UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
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[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:

Dear Administrator Jackson:

[To be developed]

Sincerely,

Dr. James K. Hammitt, Chair
Advisory Council on Clean Air
Compliance Analysis

Dr. Armistead Russell, Chair
Air Quality Modeling Subcommittee

NOTICE

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Air Quality Modeling Subcommittee

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1. EXECUTIVE SUMMARY

- [To be developed]

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 (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*, 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 (PM2.5) and ozone under scenarios with and without CAA 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. 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. 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 (September 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. November 24, 2009.

After the February meeting, EPA provided supplemental materials, which were discussed at the March 15, 2010 AQMS meeting:

- [Description of MATS results?...]
- *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)

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 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 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 their review of the integrated report on the benefits and costs of the CAA (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 pertained 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 observed 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 most significant impact on estimated benefits.

A second general comment involves the choice of air quality models. In prior discussions between EPA and the Air Quality Modeling Subcommittee of the Council, 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 the *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? Can there be significant differences between the scenarios due not to having the CAAA (e.g., in vehicle miles traveled, or VMT), but just to the different starting point (i.e., different base cases)?

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. 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, along with the widespread use and evaluation of the model in other applications by other groups, does provide 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 observed air quality data 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 compared. 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 was extracted from the model outputs; these results, which are important for benefits assessment, were not presented, discussed or evaluated in the report.

A bias in the draft report is that it presents results with a primary focus on reductions in pollutant concentrations when increases, sometimes large, are simulated. This should be identified and discussed. Are they relevant? Will they impact the health analyses? Are they numerical artifacts?

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, 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.

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. Emissions Data and Other Model Inputs

Charge Question 1: 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. We 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 Subcommitte 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
- 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 effecting model performance
- Summary of the selection process for biogenic emissions
- Extended description of development of speciated PM2.5 primary emissions with particular emphasis on organic aerosol emissions
- Justification for treatment of Mexican and Canadian emissions (e.g., emissions from Mexico were held constant over all scenarios)
- Description of boundary conditions

Meteorological Data

- Justification for using 2002 meteorology
- Additional comment regarding the applicability of 2002 meteorology for 2020 scenarios
- Performance evaluation of the 2002 meteorological modeling results

4.2. Air Quality Modeling Methodology

Charge Question 2: 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 CAA. 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. 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 provides useful diagnostic information for interpreting and understanding the contribution of various emission sources to the simulation results. However, the Subcommittee is concerned that the PPTM results might be misinterpreted as an assessment of sensitivity of PM to specific sources rather than fractional attributions. For this reason, we recommend that the discussion of this diagnostic information be de-emphasized in the final report.

The Subcommittee agrees with the method by which unidentified local controls required to achieve attainment in *with-CAAA* emission scenarios are treated in this modeling exercise. [DFO note: add a sentence saying what the method is.]

The Subcommittee identified two areas where technical information was particularly lacking in the report, and for which additional information [has been/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.

NOTE: the following text may change, pending the nature of materials supplied by EPA

The AQMS would appreciate additional information about how uncertainty is quantified and conveyed in the products of this investigation. Please convey in a technical memorandum any information about how uncertainty estimates are being incorporated into any outputs of this air quality analysis. As discussed at the meeting, the AQMS is likely supportive of the use of MATS, though we were unaware that this approach was being used, and the report does not contain a description of what was done nor the results. If the results for the $PM_{2.5}$ species shown in the MATS technical memorandum look reasonable, 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.

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 provided. It is important that the uncertainty characterization provide information as to the likely importance of the individual contributors of uncertainty and the overall confidence in the results. It should not be a laundry list of potential contributors.

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 words “validity” and ”utility” 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 would improve the reasonableness of the model predictions for estimating benefits of the CAAA.

[DFO note: perhaps combine this with the next section, unless the Subcommittee has more to say.]

4.4. Recommendations for Future Analyses

Charge Question 3b: 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 observed 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 publically 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 time. 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 may not be apparent by 2020 because of the large year-to-year variations in climate even though there may be an increase in extreme events. However, the AQMS recommends that for projections beyond 2020, meteorological and emissions simulations take into consideration the impact of climate change.

REFERENCES

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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.

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

(1) In the listing of error measures (Table 1), the RMS error should be included.

(2) In Table 1, what is "index of agreement"? Is this simply a spatial correlation over what time frame? A mathematical definition should be provided.

(3) 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.

(4) Of all error measures considered, why were only a limited number chosen for thorough/summary presentation in some figures?

(5) 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.

(6) 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.

(7) 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.

(8) 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?

(9) On Table 9: the UNITS should be kg/ha/WEEK should spell out. Depositions are FLUXES and need a time unit in the denominator.

(10) 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?

APPENDIX B: BIOSKETCHES

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