AQMS REVIEW OF CAA 812 PROSPECTIVE STUDY OF COSTS AND BENEFITS: HEALTH AND ECOLOGICAL EFFECTS INITIAL STUDIES

SEPTEMBER 9, 1998

September 9, 1998

EPA-SAB-COUNCIL-ADV-98-002

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Dear Ms. Browner:

Subject: Prospective Study I: Advisory by the Air Quality Models Subcommittee (AQMS) on the Air Quality Models and Emissions Estimates Initial Studies

The Air Quality Modeling Subcommittee (AQMS) of the Science Advisory Board's (SAB) Advisory Council on Clean Air Compliance Analysis (ACCACA, or “the Council”) met on January 22-23, 1998 in Washington DC, to review materials related to the 812 Prospective Study Air Quality Modeling and receive briefings from EPA staff and consultants.

The general charge for the meeting addresed whether a) the input data used for each component of the analysis, and b) the models and methodologies employed are sufficiently valid and reliable for the intended purpose; and if the answer is negative to either a) or b) then c) what specific alternative assumptions, data and or methodologies would the Council recommend the Agency consider using for the first prospective analysis. Although the above charge defines the general scope of the advice requested from the Council, specific modeling-oriented questions and issues were identified for individual analytical components in the briefings and discussions engaged with the AQMS at the public meeting.

This Advisory report is the product of that meeting, and summarizes the AQMS' advice to EPA regarding the prospective study design, implementation and future planning. Our detailed comments are included in the enclosed report.

Overall, we concluded that the prospective study team’s approach to the air quality assessment is comprehensive, but needs to be described more clearly and concisely. The strategy of using model results and observations is an appropriate, sound approach for the current prospective study. We offer the attached Figure 1 in this advisory to the prospective study team as an illustration of an approach that might be helpful.

In looking ahead to the future prospective studies, we suggest that the prospective study team consider use of the more comprehensive modeling platform provided by EPA's Models-3, which has recently become available for use. This platform would make it possible to apply one method of analysis throughout the U.S.. We also suggest use of more advanced interpolation schemes and we have provided a number of references and contacts for the staff. Finally, we strongly advise development and use of a more flexible and user-friendly emissions modeling system that provides the ability to better diagnose data problems and easily examine multiple scenarios. The Models-3 emissions work provides a good starting point for further development of improved user-friendly emissions processing.

We realize that the development of new emissions management modeling systems is an EPA-wide need and goes beyond the needs of the prospective studies. For that reason, we are suggesting that EPA as a whole consider a thorough review of how emissions are currently being dealt with in the Agency and recommend development of a detailed strategy for how the process could be improved in the near and long term. All of us in the AQMS would be willing to serve on the review committee since we all feel very strongly about the very key need to develop a nation-wide flexible, efficient and reliable emissions management modeling system. We also encourage the prospective study team to coordinate with other related assessment activities and reviews currently under way at EPA.

We encourage the prospective study team to explore links between air quality and climate variability and possibly climate change in future prospective studies. The current prospective analysis assumes that meteorology remains constant for the assessment years and no climate variability is considered. It will be important to consider how best to take potential climate variations into account when doing the prospective modeling in the future. It may also be important to examine emissions change strategies based on climate policy. The study team included one of these scenarios for our consideration as a possible supplemental analysis to the current prospective study. The possibility of doing an analysis including climate variability during the next iteration of the study should be given serious consideration.

The Subcommittee's most serious concern with the current prospective study involves the predictions for particulate matter (both PM_{10} and $PM_{2.5}$) in future years. Over recent years, a downward trend has been observed in the concentration of airborne particulate matter. The PM criteria document shows downward trends for all regions of the country for PM_{10} during the period of 1988-1994. More recently, in a paper by Darlington *et al.* (1997) (see References in the enclosed report documents in more detail the downward trend in PM_{10}. The EPA's *Air Quality Criteria for Particulate*

Matter, (see References in the enclosed report, U.S. EPA/ORD, 1996) shows that regional reductions in PM_{10} from 1988 to 1994 at EPA trend sites range from 17 percent to 33 percent. The 1997 paper shows that PM_{10} reductions follow similar patterns at rural, suburban, and urban locations. Although the monitoring sites are primarily in urban areas, the trend also seems to be substantiated in non-urban areas as well.

In contrast, the current prospective study pre-CAAA90 (Clean Air Act Amendments of 1990) scenario results shows an average increase in PM and the post-CAAA90 scenario shows a decrease significantly less than the decrease already observed during the initial 5 years of the prospective study I analysis period. Given the very large effect of PM on projected health outcomes, this obvious discrepancy between the documented trend in ambient PM concentrations and the simulated outcomes would raise serious doubts in the minds of many readers of the report and has the potential to undermine the credibility of the entire prospective study effort.

The AQMS suggests further review of agricultural tilling, road and other sources of dust, livestock management, and industrial point source emissions. In addition to changes in directly emitted PM, there have been substantial decreases in emissions of man-made precursors of particulate matter formed in the atmosphere and the extent to which these decreases have been accounted for needs to be checked. The AQMS also notes that the recent EPA sponsored Grand Canyon Visibility Transport Commission Assessment of Scenarios to the year 2040 (Western Governors Association Reports, 1996. See References in the enclosed report, Middleton and associates, 1996) provides an opportunity for cross-checking emission projection assumptions and techniques. We strongly advise that this trends problem be resolved first before conducting any new scenario runs in the current prospective study.

We appreciate the diligence of the prospective study team on this difficult and timely assessment. Given our particularly strong concerns over the PM emission trends, we suggest that our subcommittee provide an informal consultation on new PM emission projections as soon as they become available. We look forward to your response, particularly to the main points outlined in this advisory letter to you, and to continued interaction with your professional staff.

Sincerely,

Dr. Maureen L. Cropper, Chair
Council

Dr. Paulette Middleton, Chair
Air Quality Models Subcommittee
Council

enclosure

NOTICE

This advisory report has been written as a part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental protection Agency. The Board is structured to provide a balanced, expert assessment of scientific matters related to problems facing the Agency. This advisory report has not been reviewed for approval by the Agency; hence, the comments of this advisory do not necessarily represent the views and policies of the Environmental Protection Agency or of other Federal agencies. Any mention of trade names or commercial products does not constitute endorsement of recommendation for use.

ABSTRACT

The Science Advisory Board's Air Quality Models Subcommittee (AQMS) of the Council, has reviewed precursors to the first Prospective Study: Report to Congress. Overall, the AQMS concludes that the strategy of using model results and observations is found to be an appropriate, sound approach for the current prospective study, but needs to be described more clearly and concisely.

