulations for 2000, 2010 and 2020 with and without the 1990 Clean Air Act Amendments (CAAA). The analyses use the Community Multiscale Air Quality (CMAQ) model to simulate national and regional-scale (western U.S. and eastern U.S.) concentrations of ozone and fine particulates ($PM_{2.5}$). Differences in projected ambient concentrations of air pollutants with and without-CAAA controls are the basis for subsequent estimation of human health and environmental benefits.

In addition to the CMAQ model results, the Subcommittee reviewed documentation on CMAQ model performance, qualitative uncertainty associated with model outputs, and use of Modeled Attainment Test Software (MATS) to adjust CMAQ outputs for use in benefit estimation.

Overall, the AQMS concluded that the results of the air quality modeling were appropriate for use in the 812 analysis, pending the further quality assurance checks discussed in the Subcommittee report. The use of a single, integrated simulation platform (CMAQ) for both PM and ozone was a significant improvement over the First Prospective Study, allowing consistent and efficient estimation of air quality impacts from Clean Air Act programs. While the overall physical and chemical system being modeled is extremely complex, and there are areas of appreciable uncertainty, the CMAQ model is a state-of-the science tool. Data choices were appropriate and drew upon readily available emissions data and ambient data from multiple monitoring networks.

The Subcommittee recommends that additional detail be included in the review document, or in accompanying technical memoranda, to more clearly describe the data choices and analyses to allow interpretation of model results. As the study team selectively adds detail to the report or technical memoranda, emphasis should be placed on those portions of the analyses that have the most significant impact on estimates of PM concentration reductions, since these will have the greatest impact on estimated benefits.

Of particular concern to the AQMS was the need to document the application of MATS to the CMAQ outputs. This important step in the modeling analysis was not described in the review document. CMAQ is known to have biases (e.g., underestimation of secondary aerosol formation), and errors in the emissions inventories resulted in overestimation of some sources of $PM_{2.5}$. For these reasons, the MATS step was important to generate model projections for $PM_{2.5}$ species that are consistent with monitoring data. The Subcommittee reviewed preliminary MATS results for sample cities, to compare MATS-adjusted values with CMAQ concentrations and monitor data, and agreed that MATS-adjusted data were more representative of monitored values than CMAQ concentrations. The Subcommittee requested similar comparisons for additional locations, with an emphasis on high population areas where the majority of $PM_{2.5}$ health benefits would occur. If projections for these additional locations show reasonable values across $PM_{2.5}$

species, the AQMS supports the use of the MATS-adjusted $PM_{2.5}$ mass differences between the *with-CAAA* and *without-CAAA* scenarios as inputs for estimation of benefits.

At the March 15, 2010 AQMS meeting, the Agency presented a proposed process to revise the emissions inventories for area sources and non-EGU point sources, as well as a scaling process using the revised $PM_{2.5}$ emissions inventories to adjust CMAQ outputs without rerunning the model. The Subcommittee feels it would be preferable to run the CMAQ scenarios using the corrected emissions inventories. However, if time and resource constraints preclude this option, the scaling procedure should be clearly documented in the draft modeling report (Douglas et al., 2008) or in a separate document that also describes the MATS adjustment procedure and results, including the results of MATS with and without scaling of emissions. The draft CMAQ report also should include a note that errors in the $PM_{2.5}$ inventories for area sources have not been corrected in the simulation results presented.

For future analyses of the CAAA, the AQMS recommends additional comparisons of projected emissions to actual emissions for certain source categories; public release of baseline and projected gridded emissions data and model results; and inclusion of additional emissions categories (e.g., ammonia , methane, transboundary emissions) that are important contributors to environmental and health impacts. In addition, the Agency should assess the sensitivity of air quality model outputs to changing climate by evaluating how the choice of meteorological year influences model projections for longer time frames (e.g., longer than 30 years).

