



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

May 13, 1994

*Should be
IAQC*

EPA-SAB-DWC-94-008

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

Subject: SAB Review of Indoor Air Issue Plan

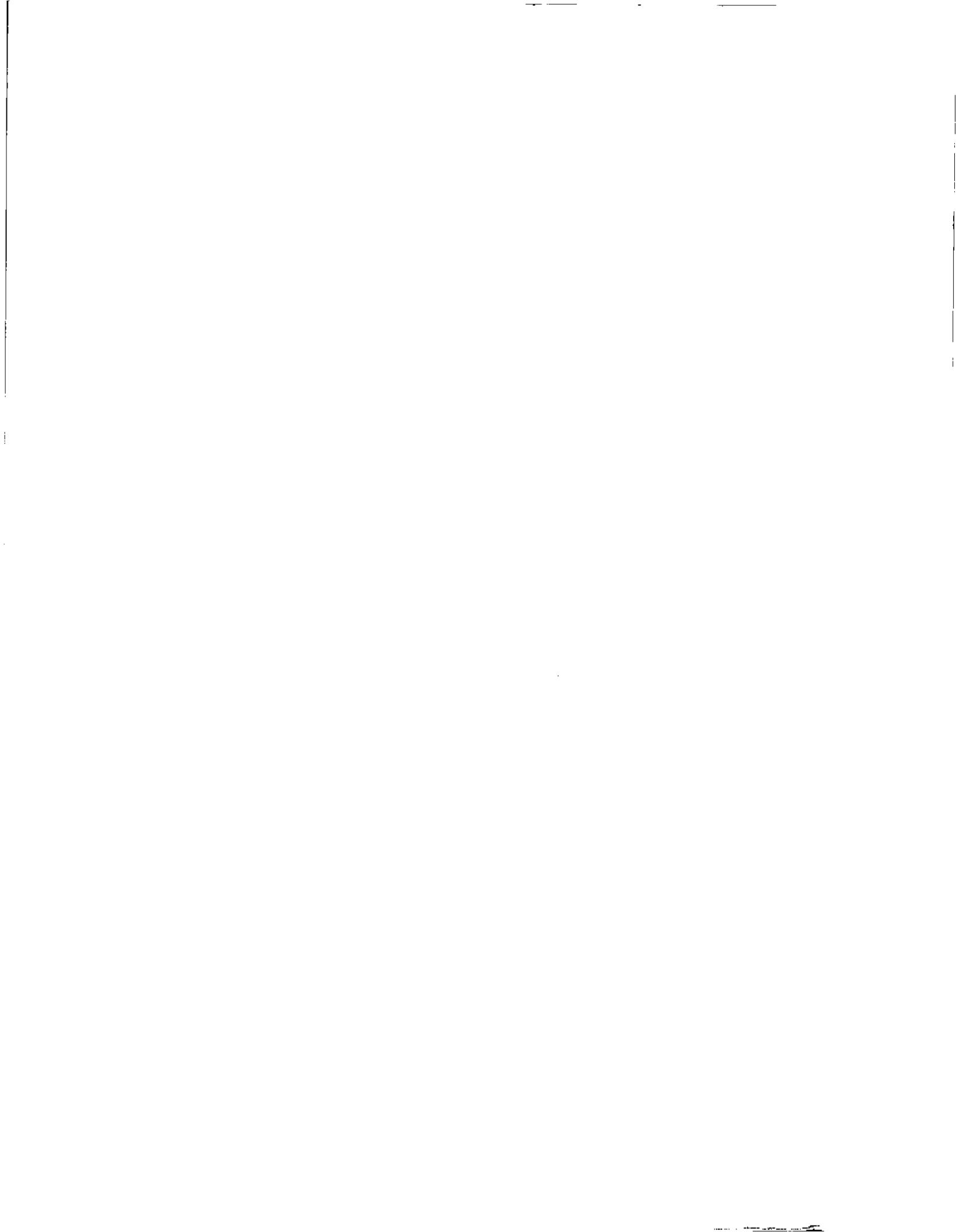
Dear Ms. Browner:

On September 8-9, 1993, the Indoor Air Quality/Total Human Exposure Committee (IAQC) of the Science Advisory Board (SAB) reviewed the Agency's Indoor Air Issue Plan (the Research Plan), one of a set of research plans prepared by the Office of Research and Development (ORD) as part of its multidisciplinary research program.

The Committee commends the Agency staff on the quality of their preparation, background documents, and presentations. The briefings were clearly focused on the nature and scope of the program, its inter-relationships with other related and complementary activity in ORD and elsewhere at EPA, and research at other federal agencies and in the private sector. Although there are not sufficient funds to adequately pursue all of the important indoor air issues, the staff has identified certain key areas for focus and developed a generally sound research program around these areas. The Committee was also pleased to note that earlier recommendations by the SAB (EPA-SAB-EEC-93-009) were given careful consideration and often incorporated into the current research plan.

The Committee found, however, several important areas where we believe that the contents of the research program *and* the Issue Plan document that reflects them can be improved. The remainder of this letter is a summary of our recommendations in this regard.

The Research Plan document, oral presentations and supporting documents provided a clear description of a coherent indoor air research strategy and program, *when examined as whole as they were during our review*. These evident strengths of the planning process and the research program, however, are not adequately captured by the Issue Plan document alone. This is a serious



shortcoming for a document that is intended to play a critical role in the strategic management of research activities in this area, and especially as a benchmark against which to measure progress and consider modifications in the future. We thus recommend that the document be revised to more fully and accurately represent the content of the presentations and the supporting materials. In particular, the Issue Plan would benefit from a more complete discussion of the approach to be used to integrate the various program elements, as well as a "Rationale" section to specifically define the working hypotheses that underlie each project area, and why these hypotheses are relevant to the overall goals.

With regard to the key scientific questions identified in the Research Plan, we would like to especially recommend increased emphasis on three areas:

1. A more explicit and clear-cut linkage of the research to health effects of potential concern.
2. Airborne particulate matter.
3. Complex mixtures.

The review of this Research Plan also identified several generic issues concerning the effectiveness of Issue Plans as a strategic management tool for the Agency's research program. These issues, which were discussed by the Executive Committee in a preliminary fashion, will be taken up in more detail by the Research Strategies Advisory Committee in the near future.

It is clear that the Agency is seriously committed to developing a strong and well-focused indoor air research program to address this important public health issue. The attached report addresses the three scientific areas mentioned above and other issues in more detail. It also includes a brief evaluation of each of the major research areas specified in the research plan. The Committee appreciates the opportunity to conduct this review, and it looks forward to your response.