For future prospective studies, the AQMS suggests that the study team consider use of the more comprehensive modeling platform of EPA's Models-3 platform which would make it possible to have a more consistent analysis of areas throughout the U.S.. In addition, the AQMS also suggests use of more advanced interpolation schemes. Finally, the AQMS strongly advises development and use of a more flexible and user-friendly emissions modeling system that provides the ability to better diagnose data problems and more easily examine multiple scenarios.

The Subcommittee's most serious concern involves the predictions for particulate matter (both PM_{10} and $PM_{2.5}$) . Recently, a downward trend has been observed in the concentration of airborne particulate matter. In contrast, the current prospective study pre-CAAA90 scenario results shows an average increase in PM and the post-CAAA90 scenario shows a decrease significantly less than the decrease already observed during the initial 5 years of the prospective study I analysis period. . The AQMS suggests several strategies that might help address this issue and strongly advises that this discrepancy in predicted and observed trends be understood or resolved first before conducting any new scenario runs in the current prospective study.

Key Words: Clean Air Act, Air Quality Models, Emissions Estimates, Prospective Study

U.S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD
AIR QUALITY MODELS SUBCOMMITTEE OF THE COUNCIL

CHAIR

Dr. Paulette Middleton, Deputy Director, RAND Center for Environmental Sciences & Policy, Boulder, CO

MEMBERS AND CONSULTANTS

Dr. Philip Hopke, Professor, Department of Chemistry, Clarkson University, , Pottsdam, NY

Dr. Harvey Jeffries, Professor, Department of Environmental Sciences & Engineering, University of North Carolina, Chapel Hill, NC

Dr. Timothy V. Larson, Professor, Environmental Engineering & Science, Department of Civil Engineering, University of Washington, Seattle, WA

Dr. Peter K. Mueller, Technical Manager, EPRI, Palo Alto, CA

Dr. James H. Price, Jr., Senior Scientist, Texas Natural Resource Conservation Commission, AU.S.tin, TX

Dr. George T. Wolff, Principal Scientist, Environmental and Energy Staff, General Motors Corp Detroit, MI (Past Chair, Clean Air Scientific Advisory Committee & Past Chair of the AQMS)

SCIENCE ADVISORY BOARD STAFF

Dr. K. Jack Kooyoomjian, Designated Federal Officer, Science Advisory Board (1400), U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460

Mrs. Diana L. Pozun, Management Assistant, Science Advisory Board (1400), U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460

U. S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD (SAB)
ADVISORY COUNCIL ON CLEAN AIR COMPLIANCE ANALYSIS
(THE COUNCIL)

CHAIR:
Dr. Maureen L. Cropper, Principal Economist, The World Bank, Washington, DC

MEMBERS:
Dr. Ronald G. Cummings, Professor of Economics and Noah Langdale, Jr. Professor of Environmental Policy, Policy Research Center, Georgia State University, Atlanta, GA

Dr. A. Myrick Freeman, Professor, Department of Economics, Bowdoin College, Brunswick, ME (Also Vice-Chair of the Health and Ecological Effects Subcommittee, HEES of the Council)

Dr. Lawrence H. Goulder, Associate Professor, Department of Economics & Institute for International Studies, Stanford University, Stanford, CA

Dr. Jane V. Hall, Professor of Economics, Department of Economics and Institute for Economic and Environmental Studies, California State University, Fullerton, CA

Dr. Paul Lioy, Deputy Director-EOSHI & Director Exposure Measurement & Assessment Division, Environmental & Occupational Health Sciences Institute, Robert Wood Johnson School of Medicine, Piscataway, NJ (Also Chair of the Health and Ecological Effects Subcommittee, HEES of the Council)

Dr. Paulette Middleton, Deputy Director, RAND Center for Environmental Sciences & Policy, Boulder, CO (Also Chair of the Air Quality Models Subcommittee, AQMS of the Council)

Dr. Richard Schmalensee, Deputy Dean, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA

Dr. Thomas H. Tietenberg, Professor, Dept. of Economics, Colby College, Waterville, ME

CONSULTANTS:
Dr. Alan J. Krupnick, Senior Fellow, Resources for the Future, Washington, DC

SAB COMMITTEE LIAISON:
Dr. William H. Smith, Professor of Forest Biology, School of Forestry & Environmental Studies, Yale University, New Haven, CT (Liaison from the Environmental Processes and Effects Committee)

SCIENCE ADVISORY BOARD STAFF:
Dr. K. Jack Kooyoomjian, Designated Federal Officer, Science Advisory Board (1400), U.S. Environmental Protection Agency, Washington, DC 20460

Mrs. Diana L. Pozun, Management Assistant, Science Advisory Board (1400), U.S. Environmental Protection Agency, Washington, DC 20460

TABLE OF CONTENTS

TABLE OF CONTENTS: CONTINUED:

1. EXECUTIVE SUMMARY

1.1 Overview

The Air Quality Modeling Subcommittee (AQMS) of the Science Advisory Board's (SAB) Advisory Council on Clean Air Compliance Analysis ("Council") met on January 22-23 in Washington DC, to review materials related to the 812 Prospective Study Air Quality Modeling and receive briefings from EPA staff and consultants. This advisory report outlines the AQMS' advice to EPA regarding the prospective study design, implementation and future planning as developed at the meeting The AQMS cites EPA Documents by referring to their Document Number as described in the January 2, 1998 memorandum "Review Materials and Charge for SAB Council AQMS Meeting to Discuss Section 812 Prospective Study Air Quality Modeling". This is document 175 cited as [175] and included a document "Section 812 Prospective Study Publicly Available Documents" [100].

Overall, the AQMS concludes that the prospective study team's approach to the air quality assessment is comprehensive, but needs to be described more clearly and concisely. The strategy of using model results and observations was found to be an appropriate, sound approach for the current prospective study.

We approached this review by examining the validity of the study assumptions and clarity of presentation. As a result of our review and discussions we are providing what we believe are constructive and feasible suggestions for improvements within the current context and constraints of the current prospective study, as well as improvements in future design for the subsequent prospective studies. Our comments focus on the modeling approach, along with detailed suggestions for improvement in the current and future prospective studies; recurrent difficulties with air quality trends and emissions estimates that still need resolution; and selection of emission change scenarios that can help address the discrepancies observed and predicted concentration trends. Specific findings are:

a) **Modeling Strategy 812 - Prospective One:** Regarding the current prospective study (referred hereafter as prospective I or the current prospective study), the AQMS suggests clarification be provided on the following topics: comparison of the prospective and retrospective studies; overall prospective strategy and scope; choice, evaluation and use of models; background aerosols; visibility estimates; treatment of organic aerosol processes; treatment of western cities; and characterizing scenarios.

b) **Modeling Strategy 812 -Prospective-Two and Beyond:** In looking ahead to the future prospective studies, the AQMS suggests that the prospective study team consider use of EPA's more comprehensive Models-3 modeling platform which would make it possible to apply one method of analysis throughout the U.S.. In addition, the AQMS also suggested use of more advanced interpolation schemes. Finally, the AQMS strongly advised development and use of a more flexible and user-friendly emissions modeling system that provides the ability to better diagnose data problems and easily examine multiple scenarios.

c) **Trends Concerns:** The Subcommittee's most serious concern with the current prospective study involves the predictions for particulate matter (both PM_{10} and $PM_{2.5}$) in future years. Recently, a downward trend has been observed in the concentration of airborne particulate matter. In contrast, the current prospective study pre-CAAA90 scenario results shows an average increase in PM and the post-CAAA90 scenario shows a decrease significantly less than the decrease already observed during the initial five years of the prospective study I analysis period. The AQMS suggests further review of primary particle emissions from agricultural tilling, road and other sources of dust, and industrial point source emissions. In addition the AQMS suggests reexamining precursor gas emission estimates and cross-checking projections with previous studies. The AQMS strongly advises that this trends problem be resolved first before conducting any new scenario runs in the current prospective study.