2. INTRODUCTION

2.1. Background

Section 812 of the Clean Air Act Amendments (CAAA) of 1990 directed the U.S. Environmental Protection Agency (EPA) to periodically evaluate the costs, benefits and other effects of compliance with the Clean Air Act. Section 812 further directed the Agency to establish the Advisory Council on Clean Air Compliance Analysis (Council) and to seek the Council's review of Agency analyses prepared under the Section. The Council and its Subcommittees have reviewed previous reports prepared for a retrospective analysis of the impacts of the Clean Air Act (for 1970-1990) and a prospective analysis (for 1990-2010). For the current review, the Council's Air Quality Modeling Subcommittee (AQMS) was asked to evaluate the air quality modeling conducted for the second prospective analysis, covering the period 1990-2020.

The draft report, *Second Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling* (Douglas et al., 2008), describes the analytical approach taken by the Agency's Project Team, including development of air emissions inventories for base years, and use of the Community Multiscale Air Quality (CMAQ) model to simulate future ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone under scenarios with and without CAAA programs. Projected decreases in air pollutant concentrations are used to estimate future benefits to human health, welfare and the environment. The AQMS is charged to review the air quality modeling component, with other parts of the integrated analysis being reviewed by the Council's Health Effects and Ecological Effects Subcommittees and by the full Council.

The *Second Prospective Analysis of Air Quality Modeling in the US.: Air Quality Modeling* draft report presents an overview of the results of applying the CMAQ model to the United States. Accompanying the report was a memorandum discussing model performance (Douglas and Myers, 2009). The report, and the attached memo, provide a brief exposition of the approach taken, including the data used in the air quality modeling (e.g., the emissions and meteorology), how those inputs are handled, and the results. There is a brief discussion of the attributes and limitations, as well as a short Summary and Recommendations for Future Research. In addition to the report, EPA staff and their consultants made a presentation to and addressed questions from the Subcommittee at a meeting on February 19, 2010. At the February meeting, the AQMS requested further clarification of the modeling analyses, including information on the method used to adjust CMAQ model outputs prior to the estimation of benefits. A teleconference meeting of the AQMS was held on March 15, 2010 to consider additional materials supplied by the Agency in response to the Subcommittee request, and to discuss and finalize the Subcommittee's advisory report.

2.2. Charge to the Subcommittee

The Air Quality Modeling Subcommittee was asked to review the draft report, *Second Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling* (Douglas et al., 2008), and address three Charge Questions. The three questions pertained to the (1) Appropriateness of the choices of the data used, (2) Methodological choices, and possible alternatives, and (3) Validity and utility of the results, and what changes should be considered for the present or future analyses.

In addition to the draft report, the following background materials were provided to the Subcommittee:

- Evaluation of CMAQ Model Performance for the 812 Prospective II Study. Memorandum from Sharon Douglas and Tom Myers, ICF International, to Jim DeMocker, EPA Office of Policy Analysis and Review (Douglas and Myers, 2009)

After the February meeting, EPA provided supplemental materials on uncertainties in the Section 812 analyses and adjustments to CMAQ model outputs using MATS, which were discussed at the March 15, 2010 AQMS meeting:

- *Chapter 3: Emissions and Air Quality Modeling Uncertainty* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. February 2010)
- *Appendix B: Uncertainty Analysis of the Integrated Air Quality Modeling System* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. February 2010)
- *Appendix C: Qualitative Uncertainty Summary Tables for Second Section 812 Prospective Analysis of the Clean Air Act* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. November 2009)
- MATS Estimates of $PM_{2.5}$ for the Section 812 Scenarios. Memorandum from Leland Deck, Stratus Consulting, to Jim Neumann, Industrial Economics (Deck, 2010).

The following sections provide the Subcommittee's general comments regarding the draft report and background materials and meeting presentations, as well as specific responses to each of the Charge Questions.

