ORBES

COMMENTS ON THE OHIO RIVER BASIN ENERGY STUDY

Collected by

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PHASE II

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February 1981

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PREFACE

The Ohio River Basin Energy Study (ORBES) was a four-year research activity undertaken by over 100 university faculty members at eight institutions in the Middle West and the area popularly known as the Ohio River valley. ORBES was mandated by the U.S. Congress in 1975 in response to concerns expressed by citizens in that area. The study was planned and funded by the U.S. Environmental Protection Agency (EPA).

The principal element of the ORBES publication series is entitled Ohio River Basin Energy Study (ORBES): Main Report (EPA-600/7-81-008), which also will be available in summary form (EPA-600/S7-81-008). The main report represents the collective end product of a 13-member interdisciplinary faculty group known as the ORBES core team. In addition to the main report, more than 50 other ORBES documents by various researchers were issued over the four-year project period.

The members of the ORBES core team are James J. Stukel, professor of environmental engineering and mechanical engineering and director, Office of Energy Research, University of Illinois at Urbana-Champaign, and Boyd R. Keenan, professor of political science, University of Illinois at Chicago Circle, both of whom also served as co-directors; and (alphabetically) Robert E. Bailey, professor of nuclear engineering and director, Program on Energy Research, Education, and Public Service, The Ohio State University; Donald A. Blome, research scientist, Institute for Mining and Mineral Research, Energy Research Laboratory, University of Kentucky; Vincent P. Cardi, professor of law, West Virginia University; Gary L. Fowler, associate professor of geography and associate director, Energy Resources Center, University of Illinois at Chicago Circle; Steven I. Gordon, assistant professor of city and regional planning, The Ohio State University; James P. Hartnett, professor of energy engineering and director, Energy Resources Center, University of Illinois at Chicago Circle; Walter P. Page, associate professor of economics, West Virginia University; Harry R. Potter, associate professor of sociology, Purdue University; J.C. Randolph, associate professor of ecology and director of environmental programs, School of Public and Environmental Affairs, Indiana University; Maurice A. Shapiro, professor of environmental health engineering, University of Pittsburgh; and Hugh T. Spencer, associate professor of chemical and environmental engineering, University of Louisville.

The core team's work grew out of ORBES Phase I, which extended from the fall of 1976 through November 1977, when ORBES Phase I: Interim Findings (EPA-600/7-77-120) was published. This latter publication, written by

Professors Stukel and Keenan, synthesized findings of the three preliminary research teams that operated independently during Phase I. As mandated by Congress, the Phase I study region consisted of portions of Illinois, Indiana, Kentucky, and Ohio, and researchers were from universities in these states. EPA officials as well as members of Congress and their staffs agreed that in ORBES Phase II the study region should be expanded to include virtually all of West Virginia and the southwestern portion of Pennsylvania.

ORBES may be unique in terms of its management framework and its openness to the public. The work of the interdisciplinary, interuniversity core team was coordinated by a management team and by a project office maintained on the University of Illinois campuses at Urbana-Champaign and at Chicago Circle. At least once a month, and sometimes more frequently, the full core team held two- and three-day working sessions that were open to the public on the various campuses and at other locations around the study region. These meetings began in the fall of 1977 and continued for two years. Moreover, during both Phase I and Phase II, open meetings on research results were held throughout the region. Early in Phase I, an advisory committee was appointed, consisting of representatives from government, business, labor, agriculture, the public, and other sectors. Committee membership was expanded throughout Phase II and reached a total of 43. Advisory committee members had an ongoing invitation to provide written or oral comments on the ORBES research. As part of their input, they reviewed a preliminary draft of the main report.

Members of the advisory committee and other project entities also were given the opportunity to contribute to the present volume, which is entitled Comments on the Ohio River Basin Energy Study. The other project entities are the core team, the management team, and the support researchers. This latter group carried out specialized subprojects commissioned in Phase II by the core team.

The comments collected in this volume cover not only the ORBES main report, but also any other aspect of the project that the writers chose to review. Each individual's review is limited to 10 pages. Of the 13 core team members, 2 contributed to this volume, as did 1 support researcher. Eleven of the 43 advisory committee members are represented by individual comments. In addition, two groups of advisors chose to pool part or all of their allotted pages: (1) utility company representatives and (2) the administrators of EPA Regions III, IV, and V.

For the convenience of the reader, a complete list of ORBES publications appears as Appendix A. Appendix B consists of rosters of the various Phase II participants.

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Core Team Comments

Robert E. Bailey
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Radioactive Release from Coal and Sabotage of the Nuclear Fuel Cycle

There is little question as to the validity of the statements within the ORBES Main Report[1*] that air quality issues are the ones for which there will be greatest concern in regards to energy development within the ORBES region during the period in which the ORBES assessment was made. There are, nevertheless, two additional classes of issues which were not mentioned but might become important in the future. Both deal with nuclear radiation. One class of issues is related to the radioactivity that is inherently contained within coal and thus emitted into the ecosphere when the coal is burned. The other class is related to radioactivity released into the environment that is initiated through acts of terrorism directed toward components of the nuclear fuel cycle that presently exists within ORBES. These components would be even more present under the Nuclear Fuel Substitution Scenario of the Fuel Substitution Scenarios.

Coal and Radioactive Release

Recent studies of The Ohio State University, which were done as part of the ORBES, indicate that, on the average, the concentration of uranium and thorium in the coal used in the Basin is 1.65 and 4.86 ppm respectively.[2] The ash content is approximately 11%. The radioactivity associated with the coal leaves as part of the ash, or as radon gas which is liberated from the coal as it is burned. The radioisotopes that are emitted are those which are associated with natural decay chains from thorium and uranium and furthermore, they are in secular equilibrium. In the case of nuclear reactors, the radioisotopes emitted are those which are fusion products and a few other activities such as tritium.

A comparison of the radiation doses received by persons within ORBES, living near nuclear and coal-fired plants[2], indicates that the population receives more radiation from the use of coal than from a nuclear power plant operating within design conditions. In all cases studied, the dose received was below the standards described in Title 10 of the Code of Federal Regulations.

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*Footnotes can be found at the end of this article.

These results are in agreement with similar calculations done elsewhere.[3]

The radioactive release and corresponding radiation dose experienced by the population from the burning of coal could become an issue if allowable levels of population dose are lowered. It is conceivable that standards will be lowered as more is learned about the health effects of low levels of radiation.[4] At the present time, coal is not considered a licensed material and thus the radioisotopes associated with coal are not under the same regulations as those from a licensed material such as uranium. This naturally leas to the question:

> **"If radiation is harmful to human health, shouldn't regulations on the control of radioactive release be directed toward the radioisotope and not the source of that isotope?"**

Should radiatioin dose from coal become an issue, this could have special significance within the ORBES region since coal has such widespread use. Impacts would be felt not only in emission controls to reduce the ash release to the atmosphere, but more importantly, such regulations would impact on the storage of ash from many facilities using large quantities of coal, since it can be demonstrated[5] that the ash from a large user, using basin coal, already exceeds limits for burial of radioactive licensed materials as specified in Title 10, Chapter 20 of the Code of Federal Regulations.

Terrorism and Radioactive Release

As the ORBES Main Report states, there are three major processes of the nuclear fuel cycle - uranium enrichment, fuel fabrication and power generation - that exist within the ORBES region. Furthermore, a study of the tranport of nuclear materials throughout the United States shows that nuclear materials are tranported within the ORBES region.[6] Each of the facilities associated with the nuclear fuel cycle is a potential target for sabotage by terrorists or other types of disgruntled persons, and could be a source of intentional radioactive release. This applies equally well to vehicles used for the transport of nuclear materials, as well as for fixed structures.

As a consequence of this realization, a vulnerability assessment of a nuclear power plant, spent fuel storage facility, was performed on a plant located within the ORBES region.[7]

These storage facilities were selected for analysis essentially for five reasons. First, spent fuel is highly radioactive and can be quite lethal if improperly handled. Consequently, its misuse could pose a significant health hazard to the general public. Second, spent fuel is stored in areas which do not provide the same level of physical protection given to the nuclear reactor itself. Third, and perhaps most important, the uncertainty surrounding the status of waste disposal and reprocessing policies in this country indicates that spent fuel inventories at reactor sites will continue to grow in the foreseeable future. Fourth, as the debate over nuclear power in general - and waste disposal in particular - heightens, spent reactor fuel could take on added symbolic significance as a target. Finally, large, well-financed and sophisticated terrorists organizations capable of complex operations exist. While the continental United States has remained relatively immune from their attacks, the potential threat these groups represent cannot be ignored.

In performing the vulnerability assessment, it should be pointed out that only non-classified sources and techniques were utilized. This was done in order to establish the degree to which relevant information about a given site could be acquired while working under these constraints. Potential adversaries could therefore avail themselves to the types of material presented in this report without resorting to provacative and risky intelligence collection methods.

The results of the study strongly imply that fuel storage facilities can be vulnerable targets which allow an adversary the opportunity to release radioactivity into the atmosphere using conventional explosives. Other direct consequences of sabotage that need to be taken into account are the injury or death of plant personnel due to an assault, radiological damage to property, non-radiological damage to the plant proper, and the economics costs of cleanup and any required downtime.

Unlike their counterparts, the potential indirect consequences of a serious act of nuclear sabotage will remain largely unrecognized until an act occurs. This is the case since indirect consequences are contingent upon not physical laws, but human response. This response in turn will be based on perceived rather than actual reality. Where radioactive materials are concerned, the gap between these two could be quite substantial. At present, the fear of radiation on the part of the general public could be exploited. Writing well before Three Mile Island, Brian Jenkins offered the following:

> "almost any terrorist action associated with the words 'atomic' or 'nuclear' automatically generates fear in the mind of the public...Nuclear power, whether in the form of peaceful energy or weapons, is the most potent and, to many people, the most sinister force known to mankind. Any sort of nuclear action by terrorists would be assured of widespread publicity. It would instill fear and create alarm...A well-publicized terrorist attack on a civilian nuclear facility, even if the terrorists failed in their intended mission, could be almost as alrming to the world as a terrorist success."[8]

More recent are the cogent statements of Kupperman and Trent:

> "Vulnerability of an installation is both physical and symbolic...if a nuclear power plant were attacked by a small band of terrorists bearing nothing more than small arms and explosives, very little physical damage would occur, but the symbolic effects - the hysterical fear of a core meltdown with its insidious cloud of radioactive materials - would cause the severest political ramifications and might force the industry to shut down partially. Thus, it may not be enough to limit the potential for substantial physical damage; we may need to win so overwhelmingly that the perceived damage would be insignificant."[9]

Mitigating the perceived damage of an attack to the point of insignificance would be a challenge indeed. In an open society, this is difficult to do for any major terrorist event, much less for one having the sensitivity of a nuclear incident. The adversary group itself should be expected to maximize the impact of their attack through the media. Public panic, as well as governmental paralysis, may be principle objectives.

Regardless of specific outcomes, there is no doubt that the event will trigger an increased awareness of the security issue at nuclear facilities. If the public perceives that a serious attack has occurred, even if there is no radiological release and the on-site security system effectively defeats the adversaries, claims will likely be made that the industry was simply "lucky this time" and that the attack is a harbinger of more serious episodes. If this view becomes pervasive, from a public relations standpoint, the industry may find itself in a "no-win" situation. Criticism of the industry would carry over to those who regulate it and set the security standards. It is contended here that strong pressures for fixed site security upgrade would be unavoidable, even if the then-present system successfully protected the installation.

This leads to the following significant question:

> **"Is it conceivable that there could be a measurable or even unacceptable loss in civil liberties as the government increases its efficiency in protecting citizenry from deliberate attempts to threaten and/or to cause the release of radioactivity?"**

This particular question has special significance for nuclear power plants when one considers that not only are there safety analysis reports and environmental impact statements that are public documents, but there are also public hearings for both the operating and construction permits.

FOOTNOTES

1. The ORBES Core Team, "Ohio River Basin Energy Study (ORBES): Main Report," Office of Research and Development, U.S. Envirnonmental Protection Agency, Washington, D.C. 20460. November, 1980.

2. Calculations were made using a modified form of the AIRDOS-II computer code. The code was modified by incorporating submodels which, a) allowed it to calculate doses from multiple sources located in varying geographical locations, and b) allowed it to calculate regional doses based on averaged concentrations of pollutant. A reference for the unmodified AIRDOS is, "The AIRDOS-II Computer Code for Estimating Radiation Dose to Man from Airborne Radionuclides in Areas Surrounding Nuclear Facilities," by R. E. Moore, et al., ORNL-5245 Oak Ridge National Laboratory, Oak Ridge, Tennessee. 1977.

3. J. B. McBride, et al., "Radiological Impact of Airborne Effluents of Coal and Nuclear Plants," Science, Vo. 202, Pages 1045-1050 (December 8, 1978), and C. E. Styron, et al., "Assessment of the Radiological Impact of Coal Utilization, Report No. MLM-2514, The Manual Laboratory, Miamisburg, Ohio. February, 1979.

4. Committee on the Biological Effects of Ionizing Radiations, "The Effects on Population of Exposure to Low Levels of Ionizing Radiation," National Academy of Science, National Academy Press, Washington, D.C. 1980.

5. R. E. Bailey, et al., "Wastewater Reduction and Treatment for Synthetic Fuel Processes in the Ohio River Basin," Water Resources Center, The Ohio State University, Columbus, Ohio. 1979.

6. "National Energy Transportation," Committee Print for the Senate Committees on Energy and Natural Resources; and Commerce, Science and Transportation, Committee Print 95-15, Volumes I and II. May, 1977.

7. B. R. Narduli and R. E. Bailey, "Sabotage Assessment of Two Reactor Spent Fuel Storage Facilities Found Within the Ohio River Basin," The Ohio State University Program for Energy Research, Education, and Public Service, Columbus, Ohio. August 5, 1980.

8. Brian M. Jenkins, "Will Terrorists Go Nuclear?", P-5541, (Santa Monica, CA: The Rand Corporation, November, 1975), pp. 4-6.

9. Robert H. Kupperman, Darrell M. Trent, "Terrorism: Threat, Reality, Response", Hoover Institution Press (Stanford University, Stanford, CA, 1979), p. 103.

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The National Environmental Policy Act, our landmark legislation for environmental protection, was signed into law 1 January 1970, just eleven years ago from the time of this writing. Thousands of environmental impact statements have since been written; and the ORBES project, although something different, was spawned of public interest in the environmental impact analysis movement of the 1970's. It was to determine the impacts on the Ohio River Valley of plausible energy futures through the year 2000. Were the futures chosen by the Core Team plausible, and were their impacts assessed with known accuracy? These questions will be debated for as long as the study generates interest, which may well be for some time to come.

Debate over ORBES is nothing new. The Core Team, along with its management group and advisory committee, fought over issues of scenario plausibility and method validation for four years. Indeed, the ORBES project was, within itself, a study of debate and contest, and this discussion was open at all times to all takers. We kept no secrets, made our results available to everyone as they became available to us, and thus made few friends while engendering the rath of many. To this day, some of our colleagues insist we selectively leaked self-serving information along the way. That is not true. Keeping the study open, as in a fishbowl, was to us, however, a more important consideration than keeping our critics appeased. The issues raised during the course of the study were profound and could never have been laid quietly aside anyway, no matter how preliminary the data seemed to be. We could never have allowed the public's windows into the study to be closed, nor would any attempt to do so have been acceptable to the Valley's citizenry or our Congress.