2. INTRODUCTION

2.1 Background

The Air Quality Models Subcommittee (AQMS) of the Council conducted a review meeting on January 22 and 23, 1998 to review draft documents pertaining to the emissions modeling assumptions, methodology, results and documentation components of the Clean Air Act (CAA) prospective study, and provide advice to the Council to transmit to the Administrator regarding the reasonableness, technical merits, and appropriate interpretations of the modeling results at this stage of the prospective study analysis. Earlier advice on the prospective study modeling assumptions, methodology, results and documentation was provided by the AQMS through its Council (U.S. EPA/SAB, 1997). This report has been produced as a result of the Subcommittee's deliberations at, and following, the public meeting.

2.2 Charge

The charge to the AQMS and the Council is to review the draft materials and provide advice to the Agency pursuant to general charge questions, consistent with the review responsibilities of the Council, as defined in Section 812 of the Clean Air Act Amendments of 1990 (CAAA90). Specifically, subsection (g) of the CAA Section 312, as amended by Section 812 of the amendments states the following:

> *"(g) The Council shall -- (1) review the data to be used for any analysis required under this section and make recommendations to the Administrator on the use of such data, (2) review the methodology used to analyze such data and make recommendations to the Administrator on the use of such methodology; and (3) prior to issuance of a report required under subsection (d) or (e), review the findings of such report, and make recommendations to the Administrator concerning the validity and utility of such findings."*

The general charge questions posed by the Agency to the Council's AQMS include the following:

a) Are the input data used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?, and

c) If the answers to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the first prospective analysis?

Although the above charge defines the general scope of the advice requested from the Council, specific modeling-oriented questions and issues were identified by the Ageny staff and AQMS M/C (members and consultants) for individual analytical components during the public meeting.

3. MODELING STRATEGY -- 812 PROSPECTIVE ONE

3.1 Overall Strategy Presentation

We strongly endorse the four study goals provided in "Analytical Strategy For the First Section 812 Prospective Study." However, the goals could be more clearly stated and important terms could be more clearly defined. We suggest that a summary of terms be developed. The document should be updated as needed and should be supplied to the Council, the Council Subcommittees, and others as appropriate, during the prospective study review process. In particular, the trend estimates and how estimates differ from model predictions and observations needs to be described. The use of terms like uncertainty analysis and sensitivity studies as well as monetized and incremental benefits and costs also needs to be clearly outlined in the context of the prospective study.

3.2 Comparing Retrospective and Prospective Studies

We suggest that the comparison be presented but the current presentation be replaced with a comparison that focuses on the pollutants included and the type of treatment needed to meet intended uses of model results. The substances included in the prospective study include both primary (i.e., directly emitted) and secondary (i.e., formed by chemical and physical processes in the atmosphere) substances. Some suggestions follow below.

The primary substances included in study are :

a) Sulfur Dioxide (SO_2)	assumed linearly proportional to emissions
b) Nitroge Oxides (NO_x)	assumed linearly proportional to emissions
c) Carbon Monoxide (CO)	assumed linearly proportional to emissions
d) Particulate Matter (PM)-primary	assumed linearly proportional to emissions

The secondary pollutants included are:

a) Ozone (O_3)	non-linearly related to NO_x and VOC via photochemistry
b) Acid Deposition	non-linearly related to NO_x, SO_2, ammonia (NH_3) emissions, Ozone, other oxidants via photochemistry, aqueous chemistry
c) PM-secondary	related to NOx, SO_2, NH_3, volatile organic compounds (VOC) emissions, free radical levels in the NO_x, VOC, O_3 system; particle composition
d) visibility	related to composition and size of PM

3.3 Scope of Study

We suggest that EPA's future descriptions of the scope of the prospective study state clearly that the CAA applies to the whole nation, while the prospective study will include only the contiguous 48-states. Because the implementation period and time for effectiveness periods of many parts of the CAA and CAAA90 are so long, the temporal domain of the Study is 20 years. Rather than simulate all years, three target years: the beginning of period, 1990; the mid-point of period, 2000; and the end of period, 2010 are selected using similar meteorology for each, thereby for the initial analysis, sidestepping the complexity of including realistic interannual climate variability.

3.4 Approach

The scope of the prospective study has determined its technical design. To further justify the study approach, the team should discuss the fact that, at present, there are no operational air quality models that simulate the entire U.S. for all substances of interest nor even for any one substance. The approach to developing annual distributions, using a variety of models for different areas and different pollutants, needs to be more carefully outlined.

3.5 Rationale for and Choice of Models

The project study team needs to provide detailed rationale underlying the choice of the specific models used in the current prospective study. The project study team also needs to comment on the quality of the model's formulation (especially the degree of completeness in representing processes believed to be important, as well as the degree of generalization, deletion, and distortion in the representation that are included) relative to the intended uses and range of the model's predictions.

Similarly, for the inputs to the models, the prospective study project team needs to specify carefully the quality of input data. This is important for two reasons: a) given the relatively large deviation from observations of several of the models' predictions for the base case, the prospective study project team needs to make a judgment as to potential sources of error: flaws in the model itself (or in its particular configuration, e.g., too few vertical layers); or inaccurate inputs, such as incorrect mixing heights; b) given that the model's predicted values may be inaccurate, the project study team needs to demonstrate that differences between two scenarios are acceptable estimates of the consequences of the differences between the inputs to the models in the two scenarios.

The current prospective study focuses on incremental concentration differences between two basic scenarios. The prospective I study asserts that the differential responses of the model are essentially independent of the concentration levels in the region of the models' predictions. This should be explicitly stated and some evidence should be offered to support the assertion.