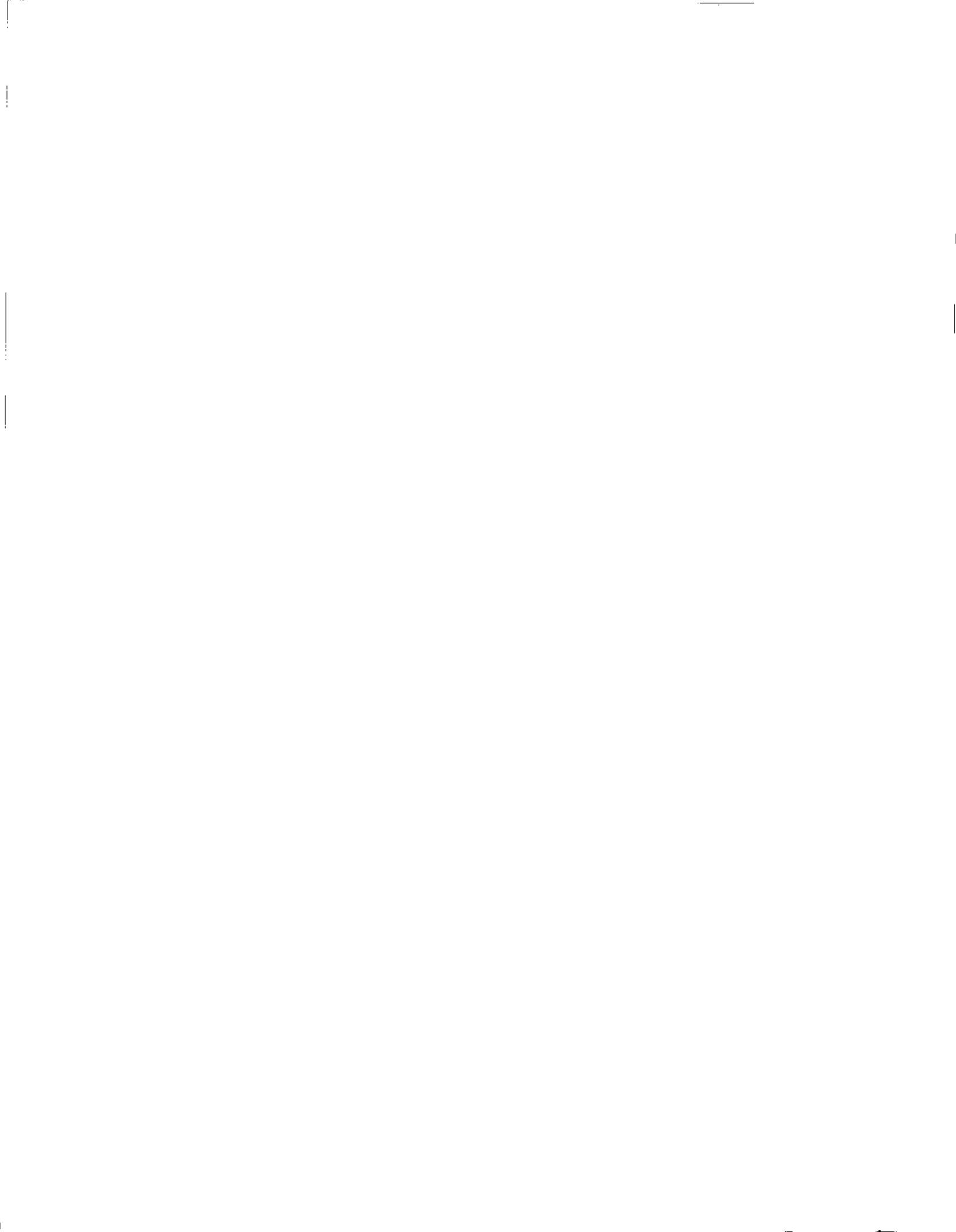
Sincerely,

Genevieve M. Matanoski

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Chair, Executive Committee
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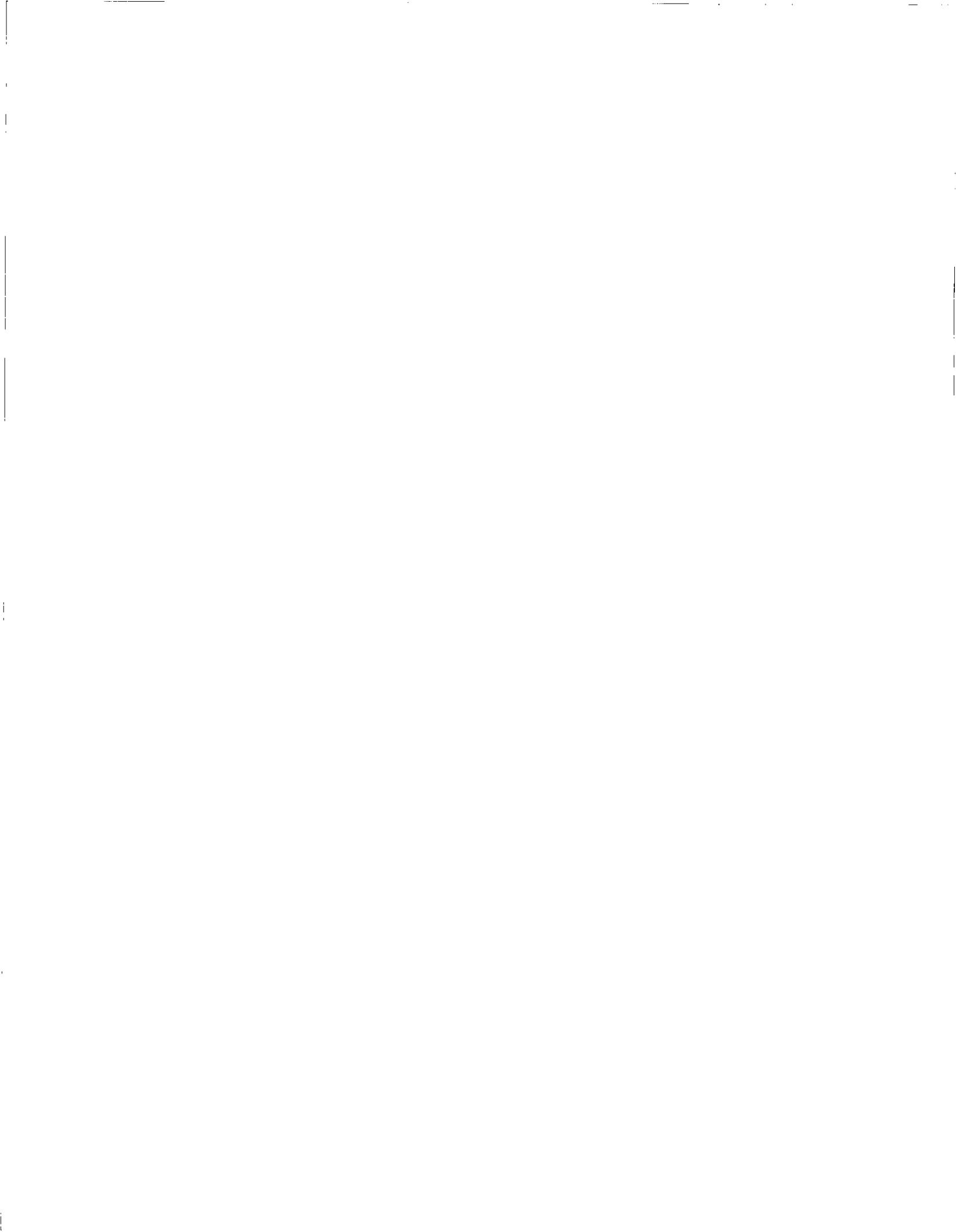
Science Advisory Board
Washington, DC

EPA-SAB-DWC-94-008
May 94



REVIEW OF THE INDOOR AIR ISSUE PLAN

**PREPARED BY THE INDOOR AIR
QUALITY/TOTAL HUMAN
EXPOSURE COMMITTEE OF THE
SCIENCE ADVISORY BOARD**



NOTICE

This 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 balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

ABSTRACT

On September 8-9, 1993, the Indoor Air Quality/Total Human Exposure Committee (IAQC) of the Science Advisory Board (SAB) reviewed the Agency's Indoor Air Issue Plan, a research plan prepared by the Office of Research and Development (ORD).

The Committee found that the Research Plan document, together with the oral presentations and supporting documents, provided a clear description of a coherent indoor air research strategy and program. They found that the program was clearly-focused, as were its inter-relationships with related activity elsewhere in ORD and the rest of the Agency, other federal agencies and the private sector. Although there are insufficient funds to adequately pursue all of the important indoor air issues, they concluded that EPA staff has adequately identified key areas for focus and developed a generally sound research program around these areas.

The Committee was concerned, however, that these evident strengths of the planning process and the research program were not adequately captured by the Issue Plan document. They recommended that the document be revised to more accurately represent the content of the presentations and the supporting materials, particularly a more complete discussion of the approach to be used to integrate the various program elements, as well as a "Rationale" section.

The Committee also commented on numerous scientific issues raised or addressed by the goals of the Research Plan. They recommended increased emphasis on a more explicit and clear-cut linkage of the research to health effects of potential concern, airborne particulate matter, and complex mixtures. In addition they addressed questions regarding the quantification of health effects that are associated with indoor environments, the identification of sensitive sub-populations, the definition of a "complex mixture" and protocols to study such mixtures, airborne particulate matter, biocontaminants, monitoring methods, and others.

Key Words: Indoor air, biocontaminants, particulates, monitoring, private sector.

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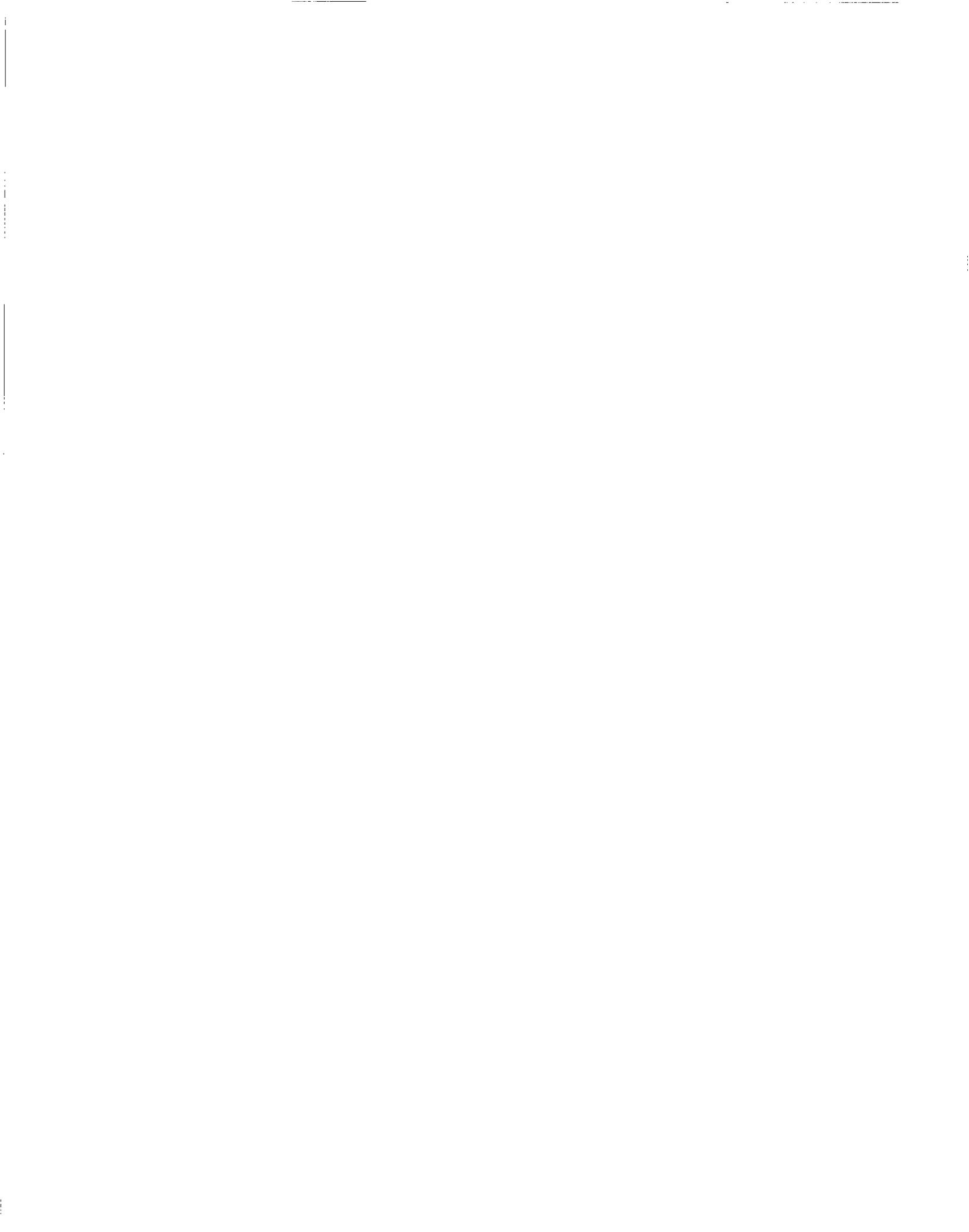
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1. EXECUTIVE SUMMARY