I worked over my part of the ORBES main report for many months, and I have reviewed with care the work of my colleagues. I am proud of the report as published and ask that it be taken as my comment for the record. Also, I look forward to the debate raging on, as we all know it will. Ours is a house with many windows, and so long as those vested with authority, be they elected officials, utility executives or college professors, use it fairly, we will succeed.

Support Researcher Comments

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My comments deal with four related topics: 1) the original, motivating force behind the ORBES study, 2) public participation in power plant siting in the ORBES Region, 3) the apparent over-emphasis of air quality aspects in the Main Report, and 4) techno-organizational strategies for problem resolution in the ORBES Region.

Motivating Force. Concerning the first topic, the original motivating force behind the ORBES study, it is noteworthy that in a careful review of the Main Report, one is unable to find any meaningful reference to the topic of public participation in power plant siting in the ORBES Region or elsewhere. Indeed, one cannot even find the term "public participation" anywhere in the report. Reference to the fact that public pressure initiated ORBES is found only in a brief statement in the Concluding Note (Main Report, p. 295). I am therefore concerned that one of the principal motivating forces behind ORBES, i.e.; public dissatisfaction with its role in the energy facility siting process, has been overlooked to a large degree in the final report.

It is inaccurate to say that the principal reason for ORBES was to address the issue of an apparent lack of coordination in the siting of new power plants in the Ohio River Valley (Main Report, p. 295). I am convinced that the central issue indicated by the public in calling for the ORBES effort was not "regional coordination", but something much more subtle and ultimately more important. An in-depth study of six case studies of new power plant siting in the Ohio River Basin by this author reveals that the central element causing dissatisfaction on the part of public participants is the unavoidable feeling that they are powerless to affect the final siting decision or, indeed, any aspect of it. In such a context, "regional coordination" is the ultimate luxury in a world wherein even the most basic facts concerning environmental and social impacts of a proposed plant are unobtainable until years after basic permits have been secured and large dollar investments have been made.

The motivating force behind ORBES therefore relates to an apparent lack of meaningful public participation in power plant siting in the Region, which

in turn engenders discontent among parties that have tried to influence the siting decision.

Public Participation.

The causes of this lack of power are many, and have been investigated elsewhere[1]. Principal among these are 1) regional siting studies conducted by the utility wherein public representatives are excluded, 2) utility maintenance of confidential regional siting study reports, 3) the purchase of land and conduct of significant site construction work before environmental reviews are complete, 4) public service commission permit reviews that are both brief and limited in scope, 5) lack of technical expertise and inadequate staff size found in state public service commissions, 6) lack of expertise found on the part of environmental groups in certain technical areas related to electricity generation and transmission, 7) costly and formal adjudicatory proceedings by certain agencies, which are held late in the siting process, 8) lack of public information until after the Draft Environmental Impact Statement is issued, 9) inadequate information transfer to the public throughout the siting process, and 10) lack of National, generic policy statements with which to guide individual siting studies, to mention only a few.

It is this author's firm conclusion that any proposed institutional solution be viewed first in the light of whether it would serve to correct the current atmosphere of mistrust which exists between utilities and environmental and other citizen groups. Such mistrust stems largely from inadequacies of the current siting process as cited above, all of which could perhaps best be viewed as originating from a closed decision-making process, as opposed to an open one.

Put another way, it is not clear that any new institutional structure is needed; rather, what is clear is that current procedures must be changed to incorporate aspects of a decision-making process more open to the public.

Air Quality.

Third, air quality seems to be used in the Main Report as the principle justification for a regional coordination mechanism. I am both impressed and unimpressed by the arguments given along this line. First, the ORBES air quality studies show, as documented in the Main Report (pp. 11-17), that under all of the coal-dominated scenarios sulfur dioxide and particulate emissions will decrease substantially from 1976 levels by the year 2000. The Report (p. 221) indicates, however, that this will still result in 1) the continuance of some episodes of poor air quality both inside and outside the Basin, 2) the maintenance of a few "hot spots" of air pollution in the Basin and 3) a decreased but perhaps still significant level of long - range transport of air pollution.

[1]Whitlatch, E. Earl, and John A. Aldrich, The Ohio State University, Energy Facility Siting Procedures, Criteria, and Public Participation in the Ohio River Basin Energy Study Region (ORBES Publication, Phase II, Grant Nos. EPA R805589 and R805603, August, 1980, 112pp).

The first two air quality problems cited above, episodic conditions and local "hot spots", do call for some degree of regional coordination, but it would appear that corrective measures for these conditions could be achieved without the creation of a strong regional body. Rather, a "loose" regional coordination system would suffice, one which does not have a large administrative overhead. Existing institutions could be used for most analysis and interpretation.

The problem area of long - range transport of air pollutants also calls for some degree of regional coordination, but the problem itself is not currently well understood. It would be premature to create an institutional structure to deal with a problem not yet entirely defined. Any discussion of potential effluent limitations could certainly be conducted without a regional organization. If some reductions were necessary, regional coordination might then be useful to achieve the desired total effluent reduction. Again, however, a strong regional entity may not be needed to achieve these reductions (see below).

Techno-Organizational Strategies.

This author is not an institution builder; however, it would seem that subregional institutions could operate within the framework of Federal and state policies on air quality. This would have the advantage of placing siting decisions closer to those affected by the decision. It must be remembered that air quality is only one of many criteria used for the siting of power plants. The public has a right to express its concern on criteria other than air quality. More than this, the essence of the problem is in allowing the public to express its concerns conveniently, directly and meaningfully. Such expression is difficult, even under the current decentralized system. Placing the energy facility siting decision more remotely at the regional level at this time would probably only exacerbate this problem. (In passing, it may be useful to observe that, of the regional organizations mentioned in the Main Report, ORSANCO seems to have most earnestly conducted public participation activities, at least in its formative years). Symptomatic of the institutional emphasis on regional forms in the Main Report is the fact that utility initiatives in other states, some involving significant public involvement, have not been discussed.

It would seem that a start at obtaining meaningful public participation could best be achieved at the subregional level; in fact, at the utility service area level. As confidence is gained by both utilities and the public in their ability to communicate and negotiate effectively, movement toward a more regional coordinating system would be possible. As an example, an open siting process undertaken by two or three utilities acting together could probably avoid the problem of local air quality "hot spots" in the Basin. Once this level of coordination and public participation were achieved, cooperative action by utilities acting through an organization such as the East Central Area Reliability Council might enable an alternative such as least emission dispatching of electricity to deal with episodic periods of poor air quality caused by adverse atmospheric conditions. As further experience by the industry is gained, an acceptance of more extensive coordination of

siting of new power plants might be possible, as well as consideration of regional means to reduce the total level of emissions on a permanent basis through the most cost-effective means. In fact, voluntary utility coordination in the latter case (total effluent reduction) would be likely, since it would be in their own self-interest to jointly cooperate in reducing the total cost of meeting effluent limitations.

Conclusion.

It is emphasized that the key conclusion from observing case studies of power plant siting is that dissatisfaction with the energy facility siting process arises principally from the feeling on the part of public participants that their comments have no effect on the final siting decision, and that in fact their comments are received only after the siting decision has in essence been made. In any discussion of alternative institutional forms, therefore, much attention should be given to the quality of public participation that might occur under the alternative forms. I find such a discussion lacking in the Main Report. If present, much more attention would have to be given to private (utility) alternatives.

Advisory Committee Comments

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The Ohio River Basin Energy Study (ORBES) Main Report authored by the thirteen members of the ORBES Core Team, dated November 1980, has been reviewed by twenty-one Regional Technical and Management Staff members in Region V. Because of the broad interest in the ORBES Project expressed in Region V from its inception, it was decided that comments on all technical areas of the Main Report and pertinent supplementary ORBES Research Reports and selected general comments on the study as a whole, except those related specifically to air quality, would be discussed directly by Region V here. Comments provided by the Region V staff on air quality and related environmental impacts discussed in the ORBES Main Report have been combined with corresponding comments from Regions III and IV and will appear elsewhere in this volume as a Tri-Regional Response.

This study was initiated by congressional action resulting from concerned citizens in the Ohio River Valley convincing their legislators that a rapidly growing problem in their area was one with which existing controls could not cope. Their legislators are to be commended for their action in responding to the citizens in directing the USEPA to conduct a thorough investigation of the overlapping "potential environmental, social and economic impact of a proposed concentration of power plants in the lower Ohio River basin." The cross-impact evaluation of this complicated interdisciplinary series of problems provided by the Technology Assessment approach used by the ORBES Core Team has served the need well.

Co-directors of the project Dr. James J. Stukel and Dr. Boyd R. Keenan are to be commended for their ingenuity and research management accomplishment in developing the unique organization and procedure used in this study and described in the report. The Core Team members, also including Drs. Stukel and Keenan, have produced an impressive Main Report and auxiliary supporting reports covering every discipline represented by the Core Team membership and the Support Researcher Roster.

The Ohio River Basin Energy Study has certainly identified and brought into better focus many of the major factors, and in some instances the submerged sub-structures, that are contributing to the escalation of some very real and potentially major issues relating to the Ohio River Basin in particular and to the huge overriding problems orginating from energy development, while protecting the health and welfare of the citizens in all areas of the nation. The Executive Summary of the Main Report (Pages 3 to 42) represents

a commendable job in summarizing the critical issues identified. The Concluding Notes section (Pages 41-42) summarizes in less than a page some key issues and some key contributors to these issues and ends on an optimistic note that solutions can be found. The succinct comments on those pages will, in all probability, challenge legislators and the public alike to delve more deeply into the contents of both the Main Report and the support documents. As stated in these pages, the solution to these problems and issues must without doubt be the result of cooperative effort from everyone involved - legislators, governmental units and officials at all levels, industry and private citizens. Whether the readers agree with all of the various segments of the many ORBES reports or not, it is our opinion that the Concluding Notes demand the attention and solemn consideration of all of us.

A major driving force that prompted Regional Management to initiate strong participation in the ORBES project was the expressed citizen interest in potentially serious environmental problems related to power development. The support of citizens and environmental organizations in Region V along the Ohio River in their effort to obtain more information about their potential problems and possible alternative solutions has always been a major interest in this office. Also, a continued effort is considered essential to be certain that citizens have available to them the necessary scientific and engineering support needed and to help keep them continually aware of the several opportunities citizens have for impacting environmentally sensitive developments in their area during the planning and pre-construction stages.

Although there are several built-in opportunities for citizens to be heard by those authorities responsible for controlling environmental impacts, these opportunities are often buried in legal red-tape. One such opportunity that exists during the planning stages of all environmentally impacting projects was not properly referenced by the ORBES reports. We would like to discuss it here briefly for the benefit of those who may want to utilize the opportunity in the future. The most recent Council on Environmental Quality Regulations on the Preparation of Environmental Impact Statements sets into place the scoping process for major Federal actions significantly affecting the environment. Most coal-fired power plants will have an Environmental Impact Statement prepared on them, therefore scoping would be required.

The scoping process is to be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. It would appear that the EIS and scoping process, if applied as intended, could be the focal point for all persons concerned. Some of the scenarios indicate there would be a significant impact upon the environment from the construction and/or operation of some of the new installations considered in the ORBES report. If an environmental impact statement was written for a power plant which indicated a violation of Federal law, regulation, or executive order, our Agency would have to indicate its objections to the project and recommend either changes in design, or that the project not be built. In order to construct and operate plants with these adverse impacts, major changes in the Clean Air

Act, Clean Water Act and other regulations would be required. We encourage citizens to become better informed on this powerful tool presently at their disposal and to make use of it whenever it is justified.

It would appear that strict environmental controls and the energy conservation alternatives will provide significant environmental benefits, with costs in the same range as the high energy development and electrical exports scenarios (see figures pages 24 and 25). When public health, worker health, water quality and agricultural impacts are taken into account, the question becomes paramount as to whether the benefits of meeting the environmental requirements are significantly more costly for the total population of the ORBES region than the SIP-non-compliance situation.

We note with great interest the various discussions of land use, as well as, those on physical crop loss. The potential demand for the disturbance of crop lands for mining, for power plant sites including water reservoirs for cooling systems, coal storage and similar uses, when added to the loss or decrease in crop production because of air and water impacts, all present a very disturbing picture. The loss of prime agricultural land has become a concern of many top agriculturists and of the Council on Environmental Quality. The Council on Environmental Quality has issued a report on the need to conserve this land resource. It may become necessary to include with the present considerations of power plant impacts on air and water and the disposal of wastes, a consideration of the type and quality of land where the proposed plant is located.

One additional comment regarding conservation measures in general is in order. Region V has been very critical of water users that require a significant amount of a river's flow to supply its cooling water needs. To minimize the amount of water withdrawn from a river, additional conservation measures have been required at such sites, for example, the use of off stream reservoirs (cooling ponds), cooling towers and recycling of cooling water. Some of the plant sitings suggested in this study could be rejected on the basis of excessive demand on a stream.

A review of the water quality aspects of this report and the reported impact of power plants in certain localities has presented some questions about whether the techniques used actually evaluate the total environmental impact such an installation can have on both water quality and aquatic habitats. The Main Report addressed only the impacts resulting from power plant pollutant loads, and water consumption. Furthermore, the document dealt only with impacts occuring during 7 day-10 year low flow conditions (Page 88), and discussed those impacts in terms of entire rivers or the entire ORBES Region (Page 57). These factors all tended to minimize the impacts of power plants on water quality and aquatic habitats. The significant conclusions that resulted from this are:

1. None of the ORBES coal dominated scenarios (Page 29) would result in aquatic habitat impacts very different from those that could have occurred in 1976 under 7 day-10 year low flow conditions;

2. Pollutant loading from power plants (Pages 29-30,152) is not a significant factor in the impacts on ORBES streams during 7 day-10 year conditions because of current high pollutant concentrations; and

3. Although power plant water consumption (Pages 30-51,152-169) might be an important factor on some of the region's smaller streams, it is only because of the existing high pollutant concentrations in those streams, and therefore, once again, the high existing levels are the most important cause of aquatic habitat impacts.

The comment should also be made that several of the parameters indicated to have been violated at 7 day-10 year conditions in the various Ohio River Basin streams are not acute toxicity parameters, but long term safe levels. Short term violations of these "safe levels" are not too likely to yield long term damage.

In our opinion, it is a mistake to minimize the aquatic habitat impacts of power plants. On a regional basis they may not seem significant but the localized impacts can be important. The ORBES report indicates that for the most part, uncontrolled power plant effluents would not significantly contribute to the impacts incurred by ORBES streams during 7 day-10 year low flow conditions, and that impacts related to power plants are "rather minor" (Page 153). The local impacts of uncontrolled power plant effluents can be substantial. Such discharges would cause water quality standards violations, even during normal flows, that could be devastating during low flows. In these cases the power plants would not just be contributing factors, they would be the primary cause of the impacts. Furthermore, the power plants can cause other aquatic impacts not necessarily related to water quality. The most important of these are impingement and entrainment of fish and other aquatic life, but habitat destruction and modification can be locally important. All of these localized impacts (water quality degradation, impingement, entrainment, and habitat modification) can significantly affect aquatic community structure and can be extremely important when rare or endangered species are involved.

The combined effects of localized water quality degradation, impingement and entrainment, and habitat modification could cause the loss of species, or promote the dominance of undesirable species. This is why power plants are controlled both through the Environmental Impact Statement process and NPDES permits.