3.6 Model Evaluation

Very little is said about model performance evaluation in the current prospective study documents. In the Document 137 description given in [100, p. 5] attached to document 175, the Review Materials and Charges memo, for example, the description reads "Report documenting fundamental elements of the criteria pollutant air quality modeling, including models, methodologies, assumptions, and draft results" with no mention of "model performance evaluation" and which was not included in document 137a. The only information in 137a is given is in Fig 4-2 and 4-3, and the statement on page 4-14, "Please note that for both the 1993 and 1995 simulation periods, the maximum simulated ozone concentration was greater than observed, especially for the high ozone days."

The Ozone Transport Assessment Group (OTAG) simulations were not intended to simulate attainment demonstrations, but instead were designed to estimate the effects of regional ozone transport for the purposes of eventually helping with boundary conditions for more localized attainment modeling. We strongly suggest that Figs 4-2 and 4-3 of the subject documents be eliminated as they provide virtually no useful information. They should be replaced by the standard scatter diagram of simulations vs. observations, which will make it much clearer the extent to which the whole set of simulations were consistent with all of the observations. Reasons for the high simulated values need to be offered and arguments advanced as to why differences among different emission scenarios are sufficiently reliable "estimates" of changes in air quality for this model.

Another advantage of using these scatter diagrams is that they give some idea of the ratio of the modeled ozone to observed ozone that can be compared with the ratio of pre-CAAA90 to post-CAAA90 values that will be used later to scale the ambient observations. Similarly Fig 4-8 and 4-9 provide little information about the quality of the modeling and need to be replaced with scatter diagrams of simulations vs. observations for these two attainment style cases. Fig 4-10 and 4-11 are also not very useful.

3.7 Use of Model Results

The prospective study project team should more clearly articulate the overall concept of the modeling study. In thinking about this we have produced a schematic which the team may want to use. Figure 1 illustrates how model results and observations are used to produce the frequency distributions for the impact analysis. Glossed over in the figure is the issue of "aggregation" of various model runs to produce a single set of "ratios" of future-to-base case. The figure shows the five model runs at the top. The middle shows the four sets of "ratios" of model results in space. The bottom shows the frequency distributions of pollutant monitor concentrations and the space-dependent scaling of these by the ratios of the model predictions. The Figure glosses over the issue of “aggregation” of various model runs to produce a single set of “ratios” of future to base case.

Figure 1 - Concentration and Concentration Distributions of Air Quality Model Predictions and Air Quality Monitor Observations. [NOTE: Figure illustrates how model results and observations are used to produce the frequency distributions for the impact analysis. F. Figure illustrates five model runs at the top; four sets of “ratios” of model results in space in the middle; and, frequency distributions of pollutant monitor concentrations and the space-dependent scaling of these by the ratios of the model predictions on the bottom.]

3.8 Clarification of Scenarios

Communication regarding the scenarios would benefit from a more explicit description of what was included and excluded in the pre-CAAA90 and post-CAAA90 scenarios. For example, in the EPA presentation to the Subcommittee, the PM-primary inventory in the post-CAAA90 scenario is indicative of this problem. We are still unclear on the issue of what is meant by freezing at 1990, but having growth overtake a downward trend.

3.9 Background Aerosols

The assumed levels of background aerosols (those directly emitted along with those that are formed in the air) were not clearly presented anywhere in the EPA documents. Background concentrations for several components by aerosol species need to be provided for our review for each major part of the country. Assumptions about background (i.e., aerosols transported into an assessment domain) need to be described and justified, because background determines the effectiveness of the projected emissions reductions within a domain.

3.10 Presentation of Results

The prospective study results presented in terms of ambient concentrations tend to focus attention on the attainment issues. We suggest using differentials and to avoid discussions regarding attainment, especially in light of the uncertainties still surrounding the emissions projections (which we will discuss later in this report).

3.11 Visibility Assessment

The approach to estimating visibility from particulate concentrations needs to be clearly outlined. Given the large differences in the contribution of different aerosol components to light extinction, it is important to provide the assumptions used in the study. The derivation of key assumptions concerning the specification of particle size distribution, aerosol composition, individual extinction efficiencies for each aerosol substance and the variation of efficiencies in space and time should be briefly described with proper citations to the published literarure.

3.12 Local Analysis for Western Sites

Given the resource limitations and current readiness of SAQM (SARMAP Air Quality Model) for aerosol application, we recommend that the detailed analysis of the San Joaquin Valley done for the Retrospective Study: Report to Congress be omitted from this current prospective study. In addition the treatment and descriptions of Denver and Salt Lake City need to be carefully outlined, since these areas are quite different from Los Angeles and Phoenix with respect to altitude, terrain and related factors.

3.13 Description of Secondary Organic Aerosols

The study does not adequately document the treatment of secondary organic aerosols. Most importantly, the AQMS M/C could not find any information on how secondary organic particles are related to VOC emissions. Given uncertainties surrounding the relative importance of biogenic and anthropogenic emissions to secondary organic particle formation, it is particularly important to describe carefully how the relevant emissions are being translated into multi-phase organics.

4 MODELING STRATEGY 812-PROSPECTIVE-TWO AND BEYOND

4.1 Consider Use of MODELS-3 Platform

EPA's Office of Research and Development (EPA/ORD) has released the first version of its MODELS-3 framework this summer. MODELS-3 is intended to be a community modeling system supporting not only air quality simulation, but also simulations of processes involving lakes, rivers, estuaries and bays. A brief description of the MODELS-3 framework is included in Appendix B of this report (U.S. EPA, 1998a and 1998b).

The current Community Air Quality Model (CAQM) included in the release will permit prediction of all air quality state variables that were included in the Prospective I study in a single model. That is, CO, NOx, VOC, O_3, SO_x, acid deposition by species, PM_{10}, $PM_{2.5}$ with composition, and visibility. By the time the next prospective modeling will be needed, it is expected that EPA/ORD will already have produced the meteorological files and other inputs to simulate the continental U.S. with a 36-km resolution. In addition, much of the Eastern U.S. will have been simulated with a 12-km resolution, and many urban areas with a 4-km resolution. Furthermore, the 30 case aggregation data set now used with RADM (Regional Acid Deposition Model) will have been converted to MODELS-3 for the U.S. by then.

The MODELS-3 system is expected to have the capability to run many simultaneously nested simulations occurring at different locations in the U.S., all sharing a large scale meteorological and chemical data set. Thus, modelers in different locations could be making consistent contributions to the prospective study at the same time. Advancements in the science can be introduced into the modeling framework without needing to replace the entire model; thus investments in input file sets and in meteorological scenarios are to be protected while still providing advances in the modeling science. Because of this flexibility, use of such a tool would greatly simplify the prospective study, permitting more time to focus on the disaggregation of benefits and costs requested by Congress rather than the initial estimation of the U.S.-wide benefits and costs by pollutant as is the case in the present prospective study.