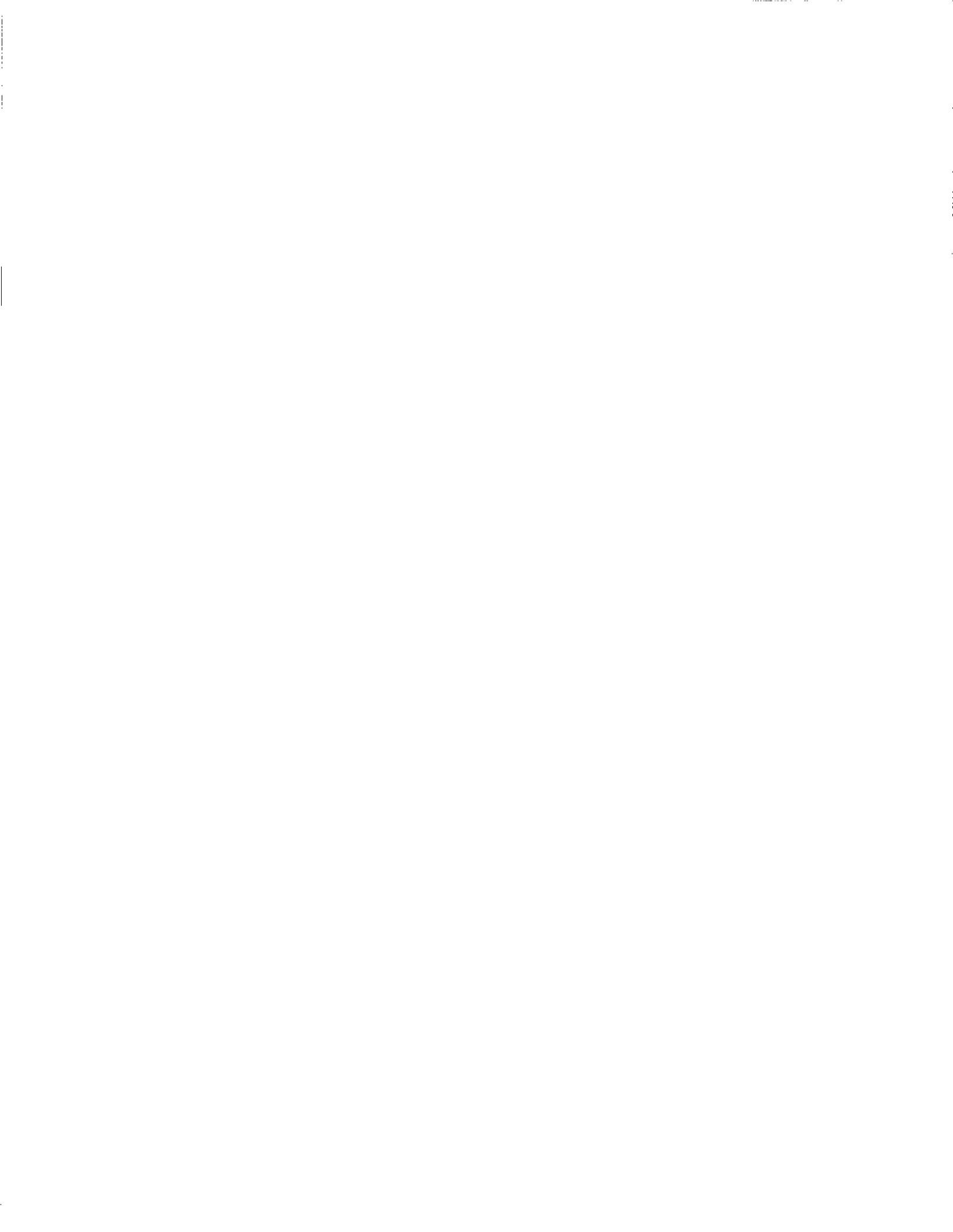
On September 8-9, 1993, the Indoor Air Quality/Total Human Exposure Committee (IAQC) of the Science Advisory Board (SAB) reviewed the Agency's Indoor Air Issue Plan, one of a set of research plans prepared by the Office of Research and Development (ORD) as part of its multidisciplinary research program.

The Committee found that Research Plan document, the oral presentations and the supporting documents provided a clear description of a coherent indoor air research strategy and program, *when examined as whole as they were during the review*. The Committee found that the nature and scope of the research program were clearly-defined, as were its inter-relationships with other related and complementary activity elsewhere in ORD and the rest of the Agency, and research at other federal agencies and in the private sector. Although there are not sufficient funds to adequately pursue all of the important indoor air issues, they found that the staff has identified certain key areas and topics for focus and developed a generally sound research program around these areas. The planned research on the biological contaminants is particularly relevant in view of the limited information available in this area. The Committee was also pleased that many of the recommendations made by SAB following its 1992 review of the Indoor Air Engineering Research Program (EPA-SAB-EEC-93-009) have been incorporated into the current research plan.

The Committee was concerned, however, that these evident strengths of the planning process and the research program are not adequately captured by the Issue Plan document alone. This is a serious shortcoming for a document that is intended to play a critical role in the strategic management of research activities in this area, and especially as a benchmark against which to measure progress and consider modifications in the future. They recommended that the document be revised to more fully and accurately represent the content of the presentations and the supporting materials. In particular, the Issue Plan would benefit from a more complete discussion of the approach to be used to integrate the various program elements, as well as a "Rationale" section to specifically define the working hypotheses that underlie each project area, and why these hypotheses are relevant to the overall goals.

The report recommended increased emphasis on three key areas of the Research Plan:

- a. **A MORE EXPLICIT AND CLEAR-CUT LINKAGE OF THE RESEARCH TO HEALTH EFFECTS OF POTENTIAL CONCERN.** In the absence of a specific hypothesis regarding the airborne agents of concern, a set of related initial questions that the Research Plan should address are: What health effects that are associated with indoor environments can be quantified? What methods can be used to distinguish indoor exposures from other (outdoor, occupational) exposures and to eliminate the effects of other



potential confounding covariates? Are there any temporal correlations that can provide insight into the sources of the observed health effects? Are there any identifiable sensitive sub-populations? Has previous research answered some of these questions?

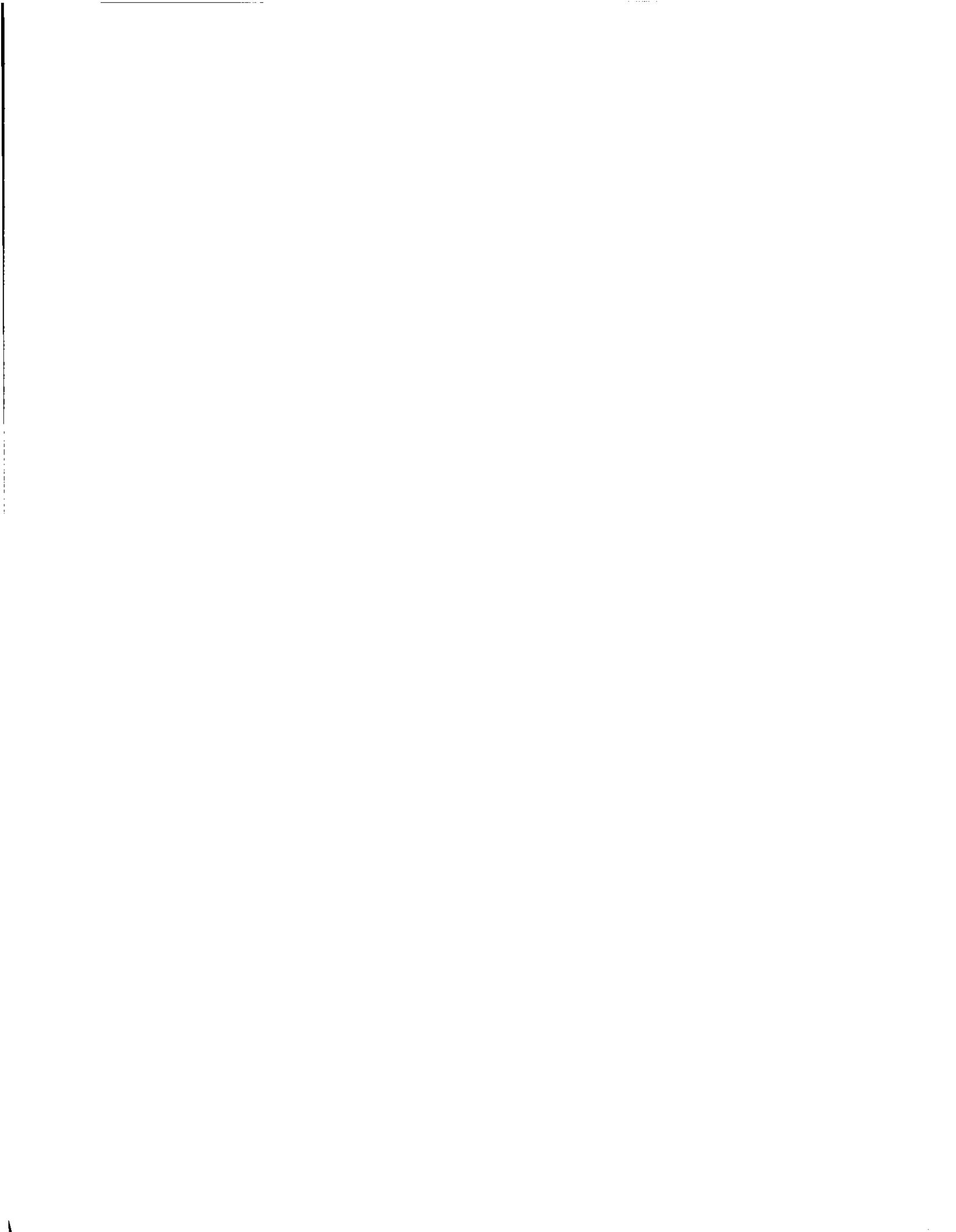
b. INCREASED EMPHASIS ON AIRBORNE PARTICULATE MATTER.