The same concern pertains to the use of 7 day-10 year low flow conditions to describe aquatic habitat impacts. This tends to mask the adverse impacts of power plants because so many factors combine during low flow to impair aquatic habitat quality that the power plant impacts are a somewhat minor incremental addition that do not really increase the total impact. In other words, the impact on the stream is going to be severe at 7 day-10 year low flows with or without power plants. The conclusion that follows this line of reasoning is that power plant

impacts are not significant. As already discussed, we disagree with this conclusion because of the potentially severe localized impacts that can occur during any flow level. They will be most severe during low flows, but they will occur all the time and be directly due to power plants.

Another concern we have with the Main Report is the rationale for projecting future pollutant concentrations. The report states that the overwhelming majority of the present high pollutant concentrations result from geochemical or nonpoint sources. Furthermore, it was considered unlikely that nonpoint sources can be brought under control during the time frame of the ORBES study period. Therefore, all of the scenarios except the strict environmental controls scenario assumed that pollutant levels will be the same in the year 2000 as they were in the mid-1970's (Page 152). The strict controls scenario assumed a 50% reduction in pollutant levels but stipulated that this is not likely to occur. They found that even with this reduction, there would be little change in aquatic habitat impacts under 7 day-10 year low flow conditions.

Perhaps on a regional basis, the non-point source (NPS) problem is greater in the ORBES Region than point source problems, but on a stream reach specific basis, point sources are the most significant pollution sources in many cases and their impacts should not be minimized. It is another artifact of the regional approach of the ORBES study that existing pollutant concentrations cannot be reduced in the next 20 years to a level that will beneficially affect aquatic habitat impacts that occur during 7 day-10 year low flows. Progress is being made in the control of industrial and municipal point sources, and efforts are getting underway to control NPS pollution as well. Considerable effort is being invested in the control of urban storm runoff, one of the primary contributors of the 20 contaminants studied by ORBES.

The Main Report stated that even if these pollution control efforts should result in a 50% reduction in pollutant levels, there would be little change in habitat impacts (Page 152). In fact, under the strict environmental control scenario (50% reduction in pollutant levels, 95% reduction in power plant effluent concentration) only four streams would improve (Page 184), with impacts changing from heavy, if pollutant concentrations are held constant, to moderate, if concentrations decrease by 50%. This lack of significant improvement can be traced in part to the methodology used. The aquatic habitat impacts were based on a calculated water quality index (Page 95). A water quality index of less than 10 resulted in light impacts; an index of 10 to 24 resulted in moderate impacts, an index of 25 to 49 resulted in heavy impacts and an index of 50 to 100 resulted in drastic impacts (Pages 95-96). So, in order to change the aquatic habitat impacts, the water quality index has to change from one of these ranges to another. The strict environmental control scenario (Page 184) would significantly improve the water quality index of many of the 19 streams intensively studied, without quite lowering the index to the next lower range. For example, the second greatest improvement would occur on the Great Miami River. Under the strict control scenario, its index would decrease from 47 to 25. Since 25 is the lowest value still considered to be in the

heavy impacts range, the Great Miami is listed in the report as having no impacts improvement under strict environmental controls. In all, under strict controls, 8 streams would have their indices lowered to 25, and were listed as having no impacts improvement.

If the indices had been reduced by one more increment to 24, these 8 streams would have had impact improvements, and the beneficial effect of the strict environmental controls scenario would apparently be much more significant than reported. The point is, it is unrealistic to put so much emphasis in an arbitrary assignment of severity of impact. An actual listing of the index changes that could occur under strict environmental controls shows that every stream improved except one, and that one remained the same. So perhaps the strict environmental controls would be more effective than noted in the ORBES Main Report.

Another aspect of the ORBES methodology that lessened the beneficial effect of the strict environmental controls scenario was the manner in which it sited power plants. Some streams were assigned more power plants under the strict controls scenario. For example, the Allegheny River improved from an index of 32 to 25 with 4 power plants added. If no plants were added that stream might drop to well within the moderate impacts range. In all, 8 streams had power plants added and 4 had plants removed. In summary, our comments, therefore, point out that the strict control scenario would result in habitat improvements that would be stream reach specific.

A question has been raised in this office regarding the assessment of the status of aquatic populations in the Ohio River and many tributaries. Reliable data on this subject is considered to be very hard to find. It may be of interest to mention that the Permits Branch, Enforcement Division, Region V has a study in progress to determine and map fish populations in the Ohio River. A report on this study is expected to be available in six to nine months from now.

It is recognized that some of the comments on water, aquatic habitats and aquatic life portions of this report are perhaps raising issues that cannot be corrected at this time or may not be considered a part of this study. All of these comments are being offered for the possible benefit they may offer in utilizing the above discussed sections of the report and possibly in guiding future investigations on these subjects. We realize that the regional approach of this study influenced the methodology used and the conclusions drawn from it. Other studies may be needed to further clarify certain details in this technical area.

A review of the discussions of economic issues in the various parts of the Main Report has raised several questions. Some of them are discussed here to call attention to the fact that, although the findings reported in this study may not be in question, this is one instance where updating of baseline data may be beneficial in the utilization of this information, particularly for guidance of congressional action. Adoption of the mid-1970's as a base period does not necessarily reflect current conditions in the ORBES Region. Furthermore, the use of historic data up to the

mid-1970's for the establishment of social and economic trends excludes possible changes in those trends in the late-1970's. Changing social and economic conditions of the late 1970's could have an effect on the study results. It must be recognized, however, that this constraint was a necessary one on a study of this size and scope. The large number and variety of elements included in this study constrain the use of later data, even when it is available. One factor is the timing of the basic social and economic indicators necessary as inputs to other parts of the study. Also, to update these elements as new information becomes available could prove to be a hindrance to the overall study effort. Another factor is the desirability for consistency in the data bases used. Social and economic indicators vary in the amount and kind of data available and the years for which it is available.

One example of such indicators is population projections; some of these projections have been updated from those used in the study. Another example is the use of mid-1970's industrial data for the fuel demand portion of the study. How much effect changes in these elements could have on the study results is difficult to determine.

Of possible significance to the study and its results is the assumed projected average annual economic growth rate for the ORBES Region. A rate of 2.47 percent was assumed for all scenarios. This percentage resulted from a study of gross regional product trends from 1960 to 1975; it was the average annual growth rate during that time period (Gross Regional Product in the Ohio River Basin Energy Study Region 1960-1975, by Walter Page and John Gowdy). Use of this rate to project growth could overstate future economic growth in the ORBES Region. First of all, the authors of the study on gross regional product state that trend analysis is not very useful for best estimates of future values and that historic trends are most useful as a "high" boundary for growth projections. Additionally, post-1975 information was not included; estimates of recent trends have been excluded. Hence, all scenarios must be viewed as incorporating a "high" growth boundary rather than a "best estimate" of future growth.

Potential error in this regard could have been partially offset by inclusion of a "low-growth" scenario in this final report. If lower growth in the ORBES Region is supported by post-1975 information, a "low-growth" scenario might move toward a more realistic projection of future conditions than does the base case. Relative to the base case, earlier reports show that lower growth rates could lead to lower growth in electricity supply and demand, coal use, emissions, costs, and impacts.

Existing power plants are assumed to purchase coal from the same supply sources as they did in 1976. Supply shifts occurring since 1976 are not reflected in the base case or in the other scenarios. Shifts within the ORBES Region and between the ORBES Region and other parts of the country to comply with sulfur dioxide requirements could have occurred after 1976. Whether the adopted assumption is realistic depends upon the nature and extent of such supply shifts.

An additional assumption is that low sulfur coal for planned power plants will be supplied within the ORBES Region from sources in Eastern Kentucky, West Virginia, or Pennsylvania. This assumption could underestimate the ORBES region demand for low-sulfur western coal.

Assumptions regarding the use of low sulfur coal relative to flue gas desulfurization to meet pollution control requirements have an effect on the cost estimates. These two strategies are reflected differently in capital and operating costs. The Main Report emphasizes capital costs in the scenario analyses, while operating costs are reflected in the consumer cost estimates.

In the analysis of other than "coal dominated scenarios" there is an emphasis on the effects of reduced coal usage. There are many unknown factors associated with other possible effects of these scenarios, such as positive employment impacts of alternative fuel usage, health impacts of nuclear generation, air quality impacts of biomass usages, etc. Thus, of necessity, many potentially significant impacts may be excluded from the analysis of these scenarios. It is important to recognize that these effects, though currently unknown, could become relevant future considerations.

In any analysis of pollution control costs and impacts, the results are usually related to the basic assumptions regarding environmental quality and needed pollution control. Resulting impacts are ordinarily highly sensitive to such basic assumptions.

In discussing pollutant emission standards, the study's approach is to compare baseline conditions to those of the Base Case Scenario, which is to be a continuation of present regional conditions. The Base Case environmental standards are defined in the study as those standards that currently exist as applied to present and future sources of pollution. For air, controls are defined as the application of "current" (as of Sept. 1978) State Implementation Plans (SIPs). However, significantly revised SIPs were submitted in 1979. These revisions could substantially alter impacts defined in the Base Case and subsequently affect assumptions in the various scenarios. The revised SIPs would have an effect on the following statements and assumptions in the study:

a. The impact of acidic precipitation (P.74)

b. The estimates of emissions of sulfur dioxide (P.70), total suspended particulates (P.73) and nitrogen oxides (P.80)

c. The SIP Noncompliance Case (P.188)

d. Cumulative pollution control costs (P.160)

The report addresses the comparative costs and associated electricity prices for coal versus nuclear generation. One key finding was that under current fiscal and regulatory schemes in the region, coal fired units have

a cost advantage over nuclear fueled units. The study notes that government subsidy in the form of insurance premiums provided nuclear developers and extensive governmental research and development in the nuclear field constitute a major subsidy for the nuclear industry not extended to coal producers. It is not clear if these subsidies are built into comparative costs or if the pollution control costs for coal fired units are accounted for. Further, if the additional cost of more stringent pollutant emission standards as a result of revised SIPs are added to the costs of coal fired units the comparative costs may be substantially altered.

The environmental, economic and social impacts are examined in the study in the context of a number of potential policies. Of the various scenarios presented and analyzed in the report, the following specific policies presently under consideration for implementation were not examined or considered:

a. The new particulate standard

b. The additional control on fine particulates proposed for 1981

c. The oil "back out" legislation and mandatory conversion orders

We certainly appreciated the opportunity of participating in this study and especially in the review of this and other reports in both their draft and final forms. It is our opinion that this inter-disciplinary study will provide useful service to the Members of Congress, Federal and State agencies and the public in formulating future plans for the ORBES Region. While we do not agree completely with all of the contents and the conclusions of the Main Report and the support studies, that is not particularly disturbing to us. In fact, it is quite probable that some of the individual parts of some scenarios would constitute a violation of existing environmental laws if carried out as described. It should be kept in mind that these scenarios are "what if" studies of what impacts would occur if certain things are done in the future. They are not predictions, or accomplished facts, or even recommendations. This thought is recorded throughout the ORBES documents. Furthermore, we are aware that the material reported represents the best judgement of experts or the consensus of experts in the various disciplines represented. However, we do not consider ourselves bound to accept it or make use of any single idea: and we recommend others consider the contents of these reports in the same way, using them as your judgement dictates. We plan to make the best possible use of these findings. Since the starting date of this project, other energy related developments have come to the foreground, for example, synfuels development. Also, these studies have helped to emphasize potentially critical occurrences such as acid rain and trans-boundary transport of air pollutants. The findings of ORBES researchers will be very useful in the future investigation of all of these items related to coal utilization. We commend all of those who participated in this study for their part in it.

Valday V. Adamkus

Utility Industry Advisors' Comments on ORBES Analyses

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I. INTRODUCTION AND SCOPE

These comments discuss many of the technical issues raised in the ORBES Main Report and the numerous background documents. The comments are based on a number of detailed, technical analyses, several of which are or will be part of the ORBES docket. These analyses and the utility industry's comments are presented more fully in a separate integrated, technical critique of ORBES: Utility Industry Advisors' Detailed Comments on ORBES Analyses. This critique and the individual technical analyses are available to the interested reader and are incorporated herein by reference.

These comments are organized into three major sections. Following this Introduction, Section II rejects the implication given in the foreward to the Main Report that the utility industry somehow agrees with ORBES. Section III gives a number of examples illustrating the major scientific and factual deficiencies which infect ORBES rendering, it unsuitable for use in any public proceeding. The brief space available here and the number of the deficiencies make it impossible to present an exhaustive list.

II. THE UTILITY INDUSTRY ADVISORS REJECT THE ORBES IMPLICATION THAT PARTICIPATION SUGGESTS AGREEMENT; THE STUDY IS INFECTED WITH A BIASED, MISLEADING PERSPECTIVE

The foreword to the Main Report congratulates the ORBES Core Team for its "open research process." Id. at 3. The reader is told:

> The project Advisory Committee, drawn from groups expected to be affected by regional energy development [including the utility industry], was an especially important part....[T]he functions of the Advisory Committee...[included] the opportunity to participate in the internal project meetings and to review research reports in draft. Id.

The implications that the utility industry had a meaningful opportunity to correct ORBES' technical shortcomings and that the industry's participation in the study indicates concurrence must be corrected.

The Advisors did provide meaningful comments on research reports and, when requested, participated in Core Team meetings. However,

operating in this manner does not imply agreement.

The Advisors' comments were often disregarded and, in the case of the air quality modeling studies, the Advisors' efforts to obtain necessary information were severely hampered. After repeated requests for information on the study modeling techniques, the industry resorted to a Freedom of Information Act request to compel disclosure. Even this request was denied and the industry was forced to litigate the refusal. Public Service Indiana v. EPA, Civ. No. IP79-315-C (S.D. Ind. filed April 3, 1979). The complete information has never been obtained.

The Main Report is plagued with a sloppy, often editorial character which misinforms and misleads the reader. A few examples are:

- Foreward, id. at 1 - "concerns about plans for accelerated power plant development." There is no accelerated development plan; power plants are constructed in response to demand for electricity.

- Executive Summary, id. at 22 - "increasing evidence ... [supports the hypothesis that] exposure to sulfates ... results in an increased mortality rate." Even the body of Main Report and the background documents do not support this statement. See Section III-D, 1. infra.

- Id at 275, 277 - Solar power should be benefitted by "tax incentives", whereas nuclear power should not receive "tax subsidies." These are merely loaded words to express the researcher's preference for solar power. The same kind of transaction is described by each.

- Id at 65 - "2 Btu's of conventional fuels to produce 1 Btu of electricity." For a good coal or oil-fired plant the ratio is about 2.9 Btu's to 1 Btu of electricity.

III. ORBES AND THE MAIN REPORT ARE INFECTED WITH BASIC ERRORS OF SCIENCE AND PRESENT DISTORTED CONCLUSIONS; THEY SHOULD NOT BE CONSIDERED IN ANY PUBLIC PROCEEDING

A. Summary and Organization of Illustrative Technical Comments

It is not the contention of these comments that all of the information and all of the study techniques used in ORBES are incorrect. Some distinguished investigators took great care in studying real scientific questions and arriving at reasoned scientific conclusions. Lamentably, however, great portions of the ORBES work and much of the Main Report contain such serious scientific defects and present their results in such a misleading light that they cannot be relied on without an independent analysis of their accuracy.