4.2 Use of Advanced Spatial and Temporal Interpolation Schemes

There are a set of spatio-temporal interpolation schemes that have been developed in recent years (Christakos *et al.*, 1993 through 1998, Bogaert and Christakos, 1997) that provide simultaneous interpolation in space and over time. These interpolation schemes include space-time cross-terms that enhance the accuracy of spatial interpolation. Furthermore, these techniques automatically include an estimation error variance in space and time. The AQMS believes that these advanced schemes provide a good format for space-time interpolation and evaluation.

4.3 Consider More Flexible Emissions Management Modeling

Throughout our review and discussions, the topic of emission uncertainties and emission scenario development continued to dominate. We appreciate the level of frustration facing the prospective study team as it cannot easily turn around new emissions modeling experiments to either test their assumptions regarding future emissions or to try new scenarios. We strongly recommend that in the next round of prospective analysis, the study team consider the development of a more flexible approach to emissions modeling. As we envision this, such an approach would compartmentalize each step in the emissions processing such that different assumptions could be made and implemented easily in the system. The Grand Canyon Visibility Transport Commission's Assessment of Scenarios (Middleton, 1996; Western Governors Association Reports, 1966) used a system that had many of these desirable components. Ongoing emissions work associated with the Models-3 effort also provides a good starting point for improved user-friendly emissions processing.

We realize that development of new emissions management modeling systems is a need that is EPA-wide and goes beyond the needs of the current and near-future prospective studies. For that reason, we are suggesting that EPA consider an Agency-wide thorough review of how emissions are currently being addressed , with a goal of recommending a detailed strategy for how the process could be improved in the near and long term. All of the AQMS' M/C would be willing to serve on the review committee since we all feel very strongly about the imperative to develop a nation-wide flexible, efficient and reliable emissions management modeling system.

4.4 Consider Climate Variability

The current prospective analysis assumes that meteorology remains constant for the assessment years. No variability is considered. It will be important to consider how best to take the potential climate variations into account when doing the prospective modeling in the future. It may also be important to examine emissions change strategies based on climate policy. The study team included one of these scenarios for our consideration as a possible supplemental analysis for the current prospective study. The possibility of doing an analysis, including climate variability, in the next iteration should be given serious consideration.

4.5 Coordinate with Other Agency-Wide Modeling Reviews

We encourage the prospective study team to coordinate with other activities and reviews. Given the resource and time constraints, the more synergism that can be developed across Agency programs, the better.

4.6 Reconciling Emission and Concentration Trends

The Subcommittee's most serious concern with the current prospective study involves the predictions for particulate matter (both PM_{10} and $PM_{2.5}$) in future years. Recently, a downward trend has been observed in the concentration of airborne particulate matter, while the prospective study documents shows an increase.

4.6.1 The Concern

The PM criteria document shows downward trends for all regions of the country for PM_{10} during the period of 1988-1994. More recently, an October 1997 paper by Darlington, *et al.,* 1997) documents in more detail the downward trend in PM_{10}. The EPA's *Air Quality Criteria for Particulate Matter* (U.S. EPA/ORD, 1996) shows that regional reductions in PM_{10} from 1988 to 1994 at EPA trend sites range from 17 percent to 33 percent. The 1997 paper shows that PM_{10} reductions follow similar patterns at rural, suburban, and urban locations. Although the monitoring sites are primarily in urban areas, the trend also seems to be substantiated by data from non-urban areas.

In contrast, the prospective study pre-CAAA90 scenario results shows an average increase in PM and the post-CAAA90 scenario shows a decrease significantly less than the decrease already observed during the initial five years of the current prospective study analysis period. Given the current attention to PM related to associated health outcomes, this discrepancy between the well-known trend in ambient PM concentrations and the simulated outcomes would raise serious doubts in the minds of many readers of the report and has the potential to undermine the credibility of the entire prospective study effort.

This concern was brought up in the September 9, 1997 letter from Dr. Maureen Cropper and Dr. Paulette Middleton to EPA Administrator Carol Browner. The letter transmitted the review by the Air Quality Models Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis (ACCACA) ("the Council") of the Clean Air Act Amendments of 1990, Section 812 prospective study emissions modeling and associated air quality modeling issues (U.S. EPA/SAB, 1997). The letter states:

> *"The particulate matter (PM) emission trends provided in the prospective study increase regardless of assumptions of growth, while recent PM concentration trends are apparently going down. This important discrepancy still needs to be examined and explained. Subsequent discussions occurred in the Council's public teleconference meetings of May 15 and June 30, 1997, which emphasized the need for the Agency to have clear text discussions on PM trends in the Prospective Study Report to Congress."*

The most complete response the AQMS has seen to our concerns is contained in the June 13, 1997 memorandum "Information for SAB Council on Section 812 Prospective Study" (U.S. EPA/OPAR, , 1997) documented the Agency's reevaluation of PM emissions projections. This memorandum acknowledged that the *National Air Quality and Emissions Trends Report, 1995* (U.S. EPA, 1995) included data that showed a 22 percent decrease in the national average of annual mean PM concentrations from 1988 to 1995. The response also provided an initial analysis to identify problems with the emissions inputs into the models and several useful corrections were made. However, at that time no model results were available and there was no way to gauge the effect of these changes on the model outcomes. Now that these results have been obtained, it is clear that further refinement is needed.

At the AQMS public meeting, it waspointed out to Agency staff that there has been a 30-year downward trend in total suspended particulate matter data and that PM fine aerosol concentrations in the East have been decreasing over the 1988 to 1995 period. The AQMS M/C also noted that the trends for PM_{10} levels are down in both attainment and nonattainment areas. The draft final report *Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling* (ICF Kaiser/SAIC, 1998) shows the modeled ambient concentration trends for PM10. In contrast, the year 2000 Post-CAAA90 scenario shows that PM_{10} would increase at over one-fourth of the PM_{10} monitoring sites and that the mode would be a 6-to-8 percent decrease in PM_{10}.

Both in the June 13, 1997 memo noted above, and at the January 22-23, 1998 AQMS public meeting, EPA staff pointed out that the current Section 812 prospective study will model costs and benefits based only on the difference between the Pre-CAAA90 and Post-CAAA90 scenarios. **The AQMS understands this point, but the actual differences could be larger or smaller if the trend simulation were more accurate. It appears that the largest part of the costs and benefits calculated in the Section 812 Prospective Study may come from controls of PM**. Because of the obvious importance of PM to the overall current and future prospective study findings, the AQMS is concerned that the discrepancy between the modeled change and the substantial PM_{10} decreases already achieved will damage the credibility of the prospective study. **Therefore the apparent discrepancy between the projections and the actual trends up to 1995 remain an important issue.**

4.6.2 Possible Reasons for the Discrepancy

The AQMS suggests further review of agricultural tilling, sources of road dust, and industrial point source emissions. There has been an extensive movement toward the use of reduced and no tilling production, field mapping, and reduced numbers of trips through fields for pest control. We also suspect that road dust emissions may well have been reduced because of actions by local agencies to control urban runoff that degrades surface water quality. In addition, economic growth will not necessarily lead to increased emissions from industrial point sources since the nature of industries continues to change. Specifically, the areas of active growth have been in high technology goods that produce relatively low emissions per unit of contribution to the economy. In addition, much of the heavy industries that might represent significant emissions have initiated aggressive control strategies for reasons other than air quality regulations (e.g., a focus on pollution prevention as well as improved community relations). Further, another significant fraction of heavy industries have moved out of the United States to locations with cheaper labor and less rigorous environmental regulations. In total, all of these changes need to be considered in the emissions estimates.