The stated major goals of the indoor air research program include particulate matter (PM) as an important class of indoor, airborne agents associated with observed symptoms. However, there is little discussion of this pollutant class anywhere in the Research Plan, and the project areas cited (lead and asbestos) are not very good general examples of the range of airborne particles encountered in indoor environments. Specifically, if PM is considered a class of indoor agents of high priority, then the research projects should consider more representative particles; in particular, the outdoor PM that infiltrates indoors, and the unvented products of incomplete indoor combustion, including environmental tobacco smoke.

c. COMPLEX MIXTURES. What constitutes a "complex mixture"? Does sequential exposure to individual agents constitute a complex mixed exposure? Is there an agreed-upon mixture that can be used to test a variety of health endpoints? Can source characterization provide a basis for "complex mixture" exposure protocols in the absence of specific identifiable toxic agents?

In addition, the report comments on numerous other scientific issues raised or addressed by the Research Plan, with emphasis on questions regarding the quantification of health effects that are associated with indoor environments, the identification of sensitive sub-populations, the definition of "complex mixtures" and protocols to study such mixtures, airborne particulate matter, biocontaminants, monitoring methods, and others.

Lastly, the review of this Research Plan also served to identify several generic issues concerning the overall effectiveness of Issue Plans as strategic management tools for the Agency's research program. These ideas, which were discussed by the Executive Committee in a preliminary fashion, will be taken up in more detail by the Research Strategies Advisory Committee in the near future.



2. BACKGROUND AND CHARGE

On September 8-9, 1993, the Indoor Air Quality/Total Human Exposure Committee (IAQC) of the Science Advisory Board (SAB) reviewed the Agency's Indoor Air Issue Plan, one of a set of research plans prepared by the Office of Research and Development (ORD) as part of its multidisciplinary research program.

The charge for the review requested that the SAB examine the Indoor Air Issue Plan with the following questions in mind:

1. Will EPA's indoor air research program as planned:
 - address the most important scientific questions that will advance our understanding of indoor air quality?
 - provide scientific and technical support to EPA's program offices and regions?
 - promote private sector involvement in indoor air research?
2. Are the projects identified in the Indoor Air Issue Plan commensurate with accomplishing the three goals above?
3. Are the planned research projects appropriate in light of EPA's leadership role in indoor air quality research, expertise, and resources?
4. Does the Indoor Air Issue Plan reflect intra- and inter-agency coordination?

During the review, presentations were made concerning ORD Indoor Air Research on: Source Characterization; Exposure Assessment; Health Effects; Risk Assessment; and Problem Solution.



3. FINDINGS

3.1 Introduction and General Findings

The Committee commends the Agency staff on the quality of their preparation, background documents, and presentations. The briefings were clear and well focused on the nature and scope of the program, its interrelationships with other related and complementary activity elsewhere in ORD and the rest of the Agency, and research at other federal agencies and in the private sector.

The Committee was also pleased to note that the recommendations made by SAB following its 1992 review of the Indoor Air Engineering Research Program (EPA-SAB-EEC-93-009) were given careful consideration and that many of them had been implemented in the current research plan. Further comment on the response of the IAQ Program to the 1992 review is provided as an Appendix to this review.

The Committee was concerned, however, that these evident strengths of the planning process and the research program are not adequately captured by the Issue Plan document alone. This is a serious shortcoming for a document that is intended to play a critical role in the strategic management of research activities in this area, and especially as a benchmark against which to measure progress and consider modifications in the future. The Committee recommends that the document be revised to more fully and accurately represent the content of the presentations and the supporting materials.

In particular, the Issue Plan would benefit from a more complete discussion of the approach to be used to integrate the various program elements, as well as a "Rationale" section to specifically define the working hypotheses that underlie each project area, and why these hypotheses are relevant to the overall goals. Each "Rationale" section needs to specifically define the working hypotheses that underlie the project area, and why these hypotheses are relevant to the overall goals. This discussion should be more specific than the "Scientific Questions and Research Needs" listing of key questions.

With regard to these key scientific questions (page 4 of Research Plan), several comments are offered:

- a) In the absence of a specific hypothesis regarding the airborne agents of concern, a natural set or related initial questions that the Research Plan should address are: What health effects that are associated with indoor environments can be quantified? What methods can be used to distinguish indoor exposures from other (outdoor, occupational) exposures and to eliminate the effects of other potential confounding covariates? Are there any temporal correlations that can provide insight into the sources of the observed health effects? Are there are



any identifiable sensitive sub-populations? Has previous research answered some of these questions?

- b) What constitutes a "complex mixture"? Does sequential exposure to individual agents constitute a complex mixture exposure? Is there an agreed-upon mixture that can be used to test a variety of health endpoints? Can source characterization provide a basis for "complex mixture" exposure protocols in the absence of identifiable toxic agents?

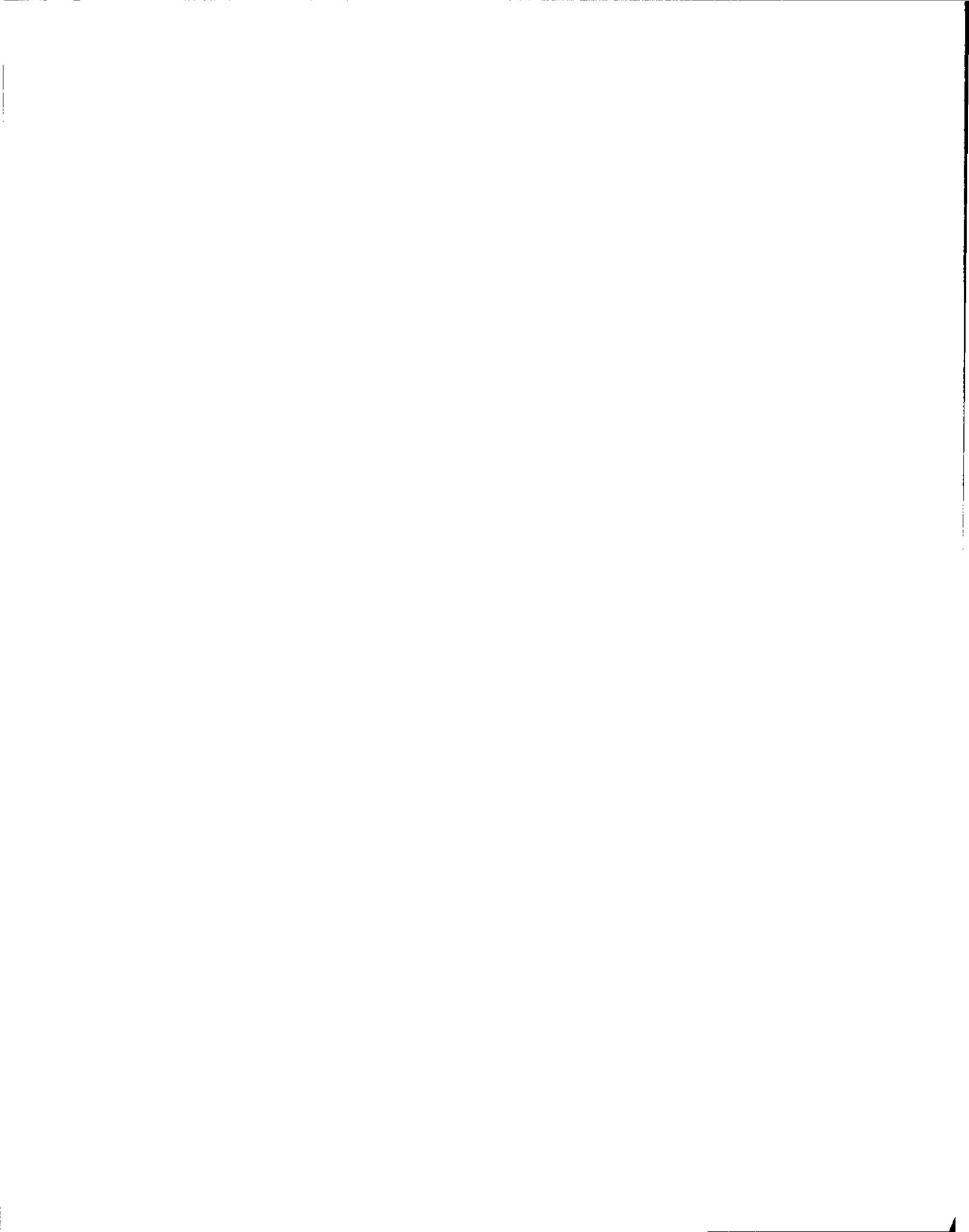
The stated major goals of the indoor air research program (see page 9 of Draft Document) include a specific listing of particulate matter (PM) as an important class of indoor, airborne agents associated with observed symptoms. However, there is little discussion of this pollutant class anywhere in the Research Plan. The only specific examples of PM pollutants are the lead and asbestos project areas. However, these are not very good general examples of the range of airborne particles encountered in indoor environments. Specifically, if PM is considered a class of indoor agents of high priority, then the research projects should consider more representative particles; in particular, the outdoor PM that infiltrates indoors, and the unvented products of incomplete indoor combustion. In addition, this class of sub-micrometer sized particles is amenable for use in "complex mixture" research.

It is clear that the Agency is seriously committed to developing a comprehensive indoor air research program that addresses what is an important public health issue. The remainder of this chapter describes the Committee's comments and recommendations relating to the EPA Indoor Air Research Program in response to the specific questions raised by the charge for the review.

3.2 Responses to Charge

Will the program address the most important scientific questions that will advance our understanding of indoor air quality?

There has been very substantial progress in the development of an EPA Indoor Air Research Program since the last SAB review of this program. The program as a whole is much more focused, integrated and coordinated among the various parts of EPA than in the past. There has clearly been some strategic planning and identification of key issues/areas for a program focus. Although there are not sufficient funds to adequately pursue all of the important indoor air issues, the staff has identified certain key areas and topics for focus and developed a generally sound research program around these areas. The planned research on the biological contaminants is particularly relevant in view of the limited information that we have in this area. Coordination and collaboration between



ORD and the Office of Air and Radiation and between the various ORD Laboratories was strongly evident in most instances.