The following technical sections illustrate the major scientific

defects which infect ORBES. These defects can be organized into six general categories:

* Inconsistencies between the Main Report and the supporting background studies;[1]
* Fundamental errors of scientific theory;[2]
* Fundamental errors of fact and application;[3]
* Use of outdated techniques and assumptions — not state of the art;[4]
* Distorted and misleading presentation;[5] and
* Study design not meaningfully related to policy questions.[6]

The following sections begin with a discussion of the deficiencies in the study plan. Subsequent sections analyze the ORBES treatment of atmospheric emissions, their transport and transformation, and the health and economic affects of the projected ambient concentrations.

B. The Study Design and Presentation of Results Frustrate any Meaningful Evaluation of Current Policy Concerns

1. Introduction

ORBES purports to be a comprehensive study which ties together information from disperate areas in order to provide decision makers with meaningful information about alternative energy development policy options. Main Report, Foreword at 1. In order to accomplish this goal,

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[1]/See Section III-E, 3. The Main Report presents crop damage estimates which are inconsistent with the background documents.

[2]/See Section III-E, 4.2. ORBES employed an ozone analysis technique which can predict effects contradictory to the real world and the predictions of accepted scientific techniques.

[3]/See Section III-D, 3. The Main Report miscalculates the "expected cancer rates" for radiologically induced cancers by a factor of 10,000 because it misinterprets its own results.

[4]/See Section III-F, 4.1. ORBES researchers employ a two point, 70-year ozone estimating technique in preference to a theoretical ozone model.

[5]/See Section III-F, 2. ORBES overestimates the extent of the least emission dispatch emission reductions. See Section III-C, 3.1. The ORBES Main Report misleads the reader concerning the techniques used in modeling long-range transport of sulfur dioxide.

the study design must be organized to produce meaningful information, the study must be carried out using meaningful techniques and the results must be presented in a meaningful form. The first and third points are briefly considered in this section; the second is disscussed beginning at Section III-C.

2. The ORBES Study Design Does not Pose Key Questions Necessary to Produce Meaningful Results for Policy Evaluation

Any study that strives, to be "useful to decisionmakers in dealing with policy and regulatory strategy issues", Main Report, Foreword at 1, should strive to answer the following questions: (a) How much is enough and (b) How do we get from where we are (or expect to be) to where we want to be through the cheapest, and least disruptive means. The omission of these questions from the ORBES inquiry is a major methodological flaw which seriously limits the study's usefulness.

Because the study fails to ask the first question, the policymaker cannot establish whether conditions under the base case are acceptable or not. This should be the logical first step in any study of this kind.

It is because this question is not asked, that the reader never quite understands why "mitigation strategies" calling for controls stricter than the "base case" are needed or examined. The reader's puzzlement over this question is only increased when, after wading through the complex narrative, he realizes that under the base case:

i) Total emission will decrease for all criteria pollutants (except NO_x);

ii) Ambient air quality concentrations will improve for all criteria pollutants (except NO_x), and for sulfates as well; and

iii) The National Ambient Air Quality Standards (NAAQS) will be attained.

ORBES also fails to ask the second key question. The study loses sight of the public goals to be promoted — decreased human and economic injury — and focuses on emission reductions. By adopting this focus, ORBES obscures answers to the second question. The reader is not given meaningful information on the cost of protecting human health; he is given information on the cost of reducing emissions.

3. ORBES Does not Present its Findings in A Meaningful Form

Meaningful results must be presented in a comprehensive and

6/See Section III-B, 2. The ORBES study design fails to consider necessary key questions.

comprehensible form. The ORBES Main Report does not do this. For example, sulfur dioxide and sulfate concentrations are never placed in context by comparing the ambient concentrations projected for different years and for different scenarios with reference levels such as the National Ambient Air Quality Standards. Table 1 in Section III-C, 2. is an example of the kind of presentation which should have been included in the Main Report in order to assist the interested reader (or the policymaker) in assessing the need for additional controls to promote basic social goals.

These are a few examples of the structural problems inherent in ORBES: the kind of problems which contribute to the reader's feeling that he is "reading all about pollution." That scattered approach may be desirable in an introductory learning experience but not in a document designed to inform national and state decision makers on complex policy questions.

C. Because the ORBES Air Quality-Related Analysis Employs Deficient Models, Inadequate Data and Presents Distorted Conclusions, it Is Not Meaningful in Itself and it Does Not Support Meaningful Inferences

1. Introduction and Summary

Air quality modeling lies at the heart of ORBES; the study purports to relate changes in atmospheric emissions from power plant operation to health and welfare effects. This can only be done using modeling techniques. ORBES attempted to model two different air pollution systems. First, the study considered sulfur dioxide emissions; their transport and dispersion over long distances; their transformation into sulfates; and the deposition of these species. The ORBES investigators attempted to model these processes over the short-term (24-hour) and the long-term (annual). They purported to evaluate the short-term air pollution impacts of each energy scenario by modeling that scenario using meteorological data for one episode — August 27, 1974. They used a different model to estimate long-term sulfur oxide and sulfate impacts, but here also they used only one year of input data.

Secondly, the ORBES researchers attempted to model the changes in ambient ozone concentrations associated with the different amounts of nitrogen oxides which would be emitted under the different energy scenarios. This aspect of the ORBES work is examined in Section III-E, 4, infra.

Summary of sulfur dioxide modeling criticisms

The ORBES Main Report does not contribute substantially to our understanding of long-range transport and transformation. On the contrary, the results presented in the Main Report are incomplete, inaccurate and misleading.

Because ORBES mishandled and misinterpreted air quality and meteorological data; employed inappropriate, unproven computer models; and used them in an inappropriate fashion, the major conclusions of the ORBES Main Report are no more than crude approximations. The crudeness and inaccuracies of the modeling results, in turn, compromise the health and welfare assessments in which they were used.

By treating hypotheses as facts, presenting estimates as precise values and by burying important qualifications in the background reports, ORBES misleads its reader into believing that it has produced a series of reliable, accurate projections. In fact, the work is so weak technically that it would never survive competent peer review. Nine of the most serious technical flaws are as follows:

i. ORBES fails adequately to point out that the National Ambient Air Quality Standards (NAAQS) are being protected throughout most of the region and that the air quality will continue to improve under all scenarios.

ii. The computer models used in ORBES did not properly represent utility emissions — the main concern of the study.

iii. ORBES does not properly recognize that the meteorological conditions favoring long-range transport are complex and not clearly defined; and that no quantitative relationship between persistent winds and long-range transport has been demonstrated.

iv. ORBES fails to recognize that it is not possible to quantify the relative sulfate contribution of low-level local sources and high-level distant sources during regional episodes because the meteorological conditions which produce elevated sulfate concentrations may be the same for both source types.

v. The ORBES computer modeling results were not statistically compared with observed data.

vi. The "conclusion" that TSP concentrations would decrease "dramatically" if power plant emissions were curtailed is a grossly misleading claim.

vii. The air quality and meteorological data base is inadequate in quantity, quality and coverage (spatial and temporal) to support the conclusions reported and ORBES researchers did not attempt to discriminate between reliable and unreliable data.

viii. The air quality assessments of the energy scenarios are unreliable and unrealistic because short-term concentration estimates were based on a single episode evaluation, and long-term projections were developed from a single set of annual meteorological data. These applications improperly ignore the large variations in meteorological conditions, which occur from episode-to-episode, and from year-to-year.

ix. The presentation of results in the ORBES Main Report camouflages their inaccuracy.

2. The ORBES Main Report Misleads the Reader by Failing Adequately to Point Out that the National Ambient Air Quality Standards are Protected and the Regional Air Quality is Improving

The NAAQS are presently being protected throughout most of the ORBES region. Violations of the sulfur dioxide and particulate standards do take place in certain locations; however, the sulfur dioxide violations are localized and the particulate violations are usually dominated by natural sources. Thomasian (1980).

The ORBES Main Report does not adequately compare regional air quality levels with the NAAQS, nor does it adequately compare its own projected future air quality levels with the standards. Table 1 is an example of the kind of presentation which should have been included in the Main Report.

Table 1: Comparison of ORBES Calculated Maximum Base Case Sulfur Dioxide Concentrations (from Utility Emissions) with National Ambient Air Quality Standards

		Episodic Level (ug/m^3)	Annual Average
	NAAQS	365 (24-hr.)	80
SO_2	ORBES 1976	94	26
	ORBES 1985	65	19
	ORBES 2000	48	13

This table gives the reader a meaningful comparison of the future calculated concentrations, taken from Tables ES-2, 3 of the Main Report at 19, 21, and the health-based primary sulfur dioxide standard. It also points out the projected trend toward improving air quality. Also see Niemann, et. al (1978) (Measured TSP concentration showed substantial improvement from 1977 to 1978.) This central fact is not fairly pointed out by the Main Report.

3. The ORBES Long-Range Modeling Techniques Are Defective; Not Even the Best Techniques Are Capable of Accurately Estimating The Effects Which ORBES Projects

3.1 The ORBES Reports Mislead the Reader by Failing Meaningfully to Disclose Central Modeling Limitations

Despite the central role of transport and diffusion in the analysis of both current and projected conditions, the Main Report devotes only a few lines to a description of the models and how they were used. Id. at 75, 78. It is inconceivable that an allegedly scientific study would not describe the primary tool used to make most of its future projections. One must go to the support documents, notably Stukel, et al. (1980), and to the references cited in those documents to assess the ORBES models. Even then many important facts are not clearly presented.

ORBES' Short-term Model Was Used to Model only One Episode for Each Scenario and Considered Only Utility Emissions

The Main Report indicates that the Prahm (pseudo-spectral) model was used to examine four specific episodes. Id. at 75. What is not said — on page 75 or elsewhere in the Main Report — is that only one case, August 27, 1974, was used for all short-term projections of the future scenario impacts. The reader is left to discover this for himself. Stukel, et al. (1980) at 105. The uniqueness of any single day or set of days — its meteorology, emissions and power generation mix — make it an inappropriate basis for making projections to the year 2000. Not only is it technically flawed to base an entire portion of ORBES on the analysis of one episode, it is grossly misleading not to disclose this fact to the reader.

There is another equally important fact about the ORBES sulfur oxide modeling which is disclosed only to the most diligent reader. The ORBES team modeled only utility emissions; the model runs did not consider the most numerous actual emission sources! This is a serious error in logic, because nearly one-fourth of the sulfur dioxide emissions in the ORBES region originate from non-utility sources. Niemann, et al. (1980) at 2-4. Moreover, many of these non-utility emissions occur at low elevations where they can produce high ground-level concentrations. The failure to include these sources renders any attempt to "validate" the model mere guesswork.

ORBES' Long-Term Model Has Never Been Subject to Peer Review

For annual modeling, the ORBES researchers used their own adaptation of the Fay-Rosenzweig model. It is known as the TRI/Fay model. Main Report at 78. Apparently, the ORBES team used this model with a single set of annual meteorological data. That is, one "resultant" wind speed and wind direction were calculated for each meteorological monitoring station in the ORBES region — using a sort of averaging technique. It is not possible to comment meaningfully on this

technique, in part, because the details of this model have never been released for peer review. See Section II, supra. This, again, is not made clear in any of the ORBES documents.

3.2 No Long-Range Transport and Diffusion Models Have Been Proven Reliable

It is important to recognize at the outset that there is no long-range transport and diffusion model that has been validated and proven. Comprehensive reviews of diffusion models recognize the serious limitations with all such models. Hosker (1980), Husar, et al. (1980), and Smith (1980). Thus, any study of the ORBES type must be speculative; the probable errors in this type of modeling are very large, ranging from factors of 3 to 5 in some simple situations to several orders of magnitude in more complex ones.

These large uncertainties arise from a number of fundamental problems. Long-range models cannot simulate the full complexity of the atmospheric processes; additionally, the necessary input data are inadequate in their geographical, vertical and temperal coverage. The magnitude of the errors is little more than a guess because the data needed for proper validation of a long-range transport model do not exist. None of these deficiencies are the fault of the ORBES team. However, the reader has a right to expect an honest acknowledgement of them. While cautioning against judgments based on inadequate data, id. at 55, the Main Report does not so much as hint at these limitations.

3.3 There Are Serious Weaknesses in the ORBES Regional Short-Term Model

The ORBES team used a version of the Prahm two-dimensional pseudospectral model, Mills and Hirata (1978) to estimate the "as if" air quality impacts on August 27, 1974 for each energy scenario. This model "transports" the total emissions from large grid squares (80 km on a side) according to a wind field developed from twice-daily upper air data. The model considers horizontal diffusion, but the atmosphere — below the mixing height — is assumed to be uniformly mixed in the vertical. The mixing heights used by the ORBES researchers were assumed to be constant over the entire area. The transformation of sulfur dioxide to sulfate and the dry and wet deposition were calculated by the Prahm model. There are a number of serious theoretical and applied shortcomings in the ORBES use of the Prahm model.

Power Plant Emissions Are Not Accurately Represented by The Teknekron Model

While the assumption that all emissions are contained within the mixing layer may be suitable for low level sources, it is inappropriate when applied to elevated power plant emissions. Yet, power plant emissions are the focus of the ORBES study. The buoyant plumes from

power plants often rise above the mixing layer, reaching the stable air above. When this happens, the plume does not interact with the ground surface until the top of the mixing layer rises higher than the plume elevation.

An example is useful in understanding this point. Suppose a power plant plume rises above the top of the mixing layer early in the evening and is transported with very little vertical diffusion by a 5 m/sec wind. By the following morning that plume would have traveled over 200 km from the source without contributing to the ground-level concentrations below. The plume would have had no contact with the ground during this period. The ORBES model would misrepresent the behavior of the plume by assuming it to be within the mixing layer. In this example the model would greatly overestimate sulfur dioxide and sulfate concentrations within the first 200 km. Moreover, the stronger winds and the wind's variation in both direction and speed (wind shear) above the mixing layer would dilute and disperse this plume quite effectively. Notably, wind shear occurs even during the persistent and stagnant conditions which the ORBES authors considered favorable to the production of elevated concentrations. Smith and Martin (1980) at A-56.

During part of the August 27, 1974 scenario modeling episode, the mixing height was low enough that many power plant plumes would have penetrated the mixing layer and would have behaved as the plume described above. This fact is never discussed by the ORBES reports.

ORBES Incorrectly Assumes that Sulfur Dioxide-Sulfate Transformation Rates Remain Constant

Estimates of the sulfur dioxide—sulfate transformation rate generally ranges from less than 0.5% to 2.5% per hour. Lower rates are found at night and in cold winter conditions; more rapid transformation occurs in warmer daytime situations. Realistic modeling of episodes would use variable transformation rates. The ORBES system did not.

This omission could produce substantial errors in the calculated sulfur dioxide and sulfate concentrations. In relatively light winds (e.g., 2 m/sec) the difference between a 0.5% and a 2.5% transformation rate would be approximately a factor of 3 at a distance of 500 km downwind.

ORBES Does Not Accurately Model Changes in Wind Speed and Direction

The ORBES model used a wind field developed from data taken at 600 m above ground. It allows no adjustment of wind speed or direction with height. This is incorrect.