In addition to changes in directly emitted PM, there have been substantial decreases in emissions of man-made precursors of particulate matter formed in the atmosphere. For instance, the CAAA90 acid deposition program requirements have led to substantial reductions in SO_2 and NO_X emissions. Further reductions are required. In addition, ozone controls are leading to substantial reductions in volatile organic compound (VOC) and nitrogen oxide (NO_x) emissions. Both assessments and ambient data indicate that these factors have been major contributors to decreasing PM_{10} concentrations.

The AQMS also advised that the recent Grand Canyon Visibility Transport Commission Assessment of Scenarios (Middleton and associates, 1996) provides an opportunity for cross-checking emission projection assumptions and techniques. That study primarily focused on visibility changes in national parks and wilderness areas in the Grand Canyon and nearby parks. The impacts of emission changes throughout the entire western U.S., from 1990 to 2040, were assessed. The emissions projections for the baseline, which was developed assuming current regulations were in place, showed an increase in visibility in 2000 and then a decrease from 2010 to 2040. Overall region- wide directly emitted fine organic carbon, other fine and coarse particles were projected to increase from 2000 through 2040. These increases were mainly associated with the steadily projected increases in road dust emissions throughout the assessment period. This emission category also was recognized to be the most uncertain. Other point sources, area sources and transportation sources were projected to have slight increases in emissions for the region, but only beyond 2010. The emissions for sulfur and nitrogen oxides, VOC and elemental carbon all showed decreases through 2010. For 2020 through 2040, emissions of NO_x, VOC, and all particles showed increases for the U.S. western regional totals.

4.6.3 Possible Steps

Considering the emission modeling tools now available and the resources to prepare the current prospective study, we are wondering what options are available for dealing with the discrepancy between observed PM air quality trends and the projections of air quality changes.   Since the emission modeling problems appear to be associated primarily with direct emissions of PM, one possibility is to look only at modeled concentrations of secondary PM (i.e., the particles formed in the atmosphere).

As another possibility, some diagnostic information may be available by examining the contribution of crustal material to $PM_{2.5}$ and by examining the RADM results before adding primary crustal materials and secondary organic particles. These results can help to suggest if it is the fine particle tail in the crustal particle size distribution that is contributing to the simulated increases in PM concentrations in both size ranges and if the secondary particles in the eastern U.S. follow the expected decreasing trend.

We also suggest that there could be problems in operating the modeling system. It may be worthwhile to obtain an expert review of the modeling effort by someone outside of the program who can visit the modelers and carefully review the process by which the modeling is performed. There have been previous instances when this approach has uncovered problems that the modelers could not detect because of their proximity and familiarity to the process. We hope that these steps will lead to a better understanding of the reasons for the divergent outcomes and permit modifications which will lead to more credible results.

4.7 Overall Quality of Emissions Inventories

The apparent results of the PM modeling exercise lead to a major question regarding the specification of the quality of emission inventories. Emission data continue to be the most substantial problem in all aspects of air quality modeling. No matter how sophisticated the effort to model the atmospheric chemistry and meteorology, the effort is doomed to failure if there are large errors in the input values of the emissions. For example, even in Los Angeles where extensive efforts have been made to produce an accurate emissions inventory, there remain important problems that need to be resolved (Fujita *et al*., 1992). Many other instances of such problems exist. Therefore, the AQMS recommends that there be strong support within the EPA to examine this problem and take action to improve the current process for assembling inventories and to specify the quality of the emissions information.

4.8 Additional Scenario Analysis

We strongly advise that the trends problem be resolved first before moving on the new scenario runs. Consequently, we recommend that no additional scenarios be run until the issues surrounding the PM trends have been adequately resolved. The Agency should use the available resources to investigate the underlying problems in the analysis.

When the trends discrepancy is resolved, we recommend that future emission scenarios be simulated. The disaggregation approach (i.e., identifying the individual impact of a variety of proposed emission management activities) suggested by some of the Council Members is important, but does not seem feasible within the context of the current prospective study. Multiple assessment runs would be needed in order to isolate the individual effects for different policies. The current prospective modeling and emissions system is not set up for quick and inexpensive turnaround. In response to these obvious problems, the prospective study team has proposed an alternative, that is, looking at additional reasonable scenarios to demonstrate the potential effects of additional controls. The AQMS believes that, given the current resource and data limitations, this is a viable alternative.

The new scenarios, if conducted, should start with a combination of the scenarios presented by the EPA staff. This would provide an upper bound on possible effects. If significant changes are indeed noted, then additional scenarios should be considered.

5 SUMMARY

The AQMS looks forward to continued interaction with the prospective study team. As a committee, and as individuals, we especially would like to assist the study team toward a successful resolution of the trend issue in the near-term. We also anticipate continuing to provide review of future prospective study designs, strategies and scenarios. Each of us will be available as individuals for consultation should be study team need more detailed assistance in the months ahead.

In developing plans for the future, the prospective study team's emphasis probably ought to be on the need to consider more comprehensive, integrated modeling approaches such as provided by the emerging Models-3 Platform. We also emphasize the need for a more flexible, comprehensive emissions modeling system that will provide the ability to better diagnose emissions data problems and to more easily examine multiple emissions management scenarios.

Again, we appreciate the professionalism of the study team and the excellent work accomplished to date on this difficult, but important, assessment.