3. General Comments

Overall, the AQMS concluded that the results of the air quality modeling were appropriate for use in the 812 analysis, pending the further quality assurance checks discussed at the February meeting and our review of additional information provided by the Agency in response to our questions. The AQMS identified a number of issues that should be addressed, either by revising the draft air quality modeling report or by preparation of one or more Technical Memoranda. In conducting this review and making recommendations, the AQMS recognizes the limited time available to conduct further analyses and modify the draft report. As such, we have focused on areas that we believe are most critical to inform potential users of the report, and to assist the Council in its review of the integrated report on the benefits and costs of the CAAA (the Second Section 812 Prospective Study).

First, the report is very brief, and in many cases lacks sufficient detail to clearly describe the analyses and allow interpretation of model results. (This pertains to most sections of the report and the memorandum documenting model performance.) For example, having increased detail on the speciation of the primary particulate matter (PM) emissions is desirable to better understand whether emission inventories are realistic in comparison with observational data. There also was little discussion about the representativeness of the 2002 meteorological data chosen as input to the air quality model or how this choice might impact the modeling results. As the study team selectively adds detail to the report, emphasis should be placed on those portions of the analyses that have the most significant impact on the estimates of PM concentration reductions, since these will have the greatest impact on estimated benefits.

A second general comment involves the choice of air quality models. In prior discussions between EPA and the AQMS, it was proposed to use two air quality models, applying CMAQ for assessing PM impacts and CAMx for assessing ozone impacts. The choice to use one simulation platform, in this case CMAQ, is appropriate for both consistency reasons as well as conservation of resources. CMAQ is a widely used model, both for regulatory and research purposes. It generally utilizes approaches that are at or near the state-of-the-science for air quality modeling, and has been evaluated in a very large number of applications.

Third, while the approach taken for emissions estimation appears reasonable, the different methods applied for *with* and *without-CAAA* scenarios may complicate interpretation of the results. In particular, how does relating all of the *without-CAAA* inventories to the 1990 inventory compare with relating all of the *with-CAAA* inventories to inventories from 2000? Could a significant portion of the differences in air quality between the scenarios be due to differences between the starting points (e.g., in vehicle miles traveled, or VMT), rather than effects of the CAAA?

Fourth, the Subcommittee has some concern with the application of two spatial domains for the modeling. CMAQ was applied using 2002 meteorology in three different configurations: a continental US domain using 36-km resolution grids, and two sub-domains (eastern US and western US) using 12-km resolution grids. The Subcommittee agrees that 2002 is a good choice for base year as it has been widely used by others for CMAQ modeling and thus this application builds on a very solid foundation and set of model application evaluations. However, the decision to use both national and regional domains introduces some issues, and the rationale for including both scales is not explained well in the document. For example, the two 12-km domains used to model seasonal ozone omit portions of the US (e.g., parts of Texas, Maine, and Florida), and the 36 km domain omits Alaska and Hawaii. How are those areas treated when accounting for the potential impacts? Also, while the report states that results from the 36 and 12-km domain simulations were compared, a quantitative comparison should be provided. (It is well established that finer grid cell resolutions will lead to increases in maximum concentrations.) The results showing the differences between *with* and *without-CAAA* simulations indicate a wide range of difference values (e.g., Fig.s IV-10 and IV-23). These very large differences in the Maximum and Minimums of the differences should be explored and explained. Also, the integrated results (e.g., Table IV-6) should be compared between the domains and any significant differences in the ozone or PM results from the different model resolutions should be discussed.

The CMAQ model performance evaluation memo (Douglas and Myers, 2009), along with the widespread use and evaluation of the model in other applications by other groups, provides reassurance that CMAQ is providing results appropriate for use in the 812 study. The Subcommittee notes, however, that the evaluation is focused on performance for a single year. It is now possible to compare model simulations against air quality observations for additional years, for 1990, 2000 and 2010 (2009 in the latter case). Multiple years can be used to control for meteorological issues. As an alternative, results of other studies that have looked at CMAQ model performance can be cited and emissions estimates from those studies can be compared to monitoring data. A weakness in the discussion of CMAQ performance, and one that should be discussed in the report, is that CMAQ version 4.6 typically underestimates organic aerosol levels, and this is suspected to be due to underestimating secondary organic aerosol (SOA) formation. The simulated reductions in $PM_{2.5}$ due to CAAA controls might be larger if this issue were corrected. The report also notes that deposition of sulfur and nitrogen compounds was calculated from the model outputs; these results, which are important for ecological benefits assessment, were not presented, discussed or evaluated in the report.