It is known that the wind always varies in speed and direction with height. This variation is due to the frictional effects of the earth's surface. Therefore, at any given time plumes from individual stacks would be subjected to different wind directions and speeds. Each plume

would rise to a different height, and the transporting wind at the final effective stack height would be different for each. To understand the significance of this point, consider two emission sources identical in all respects except that one is released at 100 m and the other at 300 m above the ground. Assume further than both are released into a neutrally-stratified — moderately dispersive — atmosphere. If the wind at 100 m were south at 10 mph, according to basic meteorological theory, at 300 m the wind would probably be south-southwest at about 14 mph. Because pollutant dispersion is proportional to wind speed, the upper plume would be 40% more dilute than the lower one and it would be transported in a different direction.

As the examples outlined above demonstrate, there are many complex and interrelated effects of failing to account for the inevitable changes in wind conditions. The interactions of these effects can result in order-of-magnitude differences in the predicted concentrations from typical source configurations.

ORRES Treatment of Vertical Dispersion Was Unrealistic

The pseudospectral model does not consider vertical dispersion; it assumes that all emissions within a column are immediately dispersed uniformly between the top of the mixing layer and the ground. This certainly does not happen, especially with emissions from power plants. The problems caused by this assumption are most serious under neutral and slightly stable conditions. Under these conditions the pseudospectral model will predict ground-level concentrations relatively close to each source. Emissions from elevated sources will not ordinarily reach the ground anywhere near their point of release, instead, they will be transported downwind and will produce diluted ground-level concentrations tens or hundreds of kilometers away.

The ORRES Regional Model Was Not Validated

The ORRES researchers might have been able to narrow several of these uncertainties if they had presented a reasonably convincing validation study. They could not present a good study because the data are lacking, but they did not even present a credible attempt.

The Main Report does not mention model validation let alone its importance. The thoughtful reader might expect to find a discussion in the support documents. The ORRES researcher present just one figure which compares predicted and observed values. Stukel, et al., Figure 2-35, at 77. As the authors acknowledge, this figure shows very limited field data for comparison. Id. at 76. Moreover, this "validation" figure is for June 11, 1976, not August 24, 1974, the episode used as the basis for the entire short-term air quality analysis. Stukel, in turn, refers the reader to Mills and Hirata (1978). However, Mills and Hirata contains no additional data or explanations. Thus, the diligent reader

is led down a string of citations to unsupported assertions; this is not the kind of science upon which policy decisions should be based.

There is another, even more disturbing aspect to the brief ORBES validation discussion. Rather than presenting clear numerical expression of the agreement or disagreement between observed and predicted data, the researchers use qualitative remarks like "generally good agreement." The reader is seldom told what prediction agrees with what measurement. Figure 2-35, id. at 77, the only presentation which compares observed and calculated data in the same diagram, uses smoothed isopleths for calculated values and AQOR averages for measured values. This kind of smoothing can greatly alter the apparent comparison and allow it to favor the desired result.

These deficiencies illustrate that the ORBES model calculations are little more than mechanical exercises. The ORBES results cannot to be taken to represent what would occur in actual episodes.

3.4 There Are Serious Weaknesses in the ORBES Regional Long-Term Model

The ORBES team used a model which they call the TRI/Fay model to arrive at their projections of annual average concentrations. Judging from the original paper by Fay and Rosenzweig (1980) this model is a simplified system for deriving annual average values around a large number of sources. The model contains algorithms to treat the conversion and deposition processes.

The TRI/Fay model suffers from many of the same weaknesses as the ORBES short-term model does. It is unable to distinguish between plumes which penetrate the top of the mixing layer and those trapped within it, and it uses fixed values for depletion and deposition.

There are two excellent reasons for doubting the validity of the TRI/Fay predictions. The first appears in Stukel, et al. (1980) at 84. There, the ORBES authors state:

> "In fact, the model predictions of the SO_4 = concentrations from just utility SO_X emissions are in closer agreement to the SURE II SO_4 = measurements than were the model predictions using all the SO_X emissions. At present, the significance of this is not known.... (Emphasis added.)

In essence, this means that the model gave better results if a significant portion of the emissions and the majority of emission points were ignored! That result raises serious questions about the validity of any results produced by that model.

Secondly, the symmetry of the long-term sulfur dioxide and sulfate projections is not consistent with a basic meteorological understanding

of the ORBES area climatology. Figures 4-9 and 4-10 from page 79 of the Main Report are good examples. They both show nearly circular predicted pollution patterns. These circular patterns suggest that the modeling reflected the effects of winds from numerous directions. Yet an examination of Niemann, et al. (1980), Appendix II-A at 2-4, shows that winds from numerous directions were not used in the annual modeling. Rather, a "resultant" wind direction was developed for each of several locations in the ORBES region. These "resultant" directions were all from the southwest, as one would expect from the regional climatology. Thus, one would expect the ORBES concentration isopleths to be elongated in a northeast-southwest axis, not circular. Moreover, since the transformation from sulfur dioxide to sulfate proceeds relatively slowly, one would expect the ORBES sulfate patterns to be somewhat more elongated and offset from those for sulfur dioxide.

Here again, ORBES offers virtually no attempt at validation. The ORBES authors described the agreement between observed and predicted data as "good," but the Fay and Rosenzweig paper shows only one comparison; also a comparison of smoothed isopleths. In fact, the agreement is rather poor. Accordingly, the results of the annual modeling are speculative, unvalidated and indeed rather puzzling.

4.0 ORBES Did Not Evaluate the Reliability of the Air Quality and Meteorological Data It Used

ORBES projected future air quality levels and estimated their significance. The accuracy of these projections depends upon the accuracy of many factors, including the air quality, and meteorological data used in the study. Air quality data should serve two important functions: to establish the base-case or current levels of pollution, and to provide part of the basis for validating the model. The meteorological data should provide the other input for model validation, and together with the emissions information, should serve as the basis for estimating the air quality impacts of future energy scenarios.

If either set of data is inadequate, or if either is improperly used, the modeling projections suffer. Unfortunately, both sets of data used in the ORBES study are inadequate, and both have been mishandled by the ORBES researchers. Because the ORBES results are based on data of poor quality they should have been qualified by appropriate caveats. They were not.

4.1 The Accuracy of the Air Quality Data Varies And They Are Inadequate For Use in Making Meaningful Long-Range Modeling Calculations

The air quality data on which many of the ORBES conclusions are based differ markedly in reliability, and in spatial and temporal coverage. The SURE II data are probably among the most accurate data available. However, they have been collected for less

than two years and not all days are represented. The American Electric Power (AEP) network has been operating for six years and the data are of generally good quality. However, this network does not monitor for sulfates; and it was designed to monitor conditions close to AEP's major power plants. Thus, the geographical coverage is limited to a band along the Ohio River and the data cannot be used to validate a regional analysis. The 1974 SURE I data are of questionable quality. Smith and Martin (1978). The remainder are a mixture of state and Federal monitoring data, some of which has been recognized as unreliable. Neimann and Mahan (1978), Appendix B.

The ORBES team should have established a screening process by which data were admitted or discarded. This was never done. Poor data were used as if they were good. For example, pages 69-70 of the Main Report contain a discussion of the sulfur dioxide nonattainment areas in ORBES region. One of the areas cited in the Report is western Pennsylvania. The source of the data used in this determination is given as the National Aerometric Data Bank (NADB). However, the ORBES background document states that "[t]he reliability of the SO_2 violation is uncertain because of the relatively low percentage of valid data." Stukel, et al. at 24, n.3.

Without an accurate data base, neither the investigators nor the reader can be certain of existing air quality levels over the study region. These uncertainties also weaken the few efforts which were made to "validate" the models.

4.2 The Meteorological Data Are Inadequate For Meaningful Use in Modeling Long-Range Transport

The accuracy and general quality of the meteorological data used by the ORBES researchers are good, and some of the time coverage is also very good. However, certain key variables are either not measured, or the spatial coverage is too low to support detailed evaluations. For example, atmospheric stability — a measure of the dispersive potential of atmosphere — is almost never measured at the elevations of power plant plumes. The height of the mixing layer is obtained only twice daily from measurements at relatively few stations; and the wind speed and direction at plume elevations is available only occasionally from a sparse network of stations. This network is inadequate to define accurately the dispersion conditions for a single stack at a specific hour, let alone for the entire, complex source pattern over the entire ORBES region. This issue is not even raised in the Main Report.

5. ORBES Presents Erroneous Air Quality Conclusions as Facts

5.1 ORBES is Misleading Because it Assumes Sulfates Result from Long-Range Transport

ORBES assumes that calculated sufate concentrations are the observed results of long-range transport.

> Thus, both data and modeling confirm that long-range transport from the lower [ORBES] region contributes significantly to the concentration averages in the upper region and to violations of NAAQS in that region. Main Report at 7. (emphasis added).

ORBES does not confirm this fact, it assumes it. In the sulfate discussion, the ORBES authors treat hypotheses as facts and blur the distinction between observed and calculated concentrations.

The Main Report states: "[a]ssuming that sulfate concentrations are a good measure of the contribution of nonlocal sources to local TSP measurements long-range transport of sulfates...contribute between 15 and 20 percent of total annual TSP concentrations...." Id. at 73 (emphasis added).

But this is just the assumption which the Executive Summary cites as a conclusion. The sulfate discussion in the body of the Main Report indicates that in two of the four episodes, emissions from utilities in the lower ORBES region contributed over 90% of the sulfate concentrations that were observed in the upper ORBES states of Ohio, Pennsylvania and West Virginia. Id. at 73. The sulfate concentrations are observed values. However, the statement that the lower ORBES region utilities contributed over 90% of the upper region concentrations is based solely upon the pseudospectral model calculations. It was not and cannot be verified by observation. By combining observed and calculated values in this way, the reader is left with the misimpression that there is some way that long-range transport contributions to the observed sulfate concentrations can be separated out from local contributions. No such separation was even attempted.

There are two related ORBES conclusions which should also be addressed. These are: the alleged documentation of a relationship between persistent winds and high sulfate concentrations; and the alleged contribution of sulfates to distant total suspended particulate concentrations.

5.2 The Relationship Between Long-Range Transport and Persistent Winds is Not Proven and May Not Be Quantifiable

ORBES' basic approach to analyzing the short-term air quality impacts of different scenarios is to estimate the emissions under each scenario and to use a "typical" sulfate episode to determine the "as if" impacts of that scenario. In this analysis, ORBES researchers assume that the persistent wind condition is typical of sulfur dioxide and sulfate episodes.

Here they made an error. Once they discovered that some high concentrations were associated with persistent winds, they assumed that long-range transport was involved and proceeded to base precise numerical

predictions on that idea. As the Main Report puts it:

> [R]egional data indicate that long-range transport of emissions, even over distances of several hundred kilometers, was and is an important factor in regional pollutant concentrations. At several locations throughout the region, between 25 and 50 percent of the 25 highest daily sulfur dioxide concentrations are associated with transport by extremely persistent winds. Moreover, under certain meteorological conditions, sulfur dioxide is transformed into sulfates thereby contributing to regional sulfate concentrations. Id. at 6.

This assertion — that long-range transport, persistent winds, and high sulfate and TSP concentrations are related — is repeated throughout the Main Report, id. at 72-74, and the support documents, Stukel, et al. (1980) at 40. This is an incomplete, misleading analysis. The ORBES team did not review those cases in which high concentrations were associated with conditions other than persistent winds; nor did they determine the contribution of local sources in the persistent winds case.

The Persistent Wind Hypothesis

Smith and Martin (1978), although recognizing that there were problems with the data, have analyzed the same data used by ORBES researchers. They have shown that less than half of the high sulfate concentrations periods were associated with persistent winds. Furthermore, there is no significant statistical correlation between wind persistence and the occurrence of the allegedly elevated daily sulfate concentrations in the SURE I data used in ORBES. In fact, Smith and Martin's analysis of the data for the six reporting SURE I stations leads to the following conclusions:

1. Most days with relatively high sulfate concentrations did not have extreme persistence of wind speed, wind direction and stability class;

2. The large majority of days having extreme persistence at each station had sulfate concentrations in the lowest range; and

3. The ratios of persistence days to total days did not vary significantly from the lowest to the highest concentration category.

While wind persistence is common, it does not imply the existence of substantial long-range transport. Relatively high sulfate concentrations showed no favoritism for persistent or non-persistent meteorological conditions.

The Contribution of Local Sources

On the other hand, one would expect high sulfur dioxide and sulfate concentrations to be produced by local sources during persistent winds. Spaite et al. (1980). In a technical support document the ORBES team states that:

> [long-range] transport does make a significant contribution, in terms of magnitude and frequency, to elevated SO_2 concentrations upwind, within, and downwind of the ORBES region. Stukel, et al. (1980) at 21,

This statement is not correct. It is based on an analysis of data from the Clifty Creek monitoring network, an AEP network designed specifically to monitor effects of local sources. An examination of the 25 highest daily sulfur dioxide concentrations in each of four years used by ORBES, shows that the persistent wind blew from the local plant toward the key monitor in virtually every case. This suggests that local — not distant — sources played the key role. Moreover, background concentrations from all other sources were very low. Long-range transport was not significantly involved in these cases. Notably, in no case were the Ambient Air Quality Standards for sulfur dioxide exceeded.

Thus, the ORBES team failed to distinguish the contributions from local and distant sources. Once they discovered that some sulfur dioxide and sulfate episodes were associated with persistent winds, they assumed that distant sources were responsible. Certainly, long-range transport can occur but, the questions are: in what concentration, where, how frequently, and in what ratio to locally-produced concentrations? The ORBES study answers none of these questions; instead it assumes its answers. The persistent wind hypothesis propounded by ORBES is not confirmed by the available data. ORBES ignored non-utility emissions which are generally low level and affect local sulfur dioxide and sulfate concentrations greatly. Spaite, et al. (1980). ORBES cannot associate any particular portion of sulfur dioxide or sulfate to long-range transport because it failed to evaluate other likely causes of the observed concentrations.

5.3 Sulfates from Regional Emissions do not Contribute Substantially to TSP Nonattainment

The ORBES Main Report states:

> Contribution to TSP Nonattainment. However, if utility sulfur dioxide emissions were controlled or if a fine particulate standard were to be implemented, TSP concentrations would decrease amatically since sulfates would decrease with such controls or such a standard. Id. at 73. (emphasis added).

Anyone who studies the suspended particulate problem recognizes that local sources are of paramount importance, especially in periods when the air quality standards are violated. Thomasian (1980), EPA (1976).

Yet, the Main Report continues:

> Data indicate that sulfates are a major contributor to the elevated TSP levels in the ORBES region. During the period August 1977 to October 1978, measurements [from] at least three regional monitoring stations indicated that elevated sulfate concentrations contributed to TSP nonattainment. . . . Id. at 73.

Examining the data referred to in the two preceeding paragraphs, however, shows no evidence that sulfates are a significant contributor to elevated TSP concentrations nor that the aggregated emissions from all ORBES power plants account for the reported sulfate concentrations.

Moreover, it is significant to note that not even the ORBES researchers claim to calculate the impact of the emissions from individual power plants on distant sulfate and particulate concentrations. To be sure, occasionally sulfates contribute to a violation in the sense that if the sulfate fraction were eliminated, the TSP standard would not be exceeded. But the sulfate fractions in those cases typically are smaller than the 20-45 percent value by the Main Report at 73, and, there is no documentation that the sulfates originated from the long-range transport of power plant emissions. There is every reason to believe that a complete cessation of utility emissions would have a negligible effect on TSP concentrations.