The EPA staff should also be congratulated on the very high quality research involving inhalation exposures to emissions from carpets that they had to undertake on very short notice as a response to the highly publicized Anderson Laboratories results on deaths of mice from carpet emissions.

The indoor air program covers a broad range of topics requiring research skills that cut across a myriad of disciplines, and includes non-inhalation exposures as well as inhalation exposures. The paramount justification or rationale for an indoor air research program is the protection and advancement of public health and comfort. A growing body of scientific information indicates that exposure to indoor contaminants is associated with a variety of acute and chronic health effects, as well as odor and irritation. Many of the regulated outdoor air contaminants can be found in higher concentrations indoors than outdoors. Moreover, indoor exposures, both direct and indirect, are particularly important for the most susceptible segments of the population (old, young and those with existing health conditions). Indoor exposures need to be considered in developing mitigation strategies for reducing exposures to regulated outdoor contaminants. Indoor air quality, in short, is a scientific issue that is of significant public health importance. The indoor air quality research program at EPA is an important public health-related program serving virtually every U.S citizen, and it is widely recognized for its high quality. The program not only needs to be continued but should be expanded.

The Committee feels that some important scientific questions currently being addressed by the EPA program may warrant further consideration, as follows:

- a) Given the large number of sources and thousands of contaminants found indoors it is difficult at best to identify and set research priorities. The EPA program apparently has chosen to focus the major part of its limited resources on volatile organic contaminants (VOCs) and biocontaminants. There is no doubt that these areas of research are important, but it is necessary for EPA to provide the justification and rationale for their choices. In addition, some overall objectives related to these contaminants would be helpful. Such a rationale might serve to better integrate the research at the different laboratories.
- b) A decision has apparently been made to exclude combustion sources from the research program. Why? Indoor combustion sources are a major source of indoor air contaminant exposures and are in many cases responsible for the major portion of exposure to air contaminants which are of concern to EPA.

- c) There was no explicit discussion of the influence of the particulate matter (PM) from outdoor sources that infiltrates into the indoor air. The many recent reports of associations between elevated ambient air PM concentrations and both mortality and morbidity are highly suggestive of a causal role for PM in adverse health impacts. Most people inhale more PM from outdoor sources while indoors than during their brief times outdoors, and the indoor exposure to PM from outdoors needs to be considered in the overall indoor pollution research, in the context of total exposure.
- d) The FY 1994 budget is estimated to be \$7.3 million, some \$1.4 million less than FY 1993. The public health importance of indoor air research and the high quality of the research being conducted under this program would strongly argue for an increase in research funding in this area. The program is considerably underfunded as it is. Efforts should be made to raise the level of funding above the FY 93 level.
- e) Over the past year the program has provided a quick research response to address "emergency issues" (e.g., Anderson Laboratory animal testing protocol). The ability of EPA's scientists to successfully respond to such "emergency issues" is a testimony to the quality of the program and its importance. Such issues have seriously drained the already inadequate indoor air research budget. In the future there are likely to be more such "emergency issues". The base research program should not be made to bear the cost of addressing such emergency issues as they arise.

Will the program provide scientific and technical support to EPA's program offices and regions?

The program has a good history of providing scientific and technical support to EPA's program offices and there is every indication that it will continue to do so. It has provided support to the Office of Radiation and Indoor Air, and Office of Toxic Substances among others. Information produced by the program has formed the basis of several documents issued by the various government agencies.

No information was presented in the review which would allow a critical evaluation of the nature or quantity of scientific support provided to the Regions. The research program no doubt has provided valuable technical information and support to the Regions, but this issue was not addressed in the review.

Will the program promote private sector involvement in indoor air research?

Many of the source, exposure, health and contaminant control research issues addressed in the EPA indoor air quality program are of great concern to groups in the private sector (consumer product manufacturers, building designers, building



construction groups, building maintenance organizations, professional organizations, trade unions, etc.). The source characterization and solutions research, because of their direct impact on products, have fostered the most private sector involvement in indoor air research. As a result of EPA's research a number of groups in the private sector have initiated their own indoor air quality research programs. These groups include: The American Society for Testing and Materials (ASTM), American Society for Heating Refrigeration and Air Conditioning Engineers (ASHRAE), the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), Carpet and Rug Institute, Honeywell, IBM, Trane, Carrier, and Johnson Controls. EPA's indoor air quality research has directly impacted the development of voluntary source testing through ASTM and is now contributing to updating ventilation standards under ASHRAE.

Are the identified research projects commensurate with accomplishing the above three goals?

In general, all the research projects are consistent with the three identified goals. Some, however, are better conceived and executed than others. The following are a few examples of projects that are directly commensurate with the program goals: the development of biological response methods for characterization of source emissions, the development of improved monitoring and analytical methods for microbiological contaminants, investigations into the nature and measurement of the effects of VOCs (e.g., sensory irritation, central nervous system, pulmonary and immune responses), various aspects of the biocontaminant health research and the indoor air assessments. The following are examples of projects which are less directly related to the program goals: Large Building Study, developing asbestos monitoring methods, Multiple Chemical Sensitivity (MCS) study, and the total building cleaning effectiveness project.

Are the projects appropriate in light of EPA's leadership role?

In general, the research areas and many of the projects within each area, as specified in the research plan, are appropriate. The following is a brief evaluation, by research area, of each of the major projects proposed:

a) Source Characterization

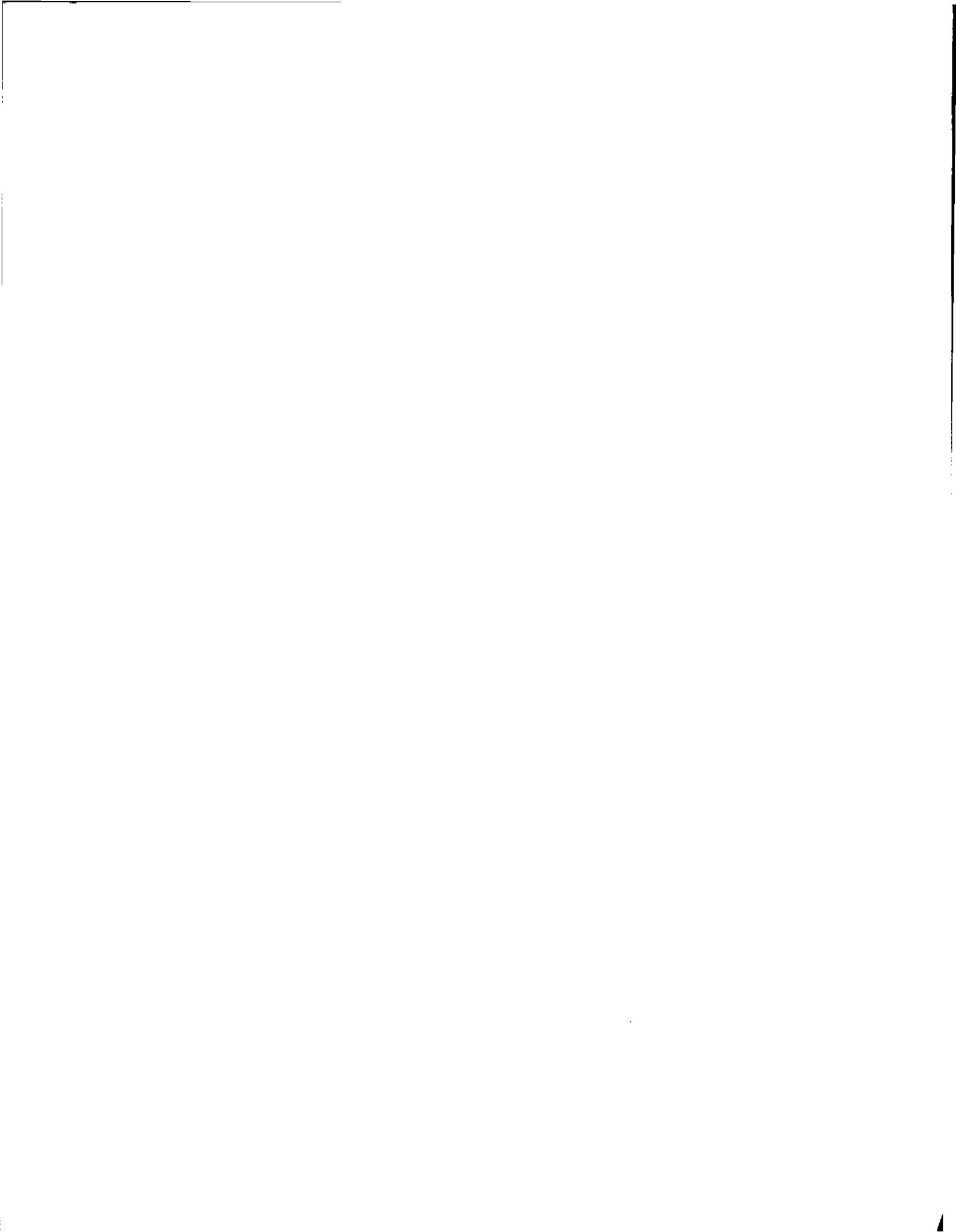
- 1) Chemical Source Characterization - this effort is well thought out and has been very productive in the past. It is highly relevant to the indoor air research program. It could be strengthened by expanding its IAQ approach to include designing and testing of "field study tools" for assessing sources and source use in field studies [i.e., source use questionnaires for use in large field studies, such as the National Human Exposure Assessment Survey (NHEXAS), epidemiologic studies, etc.]. There is a crucial need for such tools. The IAQ modeling effort should also be expanded to statistical/empirical modeling.



This expansion of effort would require closer collaboration with the Atmospheric Research and Exposure Assessment Laboratory (AREAL), the Health Effects Research Laboratory (HERL) and other EPA laboratories.

Care must be taken regarding extrapolation of source emission/modeling results obtained with the test house to the general housing stock. Are the range of conditions and environmental factors used in the test house representative of those found nationally? Would human activities alter the results obtained in an unoccupied home, and should such activities be incorporated in the testing protocols? Exchange of information between this program and ongoing or soon-to-begin field studies will be important in answering these questions.