The draft report focuses almost exclusively on the projected reductions in pollutant concentrations when Clean Air Act-related controls are simulated. However, concentration increases, sometimes large, are simulated for some pollutants in some scenarios. These modeled increases should be identified and discussed. Are the simulated increases in concentrations relevant or are they numerical artifacts? Will they impact the health analyses?

The Subcommittee also noted that the report lacks adequate discussion of the $PM_{2.5}$ components. For example, a likely large source of secondary organic aerosol is biogenic emissions from vegetation and soil biota, which is not mentioned. The report refers to nitrogen-based fertilizers as being responsible for the increased nitrate, which is true, but it is specifically the ammonia that plays a very large role and the report should say this.

A significant issue that arose during the review was the way in which the CMAQ outputs would be used to generate estimates of health benefits. CMAQ is known to have biases in the simulated formation of secondary organic aerosols, leading the model to underestimate the contribution of these components to $PM_{2.5}$. Further, errors in the emission inventories (e.g., in primary $PM_{2.5}$ from road dust re-entrainment) also can lead to biases. These biases are manifested by consistent differences, sometimes large, between observed and simulated species concentrations. The Subcommittee was concerned that these biases could significantly impact the health analyses based on the CMAQ results. At the February review meeting, the Subcommittee learned that the CMAQ results were being run through the Modeled Attainment Test Software (MATS) to transform modeled changes in $PM_{2.5}$ and ozone for input to the health effects assessment. The Subcommittee agreed that application of MATS can minimize the impact of biases in the CMAQ results. The use of MATS is an important step in the air quality modeling process, and the Subcommittee requested additional information from EPA that documented this step. (This issue is discussed further in Section 4.2 on Air Quality Modeling Methodology.)

And finally, the draft report submitted to the Subcommittee was written in 2008, which led to some historical writing issues. The regulatory scenarios included the current NAAQS for ozone, which will likely soon change, and assumed implementation of proposed air quality rules (the Clean Air Interstate Rule and the Clean Air Mercury Rule) that have been remanded or vacated by the DC Circuit Court. Also, the analyses used CMAQ version 4.6, which is no longer the most recent version of the model.

4. Response to Charge Questions

4.1. <u>Emissions Data and Other Model Inputs</u>

<u>Charge Question 1</u>: Does the AQMS support the data choices made by the 812 Project Team for the development of the air quality modeling estimates documented in the draft air quality modeling report? If not, are there alternative data sets that should have been used?

The AQMS supports the data choices made by the 812 Project Team. In particular, the AQMS concurs with the Team's use of readily available emissions data from EPA supplemented by information from the five Regional Planning Organizations (RPOs); well-tested and reasonably representative 2002 meteorology data bases for the simulations; and multiple observational data sets for model evaluations. The AQMS did not identify any alternative data that should be used, though the use of some additional data, or providing additional details of the data presented, would enhance the report. The Subcommittee recommends that additional information on data choices be included in the draft report, including clarification of the following:

Emissions Data

- Treatment of unidentified local controls (used to reach attainment for *with-CAAA* scenarios)
- Summary of the new source category code (SCC) categories included
- Extent to which technological advances have been taken into account for the non-EGU sources
- A full list of chemicals in the inventory
- Summary of the national, state, and local regulations that were on the books as of September 2005 (used to develop the *with-CAAA* emission inventories)
- Discussion of the drop in total VOC emissions from the 1990 scenario to the 2000 *without-CAAA* scenario
- Discussion of how emissions from wildfires may be affecting model performance
- Summary of the selection process for biogenic emissions
- Extended description of development of speciated $PM_{2.5}$ primary emissions with particular emphasis on organic aerosol emissions
- Justification for treatment of Mexican and Canadian emissions (e.g., transborder emissions were held constant over all scenarios, which differs from the approach used by EPA in determining the Policy Relevant Background for NAAQS reviews)

Meteorological Data

- Justification for using 2002 meteorology
- Performance evaluation of the 2002 meteorological modeling results

Air Quality Inputs

- The levels chosen for boundary conditions on ozone and PM, and their precursors, should be specified, with reasons for and likely impact of those choices.