The ORBES authors did not present enough details of the SURE II TSP and sulfate data to permit analysis of them, but examination of concurrent particulate and sulfate data from Pennsylvania shows that the sulfate/TSP ratios are relatively low. Martin and Smith (1980).

Based on air quality data from the southwestern border region of Pennsylvania — TSP and sulfate concentrations recorded at 17 stations in the Beaver Valley and Monogahela Valley in 1978 — there were 12 cases in which the Twenty-Four-Hour Primary TSP Standard of 260 ug/m^3 was exceeded. In ten of the twelve cases the standard level would have been exceeded even if the sulfate concentrations were zero. Similarly, there were 82 cases in which the Twenty-Four-Hour Secondary Standard of 150 ug/m^3 was exceeded. In 50 of these, the standard still would have been exceeded even if there were no sulfates. The sulfate fraction did tip the TSP concentration over the Secondary Standard on 32 occasions. The following table shows that the sulfate/TSP ratios on these 32 days were

quite low. The ratios were 20% or less in three-fourths of the cases.

Sulfate/TSP Ratio	Number of Cases
.10 (or less)	5
.11 - .15	12
.16 - .20	7
.21 - .25	3
.25 (or more)	5

The sulfate/TSP ratios in the two cases in which the TSP concentration was over the Primary Standard had ratios at 0.16 and 0.05. These ratios show that the sulfate fraction is generally small when TSP concentrations are quite high. Neither the Main Report nor the background documents discuss these results.

It is uncertain how much of the sulfate in the ORBES samples and in those discussed above was transported from outside Pennsylvania and how much was generated by emissions within the state.

The ORBES analysis focuses myopically on the long-range transport of power plant emissons as the cause of the standard violations. This concern is misplaced. The fact is that the entire ORBES discussion of sulfates and TSP is exaggerated and contrived. TSP problems are usually locally generated and, insofar as they can be alleviated, the solutions will be local also.

D. The ORBES Health Conclusions Are Based on Erroneous Theories, Incorrect Applications Of Theories And Are Highly Misleading

1. The ORBES Sulfate-Related Mortality Conclusions Are Misleading And Inconsistent With The Bulk of Scientific Evidence

The Executive Summary of the Main Report states that "a growing body of evidence supports the hypothesis that the annual average exposure to sulfates — or something closely related to them — results in an increased mortality rate." (emphasis added) Id. at 6, 22. Although this emphatic position is tempered later in the text, the Report states that the 1975 sulfate related fatalities in the ORBES region could be between 25,000 and zero; with "median" value of 8,000. Id. at 101-02. These conclusions have been widely cited in the press as the "facts" which the Main Report makes them appear to be. Washington Post, Feb. 4, 1981 at A13; The News, Aug. 15, 1980. The fact is that no sulfate related death has ever been identified medically. Moreover, the Main Report's conclusions are inconsistent in tone if not in fact with the ORBES background documents and with the bulk of current scientific evidence.

1.1 The Main Report is not Self Consistent and it does not Fairly Reflect the Background Reports

The work upon which the Main Report sulfate mortality calculations was based, Shapiro (1980), hardly supports the Executive Summary's statement that a "growing body of evidence" supports the sulfate mortality hypothesis. On page 3.4-4 Dr. Shapiro concludes that:

> If acid derivatives of sulfur dioxide [including sulfates], . . . contribute to health effects observed in population studies, their contribution cannot as yet be isolated from the possible influence of other elements in the suspended particulates present in the airborne mix, . . .

Again, on page 3.4-14-15, he states:

> Estimation of health damage resulting from increased population exposure to sulfate adds considerable uncertainty to the analysis. Health damage associated with changes in annual sulfate exposure of a few ug/m^3 annual average at exposure levels below 15 or 20 ug/m^3 annual average cannot be estimated with accuracy. There may be none. Based primarily on cross-sectional correlational studies, however, some quantitative damage functions have been advanced. At this time, we arbitrarily selected damage functions of 0, 3.0 and 9.0 deaths/100,000 population per ug/m^3 sulfate. . . . (emphasis added).

The Main Report appears to have turned Shapiro's hesitancy into firm conviction. In fact, the evidence which is "growing" is that suspended sulfates are innocuous at both present and future projected ambient concentrations.

In addition to changing the tone of the background document, the sulfate mortality calculations presented in the Main Report are not self consistent. Figure 7-3, id. at 159, shows that the entire ORBES area will be exposed to no more than 5 ug/m^3 of sulfate in the year 2000. Multiplying this times the ORBES sulfate "kill factor" of 3 deaths per ug, id. at 173 n. 22, and again by the projected regional population of 26.6 million in 2000, id. at 116; the number should be 3990 not 5150 as reported at page 173. This example points up another inconsistency in the Report; it does not suggest either figure is correct — the correct number is zero.

1.2 The Sulfate-Related "Kill Factor" Analysis Is Misleading

The Main Report projects between of 0 to 9 deaths per 100,000 persons exposed per microgram sulfate per cubic meter. Id. at 101-2. From this the reader is told a median annual death rate of 8000 for power generation in the ORBES region can be calculated. This is a misleading

result because it employs an "arbitrarily" selected damage function. Shapiro (1980) at 3.4-11. The subsequent mechanical operations of multiplication to produce final "body counts" provides the reader no insight into reality; it merely adds sensationalism by discussing large numbers of deaths. This approach has been very appealing to the press which, in turn, has misinformed the public.

The Main Report cites Hamilton as authority for the sulfate health effects work. Id. at 101, n.34. Hamilton's work is based heavily on the work of Lave and Seskin (1978) and Winkelstein et al. (1967). The Lave and Seskin work has been largely discredited, see Section III-D, 1.3, infra. Hamilton improperly relied on Winkelstein by converting his Buffalo mortality results from TSP to sulfate to produce unit sulfate mortality factors. This conversion is without any scientific basis since Winkelstein himself concluded that sulfur oxide had no effect on Buffalo mortality.

Another misleading tactic in the Main Report is the use of a "range" of mortality factors. By using the arbitrarily large upper limit, 9 per 100,000 without substantive evaluation, the remaining values look "reasonable." This approach makes sense for bargaining in a bazaar; it does not as a scientific study designed for policy formation.

The Main Report states "[t]he major usefulness of the damage function for the CRPES study [sic] lies not in the accuracy of the health impacts but in the comparison of the impacts between scenarios." Id. at 102. This statement is misleading because the best evidence — as discussed below — is that the correct value for Shapiro to have used is zero. The proper comparison should have been between zero and zero.

1.3 The Bulk of Scientific Evidence Shows Present and Projected Sulfate Concentrations Are Inocuous

Concern by the environmental community over possible health effects due to ambient sulfates reached a peak about 1974-75, in conjunction with publication of the CHESS monograph by EPA. A flurry of research activity began at that time, and the results of those studies, without exception, now indicate that those fears were groundless. As a result, the U.S. EPA has not promulgated a primary (health-related) ambient air quality standard for sulfate.

Briefly, the results of the research referred to above are:

i. The CHESS studies were badly flawed in design and execution. The inter-regional comparisons cannot identify which pollutant, if any, is responsible for any observed health differences. The time-series studies are badly compromised by poor air quality monitoring, failure to control for other confounding factors, and inconsistent study populations. Brown Committee (1976).

ii. Clinical exposure studies of both normal and sensitive human subjects have failed to show adverse effects due to exposures to various sulfates — including sulfuric acid — at concentrations much higher than normally encountered even in sulfate episodes. Chaney, et al. (1980), Avol, et al. (1978), Leitauf and Lippmann (1980).

iii. Subsequent epidemiological studies incorporating the most recent air monitoring techniques and controlling for such confounding variables as weather and smoking have failed to find any adverse health effects associated with sulfate. Zagraniski, et al. (1979), Bouhuys, et al. (1979), and Ferris, et al. (1979).

iv. The cross-sectional study on which ORBES implicitly based its mortality calculations, Lave and Seskin (1978), has been found to be based on flawed ambient data. Lipfert (1979). Subsequent cross-sectional studies by other researchers who have considered competing risk factors have found no consistent mortality effects attributable to ambient sulfates. Crocker (1979); Lipfert (1978).

v. Atmospheric chemistry studies have shown that the bulk of what has been measured as (non-specific) water soluble sulfate is ammonium sulfate, which is of nearly neutral pH and is one of the least irritating of the common aerosal sulfates.

vi. At least a part of the reason for finding number v., supra, is the presence of ammonia in human airways, which can initially neutralize any acid aerosol inspired. Larson (1977).

2. The ORBES Acute Health Effects Analysis Misuse The Underlying Response Data by Equating British Smoke, Power Plant Particulate Emissions and Total Suspended Particulates

The Main Report claims that as many as three cadiovascular fatalities could occur each year as the result of particulate emissions from each 1000 megawatt coal-fired power plant. Id. at 101. This estimate was made without serious consideration either of the population exposed or the actual concentrations produced by the power plant emissions.

Moreover, ORBES assumes that power plant emissions can be related directly to cardiovascular mortality. Id. However, the underlying acute health data were developed using British smoke exposure measurements. Schimmel (1978). Power plant particulate emissions, British smoke and total suspended particulates (as cited in the ORBES Main Report at 101) are three distinct quantities. There is no definite relationship between the health effects data developed using the British smoke exposures and mass concentrations of TSP or power plant particulate emissions as ORBES assumes. Thus, the analysis is so uncertain that it should be disregarded.

3. The Radiological Discussion in the ORBES Main Report Contains Serious Errors of Fact

At the top of page 103 the Main Report states:

> . . . Assuming a single year of exposure, three steps in the nuclear cycle — the mining, milling, and power generation steps — are expected to result in a total incidence of lifetime cancers among the general public of between 0.03 and 0.05 cases per year per 1000 megawatts electric of nuclear power production. Roughly half of these cases would be associated with the power generation step. In 1976 in the ORBES region, 10 million megawatts were produced by nuclear-fueled power plants. Thus, between 150 and 250 cases of cancer are expected to have occurred in 1976 because of nuclear power generation. . . . (footnote omitted)

This paragraph contains numerous errors. First, the statement that "In 1976 in the ORBES region, 10 million megawatts were produced by nuclear-fueled power plants." is clearly wrong. The 10 million figure could be an approximation of the annual megawatt-hour output from the 1,800 MWe nuclear capacity in the ORBES region; however, the authors of the Main Report used the figure as capacity in health effects analysis. Even assuming the data used in the ORBES analysis, this overestimates the effects by a factor of 10,000, as the following explanation illustrates.

According to page 66 of the Main Report there were 83,125 megawatts electric of installed generating capacity in the ORBES region. Figure 4-2, on the same page, indicates that nuclear power accounted for 2.2% of this total, or 1,800 MWe; not 10 million!

Using this value, and accepting arguendo the ORBES "cancer factor," the total number of lifetime cancers induced by each year of nuclear power generation in the ORBES region would be 1.8 (thousands of MWe capacity) time the cancer risk factors, or:

$$(0.03 - 0.05) \times 1.8 = (0.054 - 0.09).$$

There are still more mistakes. The "lifetime cancers among the general public of between 0.03 and 0.05 cases per year" was taken from Radford (1980) at 27, by rounding, Radford's factors "0.028 - 0.048" to 0.03 - 0.05. Radford bases this estimate on all stages of the nuclear fuel cycle, except reprocessing and waste managment; moreover, the major portion of the exposure (and hence the cancer risk) comes from mining and milling activities. Id. However, the Main Report indicates, that:

> . . . Within the ORBES region, only the uranium enrichment, the fuel fabrication, and the power generation steps take place at present. . . ." Id. at 102.

No mining or milling take place in the ORBES region. Using Radford's factors (Table 7A) for enrichment, fabrication and generation, only about 1/8 of the exposure (and cancer risk) will occur in the ORBES region. Thus, the figures given on page 103 of the Main Report should be 0.0035 and 0.0060, not 0.03 and 0.05.

Furthermore, the statement that "[r]oughly half of these cases would be associated with the power generation step" does not correspond either with footnote 37 of the Main Report, or Radford's Table 7A. According to both, the power generation step accounts for more than 90% of the risk attributable to enrichment, fuel fabrication and reactor operation.

Multiplying the corrected estimate for the cancers produced in the ORBES region by one year's operation of enrichment, fuel fabrication and power generation to produce 1,000 MWe, times the correct figure for the nuclear power generated in the ORBES region in 1976 gives:

$$(0.0035 \text{ to } 0.0060) \times 1.8 = (0.0063 \text{ to } 0.011),$$

not "between 150 and 250 cases."

Finally, these cases would be produced by the 1976 exposure, and would arise in the decades ahead. They are not "expected to have occurred in 1976."

4. ORBES Grossly Overestimates the Radiation Induced Health Effects Induced by Radiation and Fails to Acknowledge Relevant Literature.

The Main Report discusses the "methodological fallacy" of "argument from ignorance" and in so doing makes the statement,

> . . . the impacts of nuclear-fueled electrical generating units are evaluated without knowledge of the health effects of low-level radiation." Id. at 55.

This quotation is apparently the result of a misunderstanding of Radford's statement that "the appropriate model for lifetime projection (of health effects) is unknown at this time." Radford (1980) at 27. Radiation biologists may continue to wrangle about the "appropriate model" for relating the incidence of health effects to radiation exposure for some time to come, but most agree reasonably that the "impact" on health is about one lifetime fatal cancer per 10,000 person-rem. See e.g., ICRP Publication 26 (1977) at 12, paragraph 60.

The "health effects" estimates for radiation from nuclear power used in both the Main Report and the Jensen background report are based on Radford's report, which states that the risk estimates used are "based on the linear no-threshold dose-response relationship, derived from the draft 1979 BEIR report." Radford (1980) at 24. This draft was withdrawn, extensively revised, and finally issued July 1980, over

Radford's objections. The risk coefficients used by Radford in the ORBES analysis are about 10 times greater than those which are generally accepted. See, e.g., ICRP Publication 26 (1977) and BEIR (1980).

The radiological aspects of energy in the Ohio River Valley are not, and are not likely to become important considerations for the production of electricity in this region. Although the ORBES Main Report does not state this in so many words, the fact is clearly implied. The Core Team has handled the few radiological matters which appear in the Main Report very clumsily. The danger is that the clumsy handling of nuclear power and radiation will invite criticism which will cast doubt on the implied conclusion, which is correct, that radiation is an unimportant consideration. Three references — UNSCEAR (1977); ICRP Publication 26 (1977); and BIER (1980) — and the references they contain, provide a vast and authoritative body of information about nuclear power, the radiation associated with it, and the probable risk from this radiation. The Core Team never addresses these documents nor the fact that some of the ORBES analysis is at odds with them.

E. The ORBES Crop Damage Results are Based On Incorrect Theories, Incorrect Applications of Theory, Fail to Recognize Key Scientific Studies and Greatly Overestimate Air Pollution Damage

1. Introduction

The ORBES region covers 423 counties in the states of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia. The types of farming range from vast corn and soybean tracts in Illinois to smaller tobacco farms in Kentucky. The agricultural sector constitutes about 4% of the gross regional product. A key ORBES conclusion is that the cumulative agricultural economic damage in the region would range from $7.0 billion (1975 dollars) — under the base case and SIP noncompliance case — to $8.4 billion (1975 dollars) — under the high electric growth case — over the period 1976-2000. Main Report at 147. This "conclusion" has received wide public attention. Evansville Courier, Sept. 2, 1980, at 1.