- 2) Biological Response Methods - this is an exciting and relatively new area of investigation that should be a high priority. It represents a collaborative effort between AEERL and HERL. This work is very relevant to the overall goals of the indoor research program.
 - 3) Biocontaminant Prevention/Control - this is a relatively new area of research that is highly relevant to the research goals and very appropriate.
 - 4) Pollution Prevention - a project that is a natural extension of the chemical source characterization project. Like that project it is well thought out, productive, and important to the overall program
- b) Exposure Assessment - The "Large Buildings" study that is planned as part of the Exposure Assessment has the potential to complement BASE. The intention to conduct more longitudinal studies and to develop and test methods that can be used in surveys such as BASE makes good sense. For this reason, a mid-course reevaluation of the EPA Building Studies Program would seem appropriate. As described, the project appeared to lack a clear statement of objectives and expected outcomes. The data being gathered, under the current protocol, may not advance our knowledge of the nature of Sick Building Syndrome (SBS) such as relevant exposures or health/irritation outcomes, or define a "normal" building. A data analysis plan is needed. The study could be enhanced by a more active involvement of AEERL and HERL. For example, the building study will identify a fairly broad distribution of occupants with irritation complaints. The tails of the distribution would be an excellent population to study under more controlled conditions to better understand SBS.

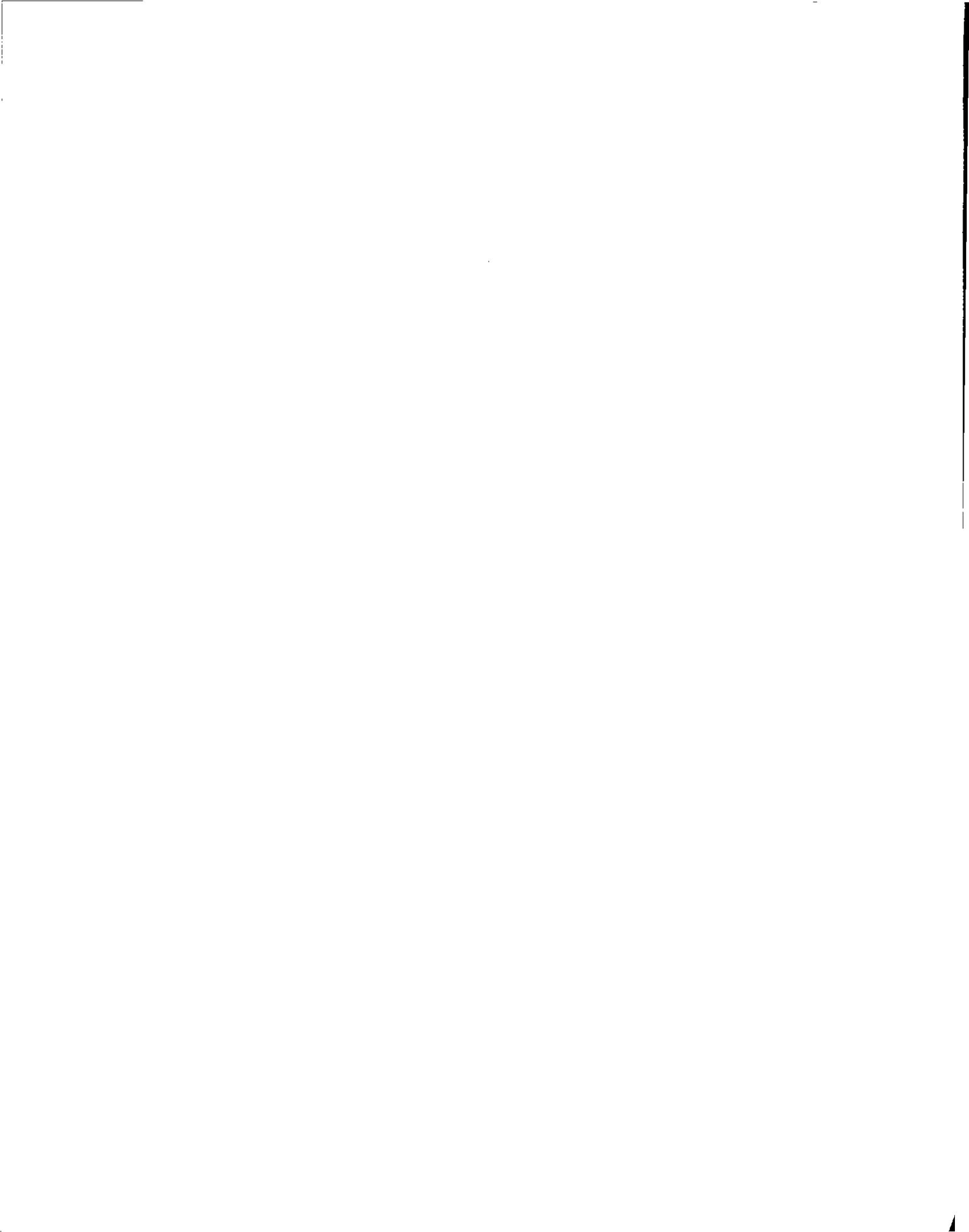


Although the "Strategic Directions" identified for the Office of Modeling, Monitoring Systems, and Quality Assurance (OMMSQA) are well-founded, their implementation in terms of the specific near-term projects, as presented, did not seem to fully meet the criteria presented in the viewgraph. The sampling and analysis methods research did not appear to address key scientific issues and problems in indoor air pollution research.

In particular, the effort to develop a standardized method for TVOCs seems misplaced. Measurement of Total VOCs (TVOCs) is widely recognized to be a screening method. Improvement in the measurement would be of the order of about 20%. Furthermore, the instrumentation that would be used is available only at EPA and perhaps a few other laboratories in the country. With respect to the TVOC methods evaluation, EPA and LBL have done work on this which has shown that the variability in TVOC measurements in real-world indoor settings with different VOC mixtures is only about 25-30%, relative to gas chromatography/mass spectrometric (GC/MS) total ion current measurements of VOCS. This is surely good enough for a screening method. Although the amount being spent is relatively small, in view of tight budgets, it could be better spent.

Research to develop better methods for reactive (polar) organics is a worthwhile effort and certainly meets a need. EPA has in the past been very successful in developing sampling and analysis methods for airborne pollutants. However, the organics selected for method development for indoor settings must have some relevance to the health effects of interest for indoor air and the kinds of organics known or suspected to be present in indoor air. The one class of compounds mentioned in this context, alcohols, can be sampled with a commercially available multisorbent sampler, thermally desorbed and analyzed by GC/MS. These alcohols are not very potent in terms of human health effects. It is important the EPA not "re-invent the wheel" in this area.

There is critical need for development of validated sampling and analysis methods for reactive and polar organics in indoor air but EPA must identify those which are most important to measure with respect to adverse health effects and those for which methods have not been well developed. They should do some strategic planning with the Indoor Air Division staff and the Health Effects Lab on this. Furthermore, there must be some consideration of the sampling period and concentrations that are relevant to human health effects. There are also constraints on indoor air sampling that do not exist in outdoor settings. Specifically, the air sampling rate must be well



below the air exchange rate of the building or room of interest and the sampling equipment must be small, unobtrusive and quiet.

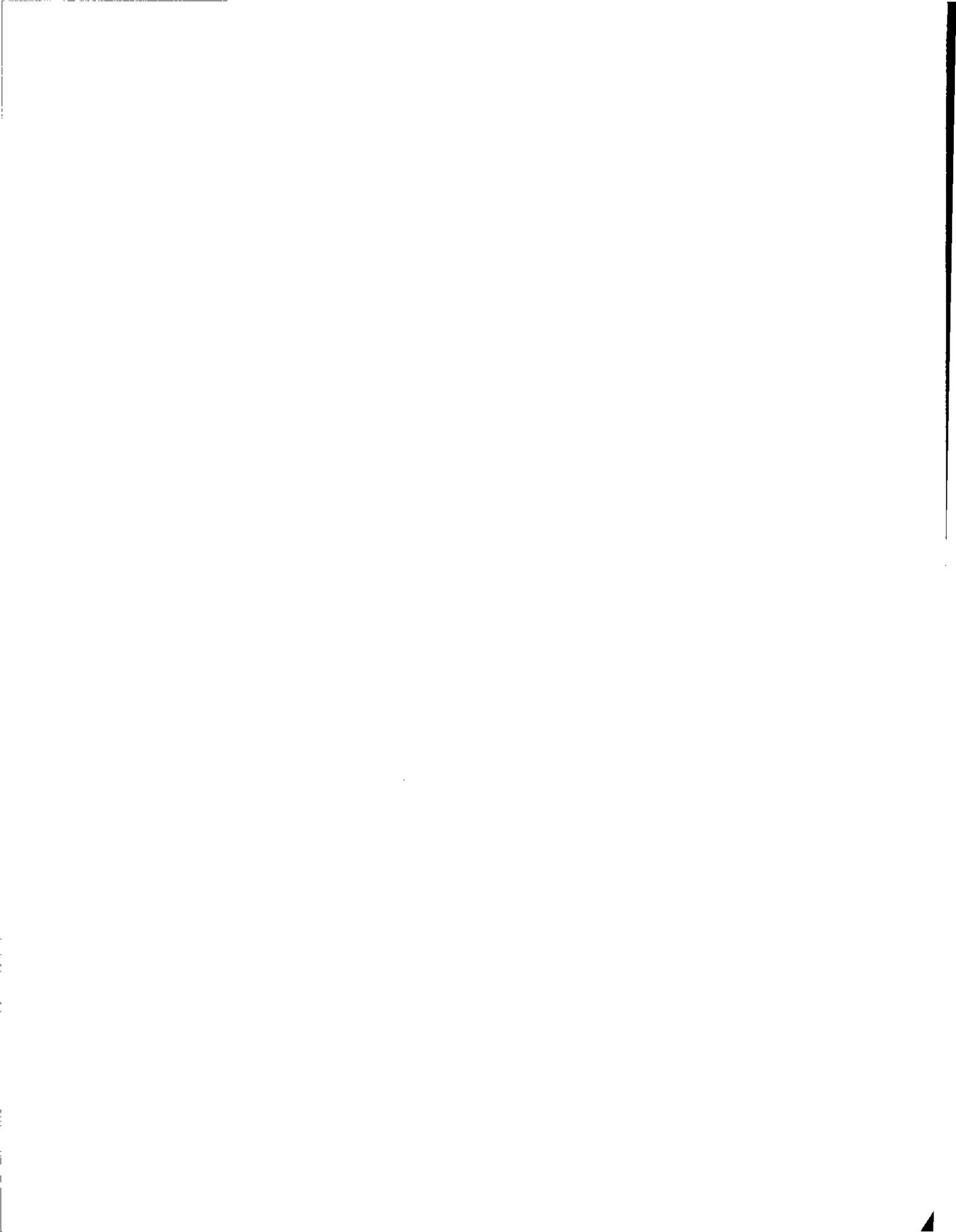
It is not clear how the Polycyclic Aromatic Hydrocarbons Measurements project relates to the overall program. It is not related to any other projects. Why is the development of a biomarker part of the project? Rationale and objectives need to be provided. This would seem to be a low priority area of research.