$PM_{2.5}$ Emissions Inventories

After the February 19, 2010 meeting, the AQMS was informed by the Agency that Fugitive Dust Transport Factors (FDTF) had, through an oversight, not been applied to PM emissions inventories prior to their input to the CMAQ model. Fugitive dust emissions include fine particulates from soil-disturbing activities (e.g., agriculture), construction of buildings or roads, and wear of road surfaces. Depending on surrounding land uses or land cover, some percent of dust is not transported into the atmosphere to affect air quality. FDTFs can be applied to relevant categories of emissions inventories to correct for this effect so that primary $PM_{2.5}$ levels are not elevated relative to monitored values.

At the March 15, 2010 meeting, the Subcommittee was briefed on Agency plans to adjust the inventories and gridded concentration projections to more accurately capture $PM_{2.5}$ differences between the various scenarios without rerunning CMAQ. AQMS members generally agreed that adjustment ratios could be used to scale the CMAQ outputs if resource and time constraints preclude rerunning CMAQ with the adjusted inventories. However, the scaling procedure to be applied to emission inventories and CMAQ outputs should be clearly documented, either in the draft report describing the CMAQ modeling or in a separate document that also describes the MATS adjustment procedure and results, including the results of MATS with and without scaling of emissions. If the latter approach is taken, the draft CMAQ modeling report (Douglas et al., 2008) should include a note that errors in the $PM_{2.5}$ inventories for area sources have not been corrected.

4.2. <u>Air Quality Modeling Methodology</u>

<u>Charge Question 2</u>: Does the AQMS support the methodological choices made for analyzing those data and developing the estimated changes in air quality conditions between the with-CAAA90 and without-CAAA90 core scenarios? If not, are there alternative methodologies that should have been used?

The AQMS generally supports the approaches used to estimate the impact on air quality of the 1990 Clean Air Act Amendments. As with the data choices, the report could be enhanced by providing further details on the modeling methodology, as discussed below. Of particular concern to the Subcommittee is the need to describe the method used to transform the air quality modeling results into changes in $PM_{2.5}$ and ozone levels (i.e., use of the Modeled Attainment Test Software, or MATS) for the benefits analysis.

The use of CMAQ for the air quality modeling is a significant improvement over modeling done for the first prospective analysis. CMAQ allows for consistent estimates of all of the key parameters needed for a comprehensive analysis of the costs and benefits of the CAAA. The tagging analysis, where emissions of precursor pollutants are tagged and tracked through a simulation, also provides useful information. The Subcommittee is impressed with the methods and approaches taken in quantifying air quality improvements associated with implementing the Clean Air Act Amendments. It appears that state-of-the-science modeling tools have been appropriately used to estimate changes in air quality associated with projected emission changes. While the overall physical and chemical system being modeled is extremely complex, and there are some areas containing appreciable uncertainty, the results presented constitute the "best of our knowledge" at the present time.

Subcommittee members expressed some concerns about the duplicate simulations in many areas of the US at 12 and 36-km model resolutions. To simplify the presentation of results, we suggest that the combined simulations should be considered as a consolidated "nested" type of modeling database. The 12-km resolution model outputs should be used when and where they are available, but 36-km resolution information should be used for regions and time periods outside the 12-km resolution domains (e.g., for ozone in "off season" periods).