The Main Report does not indicate how these estimates were developed. For this, the reader must search two documents. The Institute of Ecology (TIE) Report, Loucks, et al. (1980) develops crop loss coefficients — numerical estimates of the loss produced for different crop species from pollutant exposures. It also estimates the current and future crop yield reductions — the annual reduction in crop yield due to the exposure of regional crops to air pollution. The yield reduction estimates were used by researchers from West Virginia University to calculate monetary loss estimates. Page, et al. (1980).

2. The ORBES Crop Damage Estimates are Gross Overestimates Compared to Other Studies

The economic loss estimates projected by ORBES for the Ohio River

Basin area differ drastically from previous estimates. Benedict (1973), Moskowitz (1980). Neither the Main Report nor the background documents compare the ORBES estimates with these studies.

While not endorsing the numerical results of the Benedict (1973) model, it may be the most comprehensive such study to date. Benedict estimated the primary (farm-level) economic impacts of air pollution on vegetation at the national level and attempted to "validate" his calculation with field data. He found that his results agreed fairly well with individual state field estimates.

Benedict estimated the 1969 loss to field and seed crops, citrus, fruits and nuts, vegetables, nursery and forests, and ornamentals to be: $119,647,000 (attributable to oxidants) and $7,590,000 (attributable to sulfur dioxide). Of this national total, Benedict estimated that Illinois, Ohio, and Indiana experienced $7.5 million, $3.3 million, and $1.3 million of the damage respectively. Moskowitz (1980), revising Benedict's estimates has calculated nationwide oxidant losses to be: $130 million (1969 dollars) in 1969 and $290 million (1969 dollars) in 1974.

Page's estimate of the damage to soybeans, corn, and wheat for the year 1977 is $452.0 million (1969 dollars) for the ORBES states alone. Therefore, the ORBES researchers calculated more economic damage in the ORBES study area for the year 1977 than Moskowitz estimated for the entire nation for 1974! Moskowitz calculated that only $34.8 million (1969 dollars) worth of damage occurred in the Illinois, Ohio, Indiana three state region in 1974. Certainly this difference in magnitude should have been explored by the ORBES Report. Yet, no mention was made of this large discrepancy. The fact that the Benedict estimate compared favorably with state field estimates suggests that the ORBES estimates are gross overestimates.

3. The Main Report Is Inconsistent with the Background Documents on Which It is Based

The total crop loss estimates presented in the Main Report do not agree with those given in the Page report. The Main Report indicates the total estimated crop losses for scenarios 2, 2d and 7 is $7 billion, $7 billion and $8.4 billion (1975 dollars) respectively, id. at 147; whereas Page reports the values $8.1 billion, Table 21, $8.1 billion, Table 35, and $8.3 billion, Table 49.

There are several errors which compound to produce this inconsistency. Basically, the economic data presented in the Page report do not correlate with the conclusions reached in the ORBES Main Report. The "ozone coefficients" in Tables 11 and 13 of the Page report are different from those reported by Loucks, et al. on page 208. For example, Loucks recommends the following "ozone coefficients" for soybeans for the year 2000 (scenarios 2 and 2d): minimum, 2%; "most

probable", 7%; maximum, 20%. The Page report uses the values: minimum, 24%; "most probable", 28%; and maximum 41%. Tables 11 and 13.

Neither do the time periods over which the two reports aggregate their cumulative loss figures agree. Tables 59, 61, and 63 in the Page report are tabulated from 1977 to 2000, while the Main Report discussed monetary losses from 1976 to 2000. Thus, the ORBES Main Report appears to report cumulative monetary losses for scenarios 2, 2d, and 7 which are in error by $500 million. While this error would raise the ORBES cumulative losses estimates, either figure is a gross overestimate.

There are two major reasons for the large overestimates of ORBES. They are: (1) the estimate of ozone dosages are incorrect and (2) the ozone and sulfur dioxide yield reduction curves for soybeans, corn, and wheat are too large.

4. The ORBES Ozone Analysis is Based on Fundamental Scientific Errors; Its Conclusions are Naive

Two important conclusions emerge from a review of the ORBES ozone analysis described in Loucks, et al. (1980). First, although some of the processes that lead to atmospheric ozone formation are reasonably well understood, this basic understanding is neither described nor employed in ORBES. Second, the authors relied on a simplistic, vaguely defined, semi-quantitative analysis of dubious validity, when well defined, more quantitative (though simplified and approximate) methods of analysis were available.

4.1 The ORBES Ozone Analysis Ignores Our Fundamental Scientific Understanding of the Subject

The ORBES researchers relied on simplistic methods to estimate the ozone impacts of changes in the NO_x emissions, claiming that the more complex ozone models were untested. Loucks, et al. (1980) at 185. Their simplistic approach certainly avoided any pitfalls of the untested ozone models; however, it also avoided making use of most of the well recognized learning in this area of study.

Because the ORBES researchers rejected ozone models as "barely beyond the preliminary testing stages," they found themselves faced with a dilemma:

> Thus, the options for this study, and for the ORBES work as it relates to resource effects, were to accept both the "zero change in O_3" and "zero contribution of utilities" asumptions above or examine qualitatively the evidence on apparent trends in O_3, its effects and precursors, and as appropriate, draw conclusions expressed in terms of probable or possible responses. Loucks, et al. (1980) at 185.

Thus, the authors chose to rely on observations of past ozone concentrations and projections of future NO_x emissions to estimate future ozone concentrations. Specifically, they prepared a "trend analysis" presented in their Figure VIII-7; they "characterized" the ozone history of the ORBES region over the past 50 years by extrapolating backwards in time from the highest hourly value reported in Indianapolis for the years 1974 and 1979. Loucks, et al. (1980) at 205-06. Next, they extrapolated this "trend" forward in time another two decades and assumed that future ozone concentrations would depend solely on a proportional relationship (again assumed to exist) between projected NO_x emissions and regional ozone concentrations. This approach is incredibly naive!

Although the findings of many studies in the area of ozone formation are not regularly published, the basic descriptions have been published and were available to the ORBES researchers. Anderson, et al. (1978), Anderson, et al. (1976). Moreover, the Environmental Protection Agency has sponsored numerous reviews which were readily available. Whitten, et al. (1980), Whitten, et al. (1979), EPA (1978), EPA (1977). The text below illustrates three of the numerous fundamental problems introduced by ORBES' naive approach.

ORBES Ignored the Relevance of The Ozone Isopleth Diagram

The ozone isopleth display provides a description of the relationship of ozone to the hydrocarbon and nitrogen oxide precursors. See Figure 1. This display was developed by EPA. The diagram shows ozone concentrations plotted as a function of the hydrocarbon (HC) and oxides of nitrogen (NO_x) precursor concentrations. The isopleths — curves of constant ozone concentration — describe a family of concentric "L" shaped lines. The lines are roughly parallel to the two axes. The high ozone concentrations can be produced by low precursor concentrations if the procursor ratio (HC/NO_x ratio) is correct.

EPA developed a technique for estimating ozone concentrations, based on this isopleth diagram — EKMA — and requires its use as an ozone control strategy tool in urban non-attainment areas. 44 Fed. Reg. 65667 (Nov. 14, 1979). Several studies have been completed or are in progress which support the validity different aspects of EKMA. Whitten and Hogo (1981), Whitten, et al. (1981). While EKMA may be experimental and may not be suited for many regulatory contexts, it is based on some theoretical understanding of the ozone formation process. Smog chamber studies, computer simulations, and atmospheric observations all support the general shapes of the isopleth curves.

Despite the fact that EKMA is not a flawlessly validated tool, it does embody more scientific understanding of this complex phenomenon than a two point "seventy year trend analysis." Its discussion and use would have lead to a more meaningful examination of ozone formation and its effects on vegetation in the ORBES area.

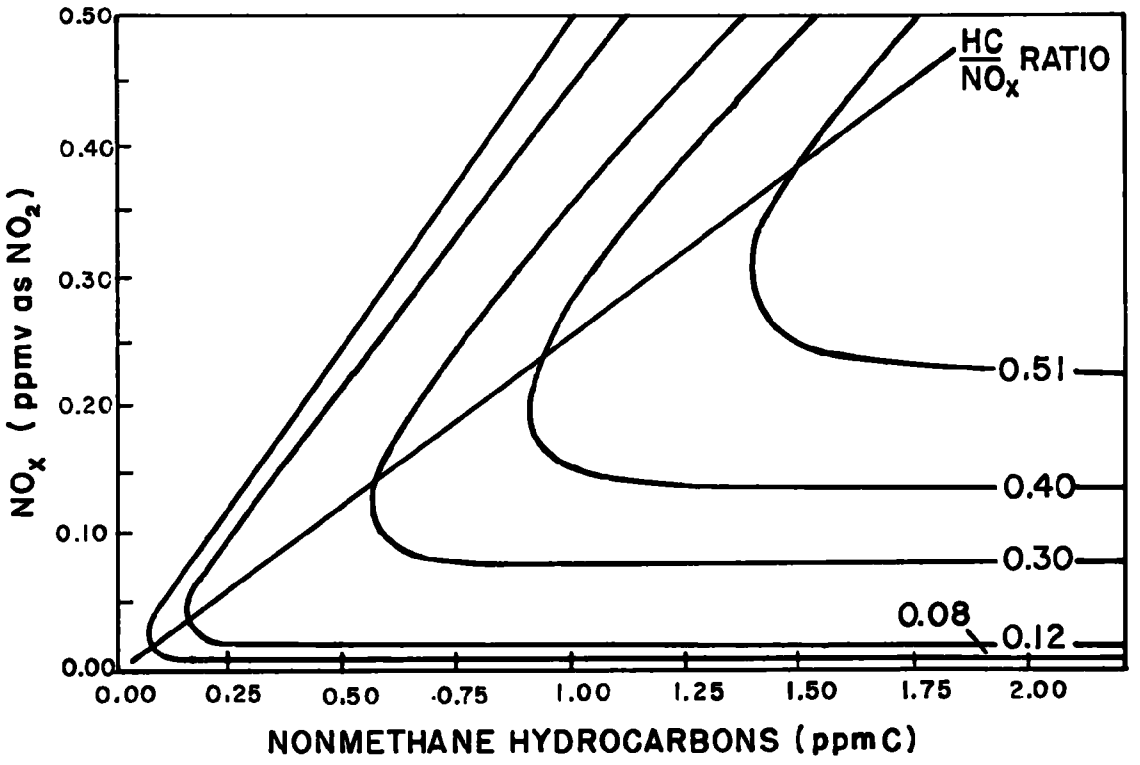

Figure 1. Standard ozone isopleth diagram.

ORBES Rejects the Use of Models Developed on Urban Ozone Studies But Uses Urban Data to Establish Rural Trends

The ORBES researchers imply that ozone models are less reliable in the rural ORBES setting because precursor concentrations are low and there are natural hydrocarbons present. Loucks, et al. (1980) at 185, 194-196. The chemistry of ozone formation may actually become less complex at lower concentrations. And while the chemistry of natural HC species is not fully understood, some knowledge is available. Isopleths based on urban chemistry should provide useful insights into rural problems. Moreover, it is difficult to reconcile ORBES rejection of theoretical models based on urban ozone studies with its use of a "trend estimating technique" which employs only (two) urban extreme values!

4.2 Example: The ORBES Proportional Model Is Inadequate to Simulate the Spatial Distribution of Ozone Necessary to Estimate Crop Damage

The peak ozone concentration depends on the local HC and NO_x concentrations and on their ratio; the rate of ozone generation is strongly dependent on the HC/NO_x ratio. In an HC rich rural environment such as found in parts of the ORBES region, the reduction of power plant NO_x emissions may increase this ratio in the plume and may, in turn, lead to an increase in the rate of ozone formation. The highest ozone concentration in the plume may not be reduced at all, yet it may be reached earlier in the day. Hence the reduction of power plant NO_x emissions can actually lead to a longer persistence of high ozone concentration and, thus, to greater crop injury. Moreover, since NO scavenges ozone during the dark hours, the reduction of plume NO emissions can lead to less scavenging and increased exposure to ozone formed from precursors emitted from other sources.

The simplistic ORBES proportional model would say that whenever NO_x emissions are reduced in a HC rich environment, ozone concentrations will also be reduced. Yet, as explored above, this is inconsistent with our scientific understanding of ozone reaction kinetics in some situations. This example illustrates that the ORBES simplistic model is not adequate for performing the kind of sophisticated analyses required to assess the effects of changes in NO_x emissions on the region's crops.

5. The ORBES Ozone Crop Loss Estimates are Based on Fundamental Scientific Errors

Section V of the TIE Report, Loucks, et al. (1980), identifies much of the relevant ozone effects literature. Based on this literature, the researchers formulated several hypotheses which lead, in turn, to the ORBES ozone damage functions. Dr. Jay Jacobson, of the Royce Thompson Institute identified fifteen key assumptions and evaluated each in light of our current knowledge. In most cases, he concluded that the ORBES researchers had erred in their judgments. Two examples — the limited

space prevents a discussion of all fifteen — of these errors are given below. (Dr. Jacobson's review was limited to the ORBES assumptions concerning ozone crop damage functions.) In disagreement with the ORBES team, the industry reviewer does not believe that these hypotheses lead to conservative estimates of crop damage. Furthermore, the yield reduction curves are based on so little valid data that they do not possess much reliability. The following paragraphs illustrate some of the flaws in the ORBES analysis.

Assumption 2: The ORBES researchers assumed that experiments with repeated daily exposures to ozone correctly represent ambient conditions. Unlike daily exposure experiments, natural ozone episodes usually occur in limited clusters of 1, 2, 3 or 4 days. They are separated by intervals of cloudy, rainy, or windy weather with less polluted air. Wolff, et al. (1977). Consequently, continuous or repeated daily exposures at constant concentrations do not imitate the patterns and fluctuating concentrations of ambient ozone. Since plants are not allowed time to recover in many experimental situation, this assumption probably overestimates the effects of ozone on yield.

Assumption 15: The author assumes that the dose-response et al. relationships for sweet corn and field corn are the same. Loucks, (1980) at 92, 93, 96. This is incorrect: it is clear from the scientific literature that sweet corn is far more susceptible to ozone injury than field corn. Heagle, et al. (1972); Heagle, et al. (1979); Oshima (1973); Thompson, et al. (1976). Although ORBES recognized differences in susceptibility between the two varieties, it did not properly account for the magnitude of the different susceptibilities. The results of a recent paper by Heagle and Heck (1981) — the same scientists whose data are relied on by Loucks — show that field corn are overestimated by ORBES by a factor of 20 to 75.

6. The ORBES Sulfur Dioxide Crop Loss Estimates Failed Adequately to Consider Relevant Scientific Studies

In considering damage to crops, three basic questions always arise. They are:

* Is there a threshold level of exposure below which no crop damage occurs?

* Does damage occur without the development of visible markings on the leaves? (The hidden injury question)

* Does simultaneous exposure to sulfur dioxide and other pollutants produce synergistic effects?

The Main Report is correct in its assessment that the overall agricultural losses due to sulfur dioxide exposure are "negligible." Id. at 21. Even so a thorough review of those papers discussed in THE Report, Loucks, et al. (1980) Section V, and other current literature, shows that the sulfur dioxide damage functions for soybeans, corn and

wheat have been overestimated. This is because ORBES answered the three key questions without considering all the relevant literature.