On the biomarkers for characterizing PAH exposures, there has been substantial work in this area for PAH metabolites in urine and for PAH adducts. It wasn't clear exactly what was being proposed here, but any work in the area should build on what has already been done and be an extension of such work, not a duplication.

There is a real need to develop sampling and analytical methods for microbiologicals. This project addresses that need. The project should be coordinated with the biocontaminant project being done by the Air and Energy Engineering Research Laboratory (AEERL).

There is a need to develop better measurement methods for asbestos and synthetic fibers, but this project does not seem to be related to any of the other projects in the program and may not belong in it.

- c) Health Effects Research - The Indoor Air Health Effects Research was well presented and the scientific questions were clearly stated. The scientific questions being asked are significant and the research plan well designed to address some of the questions identified. Progress in this area, however, is hampered by the relatively low level of funding.
- 1) Organic Vapors Project - the portions of this project related to identifying the most relevant acute signs and symptoms associated with VOC exposures and the development of both subjective and objective methods to measure those signs and symptoms is important work that has a high priority. This is highly relevant work that will advance our understanding of how indoor air quality is related to irritation, and what populations may be most sensitive. This work is a collaborative effort between HERL and AREEL. The MCS work is much more problematic, and should be reevaluated. Consideration should be given to focusing on the sensitive building populations which will be identified in the BASE Study.
 - 2) Biocontaminants Project - little information was given about this project. The human clinical and animal studies suggesting that ozone and nitrogen dioxide increase asthmatic response to house dust mites is intriguing. If borne out it will be an important finding.



3) Environmental Epidemiology - this area of research is notably absent from the research program. Environmental epidemiology should be part of the indoor research program. If HERL were involved in indoor epidemiologic research, there would be valuable links between their animal and clinical studies for both VOCs and biocontaminants.

d) Indoor Air Assessments

The indoor air bibliographic data base and indoor air assessments are valuable projects in this research area. The reports dealing with environmental tobacco smoke have been particularly valuable. The total building cleaning effectiveness study, however, while providing some useful information, does not rank high on the priority list. It is not clear how this project relates to other projects in the program.

A point of information on the EPA project to compile an Indoor Air Bibliography - DOE has compiled a "Concentrations of Indoor Air Pollutants (CIP) Database" which has been regularly updated with co-funding from the Electric Power Research Institute. This is available on computer disk.

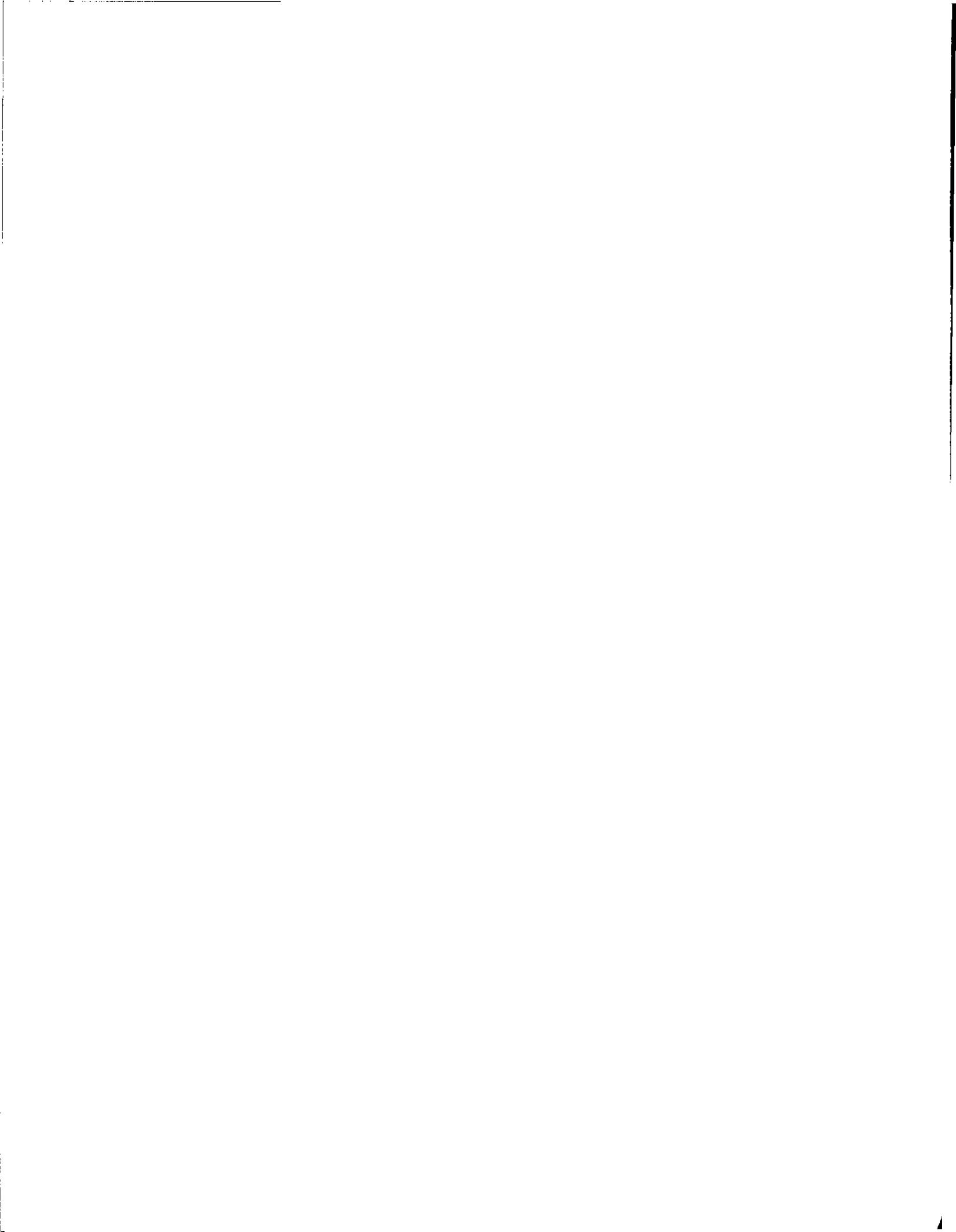
The report on environmental tobacco smoke health risks was clearly a successful venture. There did not seem to be much sense of what should be done next.

e) Solutions

This component of the Indoor Air research program appears to be in an earlier stage of development than the others. It is less developed and less integrated with other components of the research plan. There also seemed to be a more limited awareness of what kinds of research have already been done, what the important scientific issues are, and what the important research gaps are.

Of the five topics presented in the Solutions Research, the work on Air Cleaning seemed to be the most focused and strongest component. EPA has already done some valuable work on filters and there is much more work that needs to be done in this area. They should, however, make sure that they are fully aware of what has already been done and build on that.

1) Ventilation Research. The ventilation research component did not appear to have been developed. This is an area in which National Institute of Standards and Testing (NIST) and the Department of Energy (DOE) as well as many European institutions and investigators have strong, well-established research programs. In



view of the limited funds for indoor air quality research, it will be important for EPA to become informed about this ongoing research and identify research problems that are not being addressed by others. It will require the kind of inter-agency coordination that other parts of EPA have shown in order to avoid duplication of effort. Agency scientists should be on the mailing list of the Air Infiltration and Ventilation Centre (AIVC) of the International Energy Agency (Contact Martin Liddament, University of Warwick Science Park, Sovereign Court, Sir William Lyons Road, Coventry CV4 7EZ, Great Britain, FAX: 44(0)203 416306). AIVC regularly publishes reports and bibliographies on ventilation research that would be of value in identifying important research gaps that need to be filled. DOE is the designated U.S. representative to AIVC.

2) Radon Mitigation. DOE has been designated by Congress as the lead federal agency for radon research. In the memorandum of understanding signed by DOE and EPA, EPA agreed to be the lead agency responsible for research on radon mitigation, and has been conducting some productive research. Unfortunately, EPA funding appears to have been reduced in this important area.

EPA was directed by Congress to develop building codes for radon mitigation during the past year and the Office of Air and Radiation has done so. The effectiveness of active control systems for radon reduction has been successfully demonstrated in many homes. EPA's model construction standards call for the installation of passive stack control systems in houses built in areas of high radon potential. However, research on the effectiveness of the passive stack systems in reducing exposures has been limited to a few geographic regions and a relatively small number of houses. Because the passive systems are inherently simpler and more energy-efficient, if they could be clearly shown to be effective, they would be the systems of choice. Additional research by EPA to evaluate the passive stack systems in more houses and in different regions of the U.S. is recommended.

3) Cost Analysis. The proposed work on cost analysis appears to be a duplication of the work that the Indoor Air Program has already undertaken with substantial progress. It is strongly recommended that this effort not be undertaken unless it is coordinated with and complements the work already in progress.