REFERENCES CITED

Bogaert, P. and G. Christakos, 1997,:"Spatiotemporal Analysis and Processing of Thermometric Data over Belgium," *Jour. Geophys. Res.-Atmospheres*, v. 102, n. D22, pp. 25831- 25846

Christakos, G. and G.A. Thesing, 1993, "The intrinsic random field model in the study of sulfate deposition processes, *Atmos. Env.* v. 27A, n. 10, pp. 1521-1540

Christakos, G. and D. Hristopulos, 1996, "Characterization of atmospheric pollution by means of stochastic indicator parameters," *Atmos. Env.*, v. 30, n. 22, pp. 3811-3823

Christakos, G. and J. Lai, 1997, "A study of the breast cancer dynamics in North Carolina," *Soc. Sci. Mediicine*, v. 45, n. 10, pp. 1503-1517

Christakos, G. and V. Vyas, 1997, "A novel method for studying the health impacts of spatiotemporal ozone distribution," *Soc. Sci. Medicine*, in review

Christakos, G. and X. Li, 1998, "Bayesian maximum entropy analysis and mapping: A farewell to kriging estimators?" *Mathematical Geology*, v. 30, n. 3

Darlington, Thomas L., Dennis F. Kahlbaum, Jon M. Heuss and George T.Wolff, "Analysis of PM_{10} Trends in the United States from 1988 through 1995," *J. Air & Waste Manage, Assoc.*, v. 47, pp. 1070-1078, October, 1997

Fujita, E.M., B.E. Croes, C.L. Bennett, D.R. Lawson, F.W. Lurmann, H.H. Main, 1992, " Comparison of Emission Inventory and Ambient Concentration Ratios of CO, NMOG, and NO_x in California's South Coast Air Basin," *J. Air & Waste Manage. Assoc.*, vol 42, pp. 264 - 276, 1992

Middleton, Paulette and Associates,, *Grand Canyon Visibility Transport Commission Assesment of Scenarios*, Western Governors Association Reports, Science & Policy Associates, (Complete reports are available from Western Governors Association), Volumes I-IV, 1996

ICF Kaiser, Systems Applications International Inc., 1998, *"Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling,"* Draft Final Report, SYSAPP98-97/69

U.S. EPA , 1998a, EPA Third-Generation Air Quality Modeling System, Models-3 Volume 9a: System Installation and Operations Manual. EPA/600/R-98/069(a), National Exposure Research Laboratory, Research Triangle Park, NC, 131 pp.

U.S. EPA, 1998b, EPA Third-Generation Air Quality Modeling System, Models-3 Volume 9b: User Manual. EPA/600/R-98/069(b), National Exposure Research Laboratory, research Triangle Park, NC, 833 pp

U.S. EPA/OPAR, June 13, 1997, Memorandum from Mr. James DeMocker, OPAR to Dr. Jack Kooyoomjian, SAB/Council DFO entitled “Information for SAB Council on Section 812 Prospective Study”

U.S. EPA/ORD, *1996, Air Quality Criteria for Particulate Matter, Vol III of III*, Office of Research and Development, Washington, D.C., EPA/600/P-95/001cF, 1996

U.S. EPA/SAB, September 9, 1997, “Letter Report of the Air Quality Models Subcommittee (AQMS) of the Council’s Science Advisory Board on Review of the Clean Air Act Amendments (CAAA) of 1990, Section 812 Prospective Study Emissions Modeling and Associated Air Quality Modeling Issues,” EPA-SAB-COUNCIL-LTR-97-012

Vyas, V. and Christakos, G., 1997, “Spatiotemporal analysis and mapping of sulfate deposition data over eastern U.S.A.,” *Atmos. Env.*, v. 31, n. 21, pp. 3623-3633

Yang, Y-j., Wilkinson, J. and Russell, A., 1997, “Fast, Direct Sensitivity Analysis of Multidimensional Photochemical Models,” *Env. Sci. Technol.*, v. 31, pp. 2859-2868

APPENDIX A- Modeling Draft Review Materials[1]

1) DeMocker, James, Jan. 22, 1998, *"Air Quality Modeling Overview for the First Section 812 Prospective Study,"* Briefing for SAB AQMS (Item 179)

2) DeMocker, James, Jan-Feb. 1998, *"Analytical Strategy for the First Section 812 Prospective Study,"* Briefing for SAB Council, HEES, and AQMS (Item 136a)

3) Dennis, Robin L., January 5, 1998, *"Regional Particulate Model: Background Analysis for 812 Prospective Study,"* Draft White Paper, Atmospheric Modeling Division, National Exposure Research Laboratory, Office of Research and Development, RTP, NC

4) Dennis, Robin L., October, 1995, *"Estimation of Regional Air Quality and Deposition Changes Under Allternative 812 Emissions Scenarios Predicted by the Regional Acid Deposition Model, RADM,"* A Report Prepared for the 812 retrospective Study in Coordination with Jim DeMocker, OPAR, U.S. EPA

5) Douglas, Sharon, undated, *"812 Prospective Air Quality Modeling,"* SAI, Inc., San Rafael, CA (A Presentation to the AQMS) (Item 138a)

6) ICF Kaiser/SAIC (Science Applications International, Inc.), January, 1998, *"Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling,"* Draft Final report, SYSAPP98-97/69

7) ICF Kaiser/SAIC (Science Applications International, Inc.), *undated, "REMSAD: The regulatory Modeling System for Aerosols and Deposition, Modeling Primary and Secondary Fine Particle Distributions."*

8) ICF Kaiser/SAI (Systems Applications International, Inc.), Decermber, 1995, Technical Memorandum, *"Development and Preliminary Testing of the Regulatory Modeling System for Aerosols and Deposition (REMSAD),"* SYSAPP-96/11

9) Langstaff, John E., September, 1991, "Overview of the SAI Urban Airshed Model," Prepared for Barry Elman, OPPE, U.S. EPA

10) Neumann, Jim and Mike Hester, June 23, 1997, *"Evaluating Benefits of Marginal Emissions for the 812 Prospective Analysis: Overall Approach and Immediate*

---

[1] These documents are available from the U.S. Environmental Protection Agency (U.S. EPA), Office of Air and Radiation (OAR)/Office of Policy Analysis and Review (OPAR), Mail Code 6103, U.S. 401 M Street, SW, Washington, DC 20460

Action Items from June 17 Teleconference," Industrial Economics, Inc. (IEc)

11) Neumann, Jim and Mike Hester, July 14, 1997, *"Proposed Modeling Scenarios for Evaluating Benefits of marginal Emissions reductions Beyond the 812 Prospective Analysis Post-CAAA Scenario,"* Industrial Economics, Inc. (IEc)

12) U.S. EPA/OPAR, August 29, 1997, *"Analytical Strategy for the First Section 812 Prospective Study"* (DRAFT)

13) U.S. EPA/OPAR, Jan-Feb., 1998, *"Analytical Strategy for the First Section 812 Prospective Study ,"* Briefing for SAB Council, HEES and AQMS

APPENDIX B - Additional Information on Recommendation to Consider Use of EPA's Urban and Regional Community Air Quality Modeling System

Atmospheric modeling practice has evolved rapidly in the last 6 years. The EPA/ORD/NOAA program has recently released a third generation modeling system, known as MODELS-3, which is the result of more than five years of collaborative and in-house work, that has a unique formulation permitting various "science modules" to be plugged and un-plugged easily. An attractive feature of MODELS-3 is that it can grow with scientific advances without having to replace the model wholesale as occurs with present models. MODELS-3 is actually a modeling system that is capable of supporting air quality, as well as, river and ground water, and estuary models to allow a multi-media assessment to be performed similar to that done for atmospheric nitrogen deposition into the Chesapeake Bay. The present implementation of this modeling system includes the use of: a) advanced non-hydrostatic meteorological models that use four-dimensional observational data assimilation; b) multiple chemical reaction mechanisms each of which can be expanded to include new chemicals; c) primary and secondary modal aerosol sub-model; d) aqueous and cloud chemistry sub-models with wet deposition processes; e) visibility post-processors; and f) analysis and data visualization packages. The model can be operated in a telescoping, one-way nesting mode that permits it to simulate the entire United States at resolutions of 108 and 36 km, to simulate a nested region at 12 km resolution, or to simulate urban areas at resolutions of 4 or 1.3 km. Currently the model extends from the surface to 12 km with 27 logarithmically-spaced vertical layers having as many as 15 or more layers in the boundary or surface mixed layer. The model development team has produced informative scientific and operational documentation and the model will be put through at least one major evaluation exercise with field data before or just after its release to the public.