The Particle Precursor Tagging Methodology (PPTM) discussed in the report can provide useful diagnostic information for interpreting and understanding the contribution of various emission sources to the simulation results. However, nonlinear chemical reactions take place within each model grid, and re-apportioning the resulting concentrations back to the tagged "particle" from the different emission sources can become intractable. If one simply re-apportioned the species concentrations back to the different tagged "particles" in proportion to the contributions of their pre-reaction concentrations in the model grid, the identity of the tagged particles would become distorted and the meaning of tagging would be lost. Thus, the PPTM procedure remains a subject for further investigation and we recommend that the discussion of this diagnostic information be de-emphasized in the final report.

The Subcommittee agrees that unidentified local controls (ULC) are required to model attainment in *with-CAAA* emission scenarios. We note, however, that inclusion of ULC in the modeling exercise is no guarantee that such controls will actually be applied in the real world.

The Subcommittee identified two areas where technical information was particularly lacking in the report, and for which additional information was requested from the Agency: (1) the use of the Modeled Attainment Test Software (MATS) to transform the modeled changes in $PM_{2.5}$ and ozone to changes used in the health effects assessment, and (2) a discussion of sources and relative magnitudes of uncertainty in the analyses.

MATS. At the February 19, 2010 meeting, the Subcommittee learned that the CMAQ outputs were being adjusted using the Modeled Attainment Test Software (MATS), although the review document on air quality modeling does not describe what was done nor the results. MATS performs a spatial interpolation of monitored data, adjusts spatial fields based on model output gradients, and multiplies the fields by model-calculated relative response factors (RRF) to generate future-year concentrations for each CMAQ grid cell.

Following the meeting, the Agency provided information on the methods used to create $PM_{2.5}$ air quality estimates by applying MATS to CMAQ results (Deck, 2010). The aggregate national comparisons of CMAQ outputs, MATS-adjusted outputs, and data from Federal Reference Method (FRM) monitors show that the MATS-adjusted values more closely match the monitored values for $PM_{2.5}$. Additional comparisons of CMAQ, MATS, and monitored $PM_{2.5}$

were provided at the March 15 meeting for three sample locations (Tulare County, CA; Morris County, NJ; Lawrence County, TN) and MATS results at the three locations for *with* and *without-CAAA* scenarios. The $PM_{2.5}$ speciation appeared reasonable for the 3 locations, but the Subcommittee requested similar comparisons for additional locations, with an emphasis on high population areas (e.g., cities with populations over 5 million) where the majority of health benefits from reduced $PM_{2.5}$ would occur. If model projections for these additional locations show reasonable concentration values across important $PM_{2.5}$ species (i.e., consistent with monitored values), the AQMS supports the use of the $PM_{2.5}$ mass differences between the *with-CAAA* and *without-CAAA* scenarios in the 2010 and 2020 future cases as inputs into estimation of benefits.

Uncertainty. In a complex set of analyses such as are being conducted for the Second Section 812 Prospective Study, there are numerous sources of uncertainty associated with data and modeling assumptions, and as outputs from one model are input to another. A proper characterization of uncertainty is important for the appropriate further use of the results of this, and related, reports. The AQMS understands that uncertainty information has been characterized as part of the overall 812 work, and this characterization will be documented in a stand-alone report and in the integrated 812 report. Based on a quick review of the uncertainty materials provided for the March 15, 2010 meeting, the AQMS concluded that the relevant sources of uncertainty for the emissions and air quality modeling have been included. The Subcommittee recommends that the air quality modeling reports include references to the uncertainty reports and/or chapters. In addition, if scaling is used to adjust emissions inventories for $PM_{2.5}$ (as discussed in Section 4.1 above), this new source of uncertainty should be included in qualitative uncertainty summary tables that will accompany the final 812 report.

4.3. Utility of the Air Quality Scenarios

Charge Question 3a: What advice does the AQMS have for the Council regarding the validity and utility of the estimated changes in air quality conditions between the with-CAAA90 and without-CAAA90 core scenarios in the draft air quality modeling report?