4) IAQ Modeling. The model that has been developed is relatively simple and quite useful in that respect. The incorporation of the sorption/desorption processes is a valuable contribution. Development of a model that can be used as a design tool will require much more in the way of resources and expertise than is currently available in EPA's budget. Perhaps some thought should be given to working

collaboratively with the International Energy Agency on this to take advantage of the multizone air flow model that has been developed as an international effort under Annex 23. Work is now in progress to develop some validation of the model.

The IAQ modeling project is a well established effort within the solutions program. The modeling effort has been helpful in evaluating the generation, dispersal and removal of indoor air contaminants. Efforts are underway to improve the input parameters and incorporate the results from bioresponse testing and risk analysis. These efforts are in keeping with the overall research program. Validation of the model is also planned and needed. The current model requires detailed inputs, which are not typically available or measured in field studies. This project should be expanded to address the need for IAQ models which can be used to predict concentrations in homes or buildings in large field studies.

Does the research plan reflect intra- and inter-agency coordination?

EPA has made considerable progress over the past several years in the coordination and management of the various indoor air research projects being conducted at several of its laboratories. There is still room for improvement. Some of the projects are true collaborative efforts between various laboratories at EPA (i.e., biological response methods development), while others did not appear to enjoy such collaboration (i.e., Large Building Study). The strongest project efforts with the highest priorities demonstrate inter-laboratory collaboration. The weaker projects could benefit considerably from such collaboration. This is an important issues that needs immediate attention. The responsible leadership within ORD need to take a more active hand in ensuring that the level of interaction and collaboration between and among projects is high.

EPA has made a serious effort at interagency coordination of indoor air research. Other than the sharing of information it is not clear that this effort has resulted in any tangible results. Despite this, it is important to strive for interagency coordination.

3.2 Additional Comments

During the introductory remarks, the Committee was asked to advise EPA on four issues that went beyond the written charge, i.e.,: 1) the format of the research plan; 2) the overall funding level; 3) the distribution of the funds; and 4) the need for criteria documents for indoor air pollutants. The Committee's responses are contained in this section.

a) Format of the Research Plan

The basic format for presenting the plan was adequate. However, the presentations provided much more useful information and a clearer picture than the written document. More information is needed in

the plan in the following areas: rationale, objectives, setting of priorities, interrelation of projects, interlaboratory collaboration on projects, and management of projects at the laboratory level.

b) Overall Funding Level

The Committee is concerned at the prospect of a \$1.4 million (about 15%) cut in the indoor air research budget for FY94. This potential cut in the Agency's resources to develop the scientific basis for addressing indoor air pollution seems inconsistent with the Science Advisory Board's ranking of indoor air pollution as a high priority health risk in the Reducing Risk report.

c) Distribution of Funding

It was difficult for the Committee to evaluate the apportionment of funds within the "Source Assessment" program. Specifically, the relative distribution of funds between monitoring and analytical methods development was not clear. Monitoring of a wide range of airborne contaminants, as proposed in the building studies, is important, and should be encouraged. In contrast, funding for "methods development" should be given a much lower priority. It is much more important to examine whether any quantitative relationships exist between health effects and airborne contaminants that we know how to measure, rather than to develop new methods to measure other contaminants in the absence of specific hypotheses. These comments assume that methods for measurement of bioaerosols are included in other programs, as described in the research plan. Methods development in this specific area are needed.

Areas of lesser priority are in the risk assessment and solutions categories.

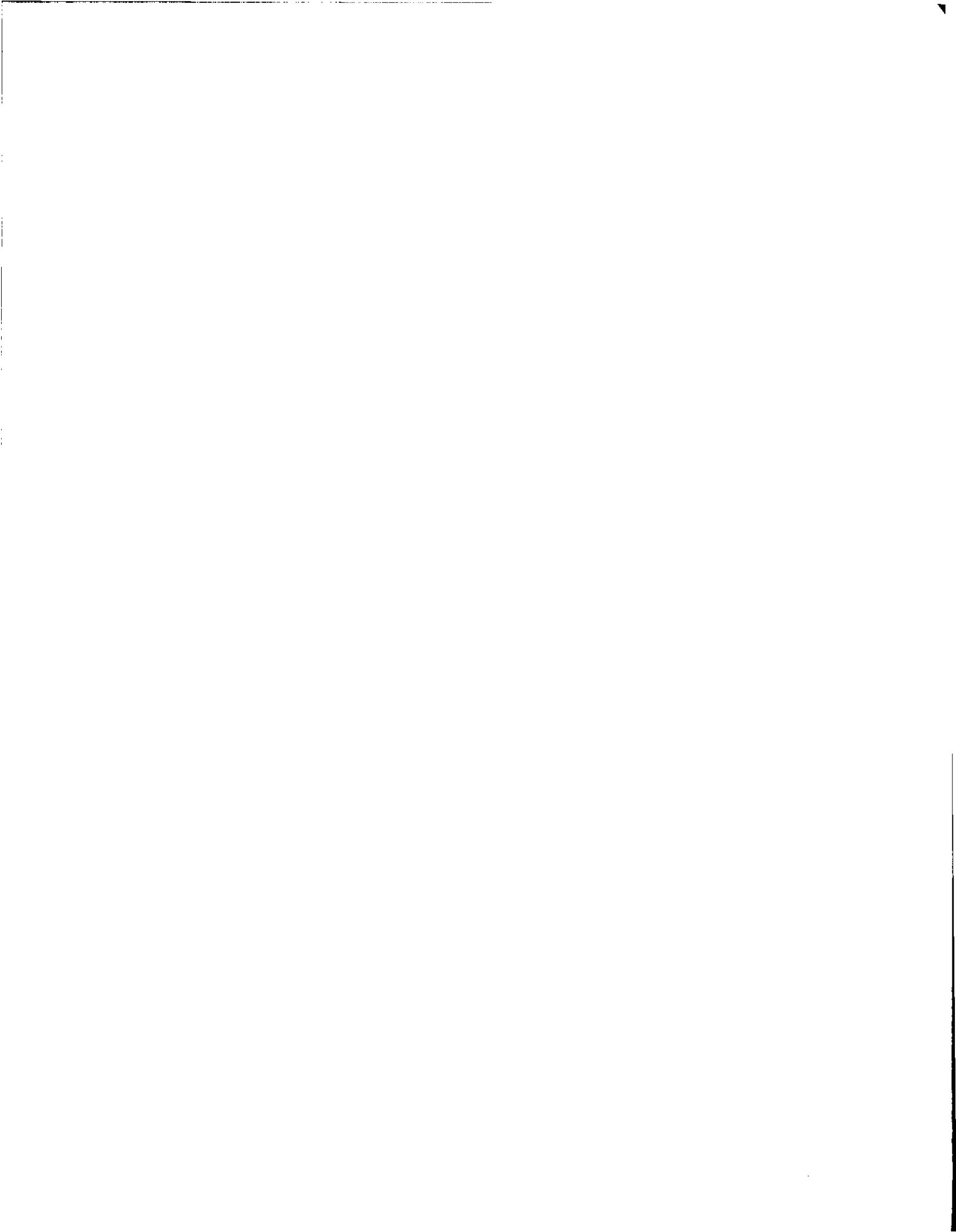
d) Need for Criteria Documents

There appears to be a need for some formal process that reviews the evidence for the health effects of a given, logical class of indoor air pollutants. This would help to focus EPA's research in this area by identifying the strengths and weaknesses of the epidemiologic and clinical evidence and by assessing the adequacy of exposure assessments and source attributions. This process could subsume current and proposed risk assessment projects. However, the Agency should not attempt to produce extensive multivolume documents patterned after the ambient air pollution criteria documents produced in the 1970s and 1980s. Rather than containing references to every study ever published on all aspects of each pollutant, the documents should be limited to a summary of the key data on characterization,



sources, exposure, health effects and control strategies that will provide practical, relevant information to State and local environmental and health agencies, public health organizations and industry. The information should be presented in an integrated manner that relates sources to exposure, exposure to health effects, and health effects to control strategies.

Such documents would be of use to a large number of individuals and groups both within and outside of EPA, and might be a useful way to establish our current level of knowledge for various classes of indoor air contaminants and to prioritize research. They might also help in establishing the public health importance of this issue. (Note: Several criteria documents for the regulated ambient air contaminants contain chapters on indoor sources and concentrations.)



APPENDIX

COMMENTS ON THE RESPONSE OF IAQ PROGRAM TO PRIOR SAB REVIEW

In 1992, the Environmental Engineering Committee of the Science Advisory Board reviewed the Agency's Indoor Air Engineering Research Program (EPA-SAB-EEC-93-009). In general, the 1992 SAB review of the program was favorable and supportive, although the SAB panel expressed concern that the research proposed during that review was "overly ambitious", given the then-current levels of funding. The budget included in the 1993 Research Plan does increase the health effects research funding substantially. This is a reasonable response.

The SAB panel encouraged further development and dissemination of the IAQ mathematical models develop by EPA researchers. The FY94 budget includes funding of a full scale test facility that will allow model testing and verification. The development of a full scale testing protocol would also contribute to the needed dissemination of these modeling efforts.

The SAB panel also urged collaboration with experienced researchers in the area of bioresponse testing. The IAQ has subsequently included scientists from HERL and AEERL as co-project officers on the extramural research conducted in this research area. Further, the SAB emphasized investigating the links between chemical exposure and bioresponse (e.g., biological gradient studies). The joint research project between IAQ engineers and HERL scientists (involving small test dynamic chambers, source characterization, and eye and nasal irritation) is a positive response to this SAB concern.

The SAB panel encouraged research on the cost-effectiveness of pollution prevention alternatives and dissemination of the cost-effectiveness analyses and models to the user community. The IAQ engineering program managers recognize the importance of this area and agree that dissemination of the cost-effectiveness of pollution prevention is necessary. They have provided consulting services to the BASE study and have on going collaborative efforts with the Office of Indoor Air economists.

Finally, the SAB panel recommended that an overall plan reflecting all four programs should be developed. This was done as part of the current 1993 SAB review.