Recent studies, including the OTAG program have shown that for regional scale analyses, simulation time periods as long as 18 days are probably necessary and that to simulate ozone formation for a week period or longer over any of the mid-size urban areas in the eastern U.S., the outer 36 km grid needs to cover at least the entire eastern U.S. This sets new standards for good modeling practice. The prototype of MODELS-3 is being used in a 1995 full-summer season simulation for the eastern U.S. The EPA has committed to re-doing the so-called 30 case "aggregation" data set used to estimate annual deposition using the Models-3/CAQM system and to extending the 36 km meteorological simulations to include the continental U.S.

The model is intended to be a "community" model in that it would become freely available. Because of its design, it could be expanded or have additional functionality added to the basic system. It is intended that at regular intervals the new additions and advances will be evaluated and certified for use with the rest of the system and will become readily available for use by the entire user community.

The widespread dissemination and use of such a community tool for both the regional and urban atmospheric chemistry modeling research community, as well as for meeting the EPA regulatory requirements to produce State Implementation Plans (SIPs) by the states is expected to result in a well-documented and well-understood set of simulations conditions and model file sets. These should permit individual investigators or private companies to conduct high quality modeling exercises in a nested mode without having to bear the full expense and effort to produce their own analyzed and well-understood scenarios.

Additional advances in the MODELS-3/CAQM system that are currently planned include:

a) The enhancement and modification of the North Carolina Supercomputing Center's SMOKE emissions processor system for use in the MODELS-3 framework. The SMOKE system can produce an OTAG-domain emissions inventory file set in only 12 minutes of clock time. Work to expand the SMOKE system includes the addition of the processing options to include special calculations for reactivity that permit placing the emissions in the correct locations at the correct times for different classes of VOC, e.g., industrial VOC emissions would be incrementally added to the correct SCC (Source Classification Codes), alternative fuel emission would be associated with on-road VMT (Vehicle Miles Traveled).

b) The addition of the direct differential method for simultaneously computing local sensitivity of ozone (or other model state variable) to as many as 30 different VOC emissions changes at the same time as the species are being computed (or other relevant parameters). This method has recently been refined and implemented (Yang et al., 1997) in another modeling system and it needs to be integrated into the CAQM (Community Air Quality Model) system.

c) The integration of a fully "study planner" support system into the MODELS-3 decision support framework.

APPENDIX C - GLOSSARY OF TERMS AND ACRONYMS

ACCACA	Advisory Council on Clean Air Compliance Analysis (the Council)
AQMS	Air Quality Models Subcommittee (of the Science Advisory Board, SAB/Council, U.S. EPA)
ADV	SAB Advisory Report
AUSPEX	Atmospheric Utilities Signatures Predictions and Experiments (A Cross-Tracer Study/Experiment)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAAA90	Clean Air Act Amendments of 1990
CAQM	Community Air Quality Model
CO	Carbon Monoxide
EPA	Environmental Protection Agency (U.S. EPA)
LTR	SAB Letter Report
M/C	Members/Consultants
MODELS-3	EPA's Third-Generation Air Quality Modeling System Advanced Object-Oriented and Network Aware Models Program Developed by EPA's National Exposure Research Laboratory, Research Triangle Park, NC
NH_3	Ammonia
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen Oxides
O_3	Ozone
OAR	Office of Air and Radiation (OAR, U.S. EPA)
OPAR	Office of Policy Analysis and Review (OAR/OPAR, U.S. EPA)
OPPE	Office of Policy Planning and Evaluation (OPPE, U.S. EPA)
ORD	Office of Research and Development (ORD, U.S. EPA)
OTAG	Ozone Transport Assessment Group
PM	Particulate Matter (PM_{10} and $PM_{2.5}$; that is, particulate matter that is less than or equal to 10 micron and 2.5 micron in size, respectively)
PM-Primary	Primary Particulate Matter
PM-Secondary	Secondary Particulate Matter
RADM	Regional Acid Deposition Model
SAB	Science Advisory Board (U.S. EPA/SAB)
SAQM	SARMAP Air Quality Model
SARMAP	SJVAQS/AUSPEX Regional Modeling Adaption Project
SCC	Source Classification Codes

SCCSMOKE Supercomputing Center SMOKE (in North Carolina)

SIPs	State Implementation Plans
SJVAQS	San Joaquin Valley Air Quality Study
SMOKE	Sparse Matrix Operator Kernel Emissions Processor (The North Carolina Supercomputing Center's Emission Processor System for Use in the MODELS-3 Framework)
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
U.S.	United States
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds

DISTRIBUTION LIST

Administrator
Deputy Administrator
Assistant Administrators
Regional Administrators
Office of the Administrator
Office of Cooperative Environmental Management (OCEM)
Deputy Assistant Administrator for Air and Radiation
Director, Office of Policy Analysis and Review (OPAR)
Director, Office of Air Quality Planning and Standards (OAQPS)
Deputy Assistant Administrator for Policy, Planning and Evaluation (OPPE)
Director, Office of Policy Analysis (OPA)
Director, Office of Regulatory Management and Evaluation (ORME)
Director, Office of Strategic Planning and Environmental Data (OSPED)
Deputy Assistant Administrator of Research and Development:
Deputy Assistant Administrator for Science - ORD
Deputy Assistant Administrator for Management - ORD
Director, Office of Science Policy
Director, Mega Laboratories and Centers
Director, Research Laboratories
EPA Headquarters Library
EPA Regional Libraries
National Technical Information System (NTIS)
Library of Congress

United States Environmental Protection Agency
Science Advisory Board Washington, DC
EPA-SAB-COUNCIL-ADV-98-002
September 1998
www.epa.gov/sab

AN SAB ADVISORY: THE CLEA ACT SECTION 812 PROSPECTI STUDY OF COSTS AND BENEF AIR QUALITY MODELS AND EMISSIONS ESTIMATES INITIAI STUDIES

BY THE ADVISORY COUNCIL ON CLEA COMPLIANCE ANALYSIS OF THE SCIE ADVISORY BOARD