Given great uncertainties in the data and a large number of methodological choices even in the simulations of the past and current air quality, let alone the realism of input information for future air quality, the AQMS recommends that the word “validity” not be used to characterize the current 812 Project modeling study. That said, the AQMS considers the current modeling exercise to be on good technical ground, given the use of the state-of-the-science of the model and the input information provided at the time. In addition, use of the predicted model concentration changes rather than predicted absolute concentrations improves the reasonableness of the model predictions for estimating benefits of the CAAA.

4.4. Recommendations for Future Analyses

> <u>Charge Question 3b</u>*: What specific improvements does the Council AQMS recommend that the 812 Project Team consider, either for the present analysis or as part of a longer term research and development program?*

For potential longer-term research and development efforts, the AQMS has the following recommendations.

1) Expand comparisons of model results to observational data.

For longer-term future activities, a continuing evaluation of the accuracy of future emissions projections over time would provide a valuable service. For example, the comparison of 2010 emission projections made in the first prospective analysis with those resulting from the second (current) analysis provides helpful insights. It will also soon be possible to compare the current assessment's 2010 projections with actual 2010 emissions for certain source categories like EGUs, or with more recent estimates, such as mobile source emissions from the MOVES model. It might also be useful to employ "modern" emission estimation tools to back-cast historical emissions inventories to allow more accurate "apples vs. apples" evaluations of the nature and effects of changing emissions over time.

2) Make all data publicly available.

The baseline and projected gridded emissions data and model results for the base year and future projections would be useful data sources for future applications and evaluations if they were made publicly available through integrated data delivery and analysis platforms like datafed.net. In addition, the utility of the current report would be substantially improved by providing the MATS-adjusted model results to relate the estimated changes among PM species and source category contributions *with* and *without-CAAA* influences for the baseline and future projection years.

3) Consider expanding the scope of the analysis.

At some point it may be useful to consider "beyond the current CAAA" control strategies (such as reductions in ammonia or methane) that would allow for more efficient future air quality improvements than current CAAA mechanisms allow. As overall emissions continue to decrease, it is important to incorporate the methane emissions since they have direct impacts on background ozone concentrations. In addition, it would be useful to expand the ozone season to cover potential high ozone events in the winter and spring. Transboundary and trans-continental transport of emissions also need to be addressed more critically. In the development of the emissions inventory, it would be useful to consider the weekday, Saturday and Sunday emissions inventory since they have major impacts on air quality, especially in the urban areas.

4) Define future scenarios to incorporate longer term effects.

Because of the difficulty in predicting future emissions, the Agency might consider two bounds, high and low, for future emissions. In particular, the potential impact of climate-change-based actions, resource availability, and related economic impacts need to be incorporated. The impact of climate change by 2020 likely will be small compared to naturally occurring, large year-to-year variations in annual meteorology. However, if air quality scenarios are being considered for longer times into the future, the AQMS recommends that the Agency study the suitability of choosing a single year (2002 in the current study) for assessing impacts. For example, sensitivity of air quality model outputs to changing climate could be evaluated using meteorological data from “hot” vs. “cold”, or “wet” vs. “dry” years.

REFERENCES

Deck, L. 2010. MATS estimates of $PM_{2.5}$ for the Section 812 scenarios. Memorandum from Leland Deck, Stratus Consulting, Inc. to Jim Neumann, Industrial Economics, Inc. March 9, 2010.

Douglas, S. and T. Myers. 2009. Evaluation of CMAQ Model Performance for the 812 Prospective II Study. Memorandum from Sharon Douglas and Tom Myers, ICF International, to Jim DeMocker, EPA Office of Policy Analysis and Review. November 24, 2009.

Douglas, S.G., J.L. Haney, A.B. Hudischewskyj, T.C. Myers and Y. Wei. 2008. Second Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling, draft report. Prepared by ICF International for James DeMocker, EPA Office of Policy Analysis and Review. September 30, 2008.

APPENDIX A: TECHNICAL CORRECTIONS

The Subcommittee's advice and responses to the charge questions are contained in the body of this report. However, in the course of the review, the following technical errors were noted in the materials provided by the Agency. This is not intended to be an exhaustive list.

Regarding the *Second Prospective Analysis of Air Quality in the US: Air Quality Modeling*, dated 30 Sep 2008:

1) Emissions should be reported as FLUXES and thus have an AREA and a TIME in the denominator (e.g., per km2, per year). A unit like kg/km2/day would make it easier to compare the results shown here with other emissions presentations.
2) On Fig III-2a, why does Idaho stand out for VOC 2020-2000 wCAA?
3) The coloring scheme used for Fig. III-2 is somewhat misleading, showing sharp discrepancies in positive and negative emissions change regions where emission changes are probably small. There is a "zero" dividing line, drawing undo attention to relatively small emissions increases or decreases. There should be one color where "small" (+ or - 5%, 1% ?) emission changes can be differentiated from more substantial changes.
4) There is no mention at all of vertical domain size and resolutions for CMAQ. There might be problems if the "top boundary condition" is specified rather than simulated if the "top" of the model is not relatively high above the maximum daytime boundary layer depth.
5) The metrics used to describe “exposure” (e.g., ppb-hrs-grid cells) need better definition. Is the reported value the number of grid cells or the area of the cells? Is the value integrated over all hours or at some daily maximum? It should also be noted that this is not a true exposure, merely a surrogate for exposure.
6) For the ozone discussion of the effects of the CAAA, daily maximum 8-hour ozone concentrations for July 15, 2002 are presented. The significance of this day is unclear, given the regulatory requirements of the CAAA and the form of the 8-hour ozone NAAQS. A better metric would be projected 8-hour ozone Design Values.

Regarding the *Evaluation of CMAQ Model Performance for the 812 Prospective Study*, memorandum dated 24 Nov 2010:

7) The analysis of the modeling results examines differences is predictions between a base case and various scenarios, yet the performance evaluation is done for absolute values of concentrations, not differences in concentrations. The analysis should compare predicted and observed differences between 1990 and 2000.
8) The analysis of the modeling results examines values above a threshold, yet the performance evaluation is done for average concentrations, not values above a threshold. This should be corrected.
9) In the listing of error measures (Table 1), the RMS error should be included.
10) In Table 1, what is "index of agreement"? Is this simply a spatial correlation over what time frame? A mathematical definition should be provided.

11) On pg. 3 it is noted that the model grid cell that contains an observation site is used for comparison. Apparently no surrounding model cells are considered. Unfortunately this comparison method will then depend strongly and inappropriately on model resolution, especially in regions of strong gradients. This assumption seems inappropriate for 12 or 36-km grid. It would be better to interpolate results to observation locations from nearest model grid centers, or better yet, to include several closest grid cells to provide a "range" of model calculations that could be representative of a particular observation location.
12) Of all error measures considered, why were only a limited number chosen for thorough/summary presentation in some figures?
13) Many figures use inappropriate axis scales, making them difficult to read. For example, on Fig 19, the y-scale goes from 0-8, but the highest value shows is less than 1.
14) The results of percent differences (e.g., Fig. 20) are skewed by the occasional large percentage difference. Consider using a scale that allows more meaningful plotting of results, to show both small and large percentage differences in a visually meaningful manner.
15) It is never clearly spelled out, but all deposition results refer to WET Deposition only. This needs to be explicitly stated. For the wet deposition studies it would be extremely useful to show WATER deposition also.
16) A general problem with deposition measurements (and most other concentrations) is the relatively large small-scale variability of the parameter measured. For individual storms, deposition variability of a factor of 3 is not unusual over spatial scales comparable to the grid resolutions of these simulations. Aren't there NAPAP results that address the issue of representativeness of individual deposition monitors?
17) On Table 9: the UNITS should be kg/ha/WEEK should spell out. Depositions are FLUXES and need a time unit in the denominator.
18) There is a wrong or inconsistent reference in Fig 21a to the units of deposition (kg/ha vs. g/km2) 1 kg/ha = 10^5 g/km2?