6.1 ORBES Does Not Properly Take Account of Plant Sulfur Dioxide Threshold Responses

The ORBES researchers rejected the use of a damage threshold and extrapolated the damage function and yield loss estimates to zero concentrations. They justified this extrapolation by citing research results which show that very low concentrations of sulfur dioxide can affect plants. This approach gives equal weight to both acute and chronic damage and artificially overestimates sulfur dioxide damage. Current evidence points to the existence of threshold levels for injury. Irving, et al., (1980). The ORBES researchers should at least have used the threshold for injury — any identifiable or measurable plant response — to approximate the threshold for damage — injury which significantly reduces the dollar value of the crop or plant. By doing this a more realistic — though still conservative — estimate for sulfur dioxide damage would have been made.

6.2 ORBES Uses the "Hidden-Injury" Hypothesis Without Considering Key Studies

Loucks, et al. (1980) discusses the evidence for and against the occurrence of hidden injury and cites various papers discussing the problem. However, it does not discuss the work of Jones, et al., (1979) on soybeans; Heck and Dunning (1978) on oats; Brisley and Jones (1980) on wheat; Davis, et al. (1966) on Arizona range grasses; and the work of the Selby Smelter Commission (1914) on barley. All of these studies showed no yield reductions unless definite leaf markings appeared on the plants. Moreover, the amount of yield loss correlated very strongly with the percentage of the leaf area destroyed.

These key scientific studies should have been considered in any scientific study attempting to estimate sulfur dioxide crop damage. Most were not even mentioned by ORBES. The results of Jones, et al. (1979) were dismissed as being biased because of certain assumptions that were made in the paper. Whatever assumptions were made, however, the experimental results of this study should have been considered on their merits. Those results showed that there was no reduction in yield without accompanying leaf destruction.

To support the hidden injury thesis, the TIE Report cites several studies: Sprugel, et al. (1977 and 1979), and Miller, et al. (1979), are prominent among them. These papers indicate that significant reductions in yields of soybeans can occur without accompanying injury symptoms. Several points should be made. First, the TIE Report itself states that the Sprugel results should be interpreted in light of the fact that other pollutants could have caused or exacerbated the damage observed. Loucks et al. (1980) at 103. Thus, these results can hardly be depended upon to produce accurate reduction functions for soybean.

Sprugel and Miller's yield loss data disagree with those obtained by previous workers especially in field experiments. Heagle, et al. (1974); Jones, et al. (1979). While Sprugel and Miller's work was based on a single replication, the work of Jones, et al. (1979); Heck and Dunning (1978); and others were found to be statistically significant.

6.3 Minimum Thresholds for Individuals Crops

Soybeans: According to the Loucks, et al. (1980), only one study has been reported that describes the effects of chronic sulfur dioxide exposure on soybean yield under experimental conditions in the field: that is, Sprugel and Miller (1977 and 1979). Because of the lack of replication, however, this study should be interpreted with great caution. Results from the numerous studies by Jones, et al. (1979) are dismissed as being biased. Jones found no reduction of yield unless there was accompanying damage to the leaf. Many studies carried out in the field found no reduction in yield of soybeans growing in the vicinity of power plants in the Tennessee Valley.

Observations made over the period of years indicate that for soybeans to develop leaf markings the sulfur dioxide concentration has to average about 0.7 ppm for one hour or about 0.33 ppm for three hours. These values are very close to those observed for sensitive plants around the Sudbury area in Canada by Dreisinger and McGovern (1970). This may be the threshold for injury; the threshold for damage should be somewhat higher. Also see Jones, et al. (1979).

Wheat: The authors mention the so-called "Biersdorf" experiments, Loucks, et al. at 106-07, because they say that the literature does not contain relevant yield reduction studies for wheat. The data are available. Stratmann (1963), and Guderian and Stratman (1968) reported results of studies in which wheat, together with 22 other species, were grown in wooden tubs at different distances from a known source of sulfur dioxide.

These studies show that wheat exposed to doses of 32,000 ug/m^3-hr suffered no yield reductions. This dosage is almost twice that of the dosage alleged to have occured in the vicinity of the Clifty Creek power plant. Loucks, et al. at 110. Based on these results, the expected wheat yield reductions around Clifty Creek station should be zero.

Corn: The ORBES investigators found no pertinent data for corn yield loss due to sulfur dioxide exposures. Id. at 111-112. However, based on the fact that one researcher found that sulfur dioxide concentrations as low as 0.01 ppm for ten minutes could increase stomatal openings in corn and that another found similar results in broad bean, the TIE Report concludes that this concentration could lead indirectly to injury in corn. Id. The hypothesized injury mechanism is that the open stoma could cause the plants to suffer more from droughts.

Any quantitative bridge between observing stomatal openings in beans and estimating the percentage of corn yield loss is tenuous at best. More importantly, it is unnecessary. Although actual yield reductions were not reported, Guderian (1977) found that corn growing in a mixture of sunflowers, peas and beans suffered no significant reduction in green matter when exposed to 1000 ug/m^3 of sulfur dioxide for 48 daylight hours and to 2000 ug/m^3 for 24 daylight hours. Both of these exposures resulted in a doses of 48,000 ug/m^3-hr. This is considerably higher than any dose which would occur in the No. II exposure zone at Clifty Creek. Loucks et al. (1980) at 106.

Corn is among the most resistant plants to sulfur dioxide. Based on the assumption that leaf damage would have to occur before reduction in yield would result, it is unlikely that yield losses would occur as long as the second highest one-hour exposure in a month is 1.0 ppm.

F. The ORBES Least Emission Dispatch Analysis is Totally Unrealistic

1. The ORBES Model for Least Emission Dispatch is Totally Unrealistic

The ORBES conceptual model for the least emission dispatch (LED) discussed in the Main Report principally at pages 204-207, and in Teknekron (1980), is so totally unrealistic that it does not provide any meaningful insights into the subject. Three fundamental problems with the Teknekron concept are: system variability, dispatch order, and region of dispatch.

The meaning of LED varies tremendously from system to system depending on such factors as excess capacity, generating mix, system balance, etc. Because none of these factors were taken into account, any conclusions from the Teknekron analysis have no direct applicability to any system. Moreover, because no real world system has the make-up implicitly assumed by ORBES, the inferences made in the study have no relation to LED as strategy in the real world.

The Teknekron model assumes that generating units will be dispatched on a purely least emission basis. This is a naive and meaningless assumption as any power engineer knows. ORBES assumes that LED would be implemented on a state-wide basis. This is another naive assumption; it ignores the fact that there are several interstate system serving the ORBES region. Given this fact, statewise dispatch would lead to chaos for the region as a whole.

2. ORBES Presents Misleading Overestimates of the Emission Reductions Achievable Through Least Emission Dispatch

Teknekron (1980) finds that LED could reduce emissions of sulfur dioxide by 21 percent in 1985 and 45 percent in 2000 in the ORBES region. (These percentages vary throughout the Main Report compare pages 15 and 131 — 55% reduction in 2000 — with pages 204-207 — 45% reduction in 2000.) These are substantial emission reductions. But two

facts make these reductions very misleading. First, the LED reductions are only compared to the high electric growth scenario; they are not compared with the base case. Second, although emissions may be reduced within the ORBES region they will increase at plants immediately adjacent to the region.

3.1 ORBES Is Misleading Because it Compares LED Only With the High Growth Scenario

Teknekron points out in their report at page 121 that the effect of LED depends on assumed electricity growth rates and other assumptions that determine the number of new units that are forecast to be built. New units are subject to the revised New Source Performance Standards and hence have low emission rates. Each substitution of a new unit for an existing unit reduces emissions. The more new units there are, the more effective LED appears to be. Teknekron tested LED only on the high growth scenario. This exaggerates the potential effects of LED because assumed high electricity growth rates will result in forecasts of more new units being built. This point is not drawn to the reader's attention in the ORBES Main Report and is an example of the kind of misleading omissions which indicate a consistent bias to the study.

3.2 ORBES Exaggerates the Apparent Emission Reductions by Failing to Discuss Emission Increases in Adjacent Regions

Teknekron notes that some of these apparent reduction result from the geographic boundaries of the ORBES region. Teknekron (1980) at 119. The Main Report merely mentions that some generation might be shifted out of the ORBES region. Id. at 131, n. 5. This does not adequately alert the reader to the fact that a large fraction of the emission reductions are illusory.

The effect of LED for the systems with plants both inside and outside the ORBES area is to shift generation from units with high emission rates in the ORBES region to units with lower emission rates outside of but adjacent to the ORBES region. Hence, the emission reductions within the ORBES region are correctly reported but the total emission reductions were less than the reported values. The difference is the emission increase which occurs outside of the ORBES region.

Teknekron notes that for the year 2000, about 30 of the 45 percent emission reduction was due to LED. Id. at 119. The impliction is that the other 15 percent — one third of the total — is due to the shifting of load outside of the geographic boundaries of the ORBES region. Thus, while the reported emission reductions may be technically correct emissions within the ORBES geographic boundaries; they mislead the reader because they do not pertain to the effect on the total emissions of the affected systems.

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This section provides comments on various issues as noted by the underlined headings.

Mining and Use of Coal--The congressional mandate to ORBES states "The Study should also take into account the availability of coal and other energy sources in this region." In spite of the vastness of the coal supply in the region, the report is for the most part written in a negative posture for use of coal. It states "In general, the reclamation of surface-mined land for permanent land use tends to be a slow process." and notes two years for quick-growing cover after cessation of mining. It talks about significant increases in land use for surface mining for a number of scenarios as compared to the base case. These comments and others leave many readers with the impression that a vast amount of land is being lost forever. It would seem a report dealing with such an important subject as our nation's future energy requirement, a matter which will extend beyond the lifetime of those involved in making and commenting on the study, would not consider a period of five, ten, or more years as a significant time for reclamation. The report also fails to point out that under today's reclamation regulations, many surface-mined areas have been restored to a condition better than existed before mining and in some cases land has been restored to agricultural use within two or three years.

The assertion that numerous counties would experience a "boom town effect" from mining of coal for various scenarios is without documentation. Possibly the authors have been confused with the improved standard of living that has been realized in the coal areas with the higher price for coal and resulting higher wages for miners. This has resulted in the building of new homes, hospitals, and other amenities. The gradual increase in use of coal to meet future energy needs, even with greater emphasis to achieve more energy independence, will produce stable communities; not "boom towns." The eastern coal areas, while not heavily populated, can cope with growth in mining. Conditions in the eastern coal field are not comparable with those in the West.

Plant Siting--The siting of future power plants for each of the scenarios analyzed is based on support reports entitled, "The Ohio River Basin Energy Study" and "Energy Facilities Siting Model" Vol. I Methodology and Vol. II Sites and On-Line Dates, respectively. The voluminous and impressive detailed description of the modeling technique in Vol. I yields at best a program that can only provide very preliminary screening of potential sites. In fairness to the authors, neither time nor money allotted for this project could possibly allow selection of candidate sites that would meet all environmental requirements. To evaluate and select sites based on meeting Prevention of Significant Degradation (PSD) alone would be an overwhelming task. As noted in the support report, many simplifying assumptions were made. This was necessary to alleviate the need for making modeling studies beyond those accomplished to date. The methodology employs a technique of grading siting components such as water availability, agricultural land, forest land, impact on air quality, etc. and uses the gradings as input into the modeling program. In most cases, grading cannot be established by any quantitative analysis. The grading is highly dependent on the opinion and judgment of the grador. Thus, the modeling program for site selection is

highly sensitive to the grading of the many components. In summary, the results of the ORBES Siting Study should not be construed as being authoritative. Both good and bad sites may have been selected. For purposes of the scenario development and analyses of environmental impacts, a much simpler and less expensive procedure could have been used to site future units through the region without identifying specific counties.

Power Plant Cooling--The report's evaluation of operation and resulting environmental impacts of different types of cooling cycles for power plants, direct cooling, cooling towers, and cooling ponds is totally inadequate and is presented in a biased manner. Possibly this is a lack of adequate research. For example, in a supporting research report under "Terrestrial Ecology" it is stated that quantitative data on cooling tower effects are not available. Actually, there are many publications citing the quantitative effects of cooling tower operation. The authors note that, of the alternatives, the direct-cooling cycle is the least consumptive of water, but do not indicate any credit for this in their evaluations. Likewise, they do not point out that generating units with cooling towers consume more auxiliary power and operate at lower efficiency because the turbine cannot attain the low back pressures that can be realized with a direct cooling cycle. These two factors result in higher costs for the production of electric power. Throughout the sections discussing water for each of the scenarios, the report talks about the once-through cooling cycle with such phrases as "water withdrawl would increase drastically" with the addition of a large number of power plants on the Ohio River. The way it is presented leaves the uninformed reader to believe the water is taken out of the river and not returned. It is true that more water would be withdrawn if there are more plants. However, the amount of withdrawl is not meaningful unless it can be proven that the withdrawl and returned water impacts substantially on the environment of the river.

In further discussion of the direct-cooling cycle, the report states that the rise in river temperature caused by the discharge would be damaging locally; especially to sensitive bank habitats. This statement and the report's general assumption of no strict effluent controls on the water discharge from power plants for all scenarios, "except the strict environmental case," indicates the authors are either unaware of the very strict existing regulations controlling discharges from power plants or they have chosen to ignore them. For example, there are regulations which set limits on the rise in river temperature caused by the effluents from the direct-cooling cycle. During the course of the ORBES Study the Core Team was told that such limits exist and that power plant outputs have been and will be restricted to the level required to prevent exceeding the specified temperature limits. The implication of the ORBES Report seems to be that the present regulatory standards are incorrect. If the authors of the study have developed evidence to prove this, it should be stated forthrightly if the report is to achieve its purported goal of providing meaningful information for "decision makers."

Social-Economic Impacts--The report's treatment of social values (p. 107) is nebulous and lacking in basic scientific quality and authenticity. The report largely relies on the work of Dr. Potter, "Social Values and Energy Policy." He was quick to point out major shortcomings in his own research

(p. 2), as well as possible, the entire ORBES endeavor: "One of these limitations often is the adequacy of the data for the specific problem." We agree with his observation since no original data were collected for the study. In a survey of "The Socioeconomic Dimensions of Electric Power in the ECAR Region," conducted by Dr. Frank Clemente of the Pennsylvania State University and commissioned by ECAR, substantial data and information were obtained from electric power users covering; the economic costs of electric power interruptions, the value of reliable electric power as defined by consumers in the ECAR region, the basic implications of current and projected socioeconomic trends in the ECAR region over the period 1960-1990, and the socioeconomic impact of power plants as viewed by community residents and leaders. Space does not permit listing results of the survey to identify the positive benefits of have reliable and adequate electric power as viewed by respondents. The survey results do not support many of the observations presented in Section 4.8 of the Main Report.

As to the item of economics, the statement "Whether utility expansion contributes to economic growth is unknown." (p. 55) raises the questions as to whether the authors make this as a casual observation or have made studies of sufficient depth to verify the statement. A survey for the Committee for Great Lakes Economic Action (encompassing portionf of three ORBES states) concludes "uncertainty about energy supply" represents one of the "impediments that must be overcome if new growth in the regional economy is to be stimulated," "Heavy manufacturing, which long undergirded this region's economy dominance, is growing slowly in the United States, still more slowly in the region.," and "Non-manufacturing jobs (i.e., those highlighted by ORBES) in the region are not growing fast enough to absorb those displaced by the substitution of capital for labor, absolute losses of employment in some basic industries, natural increase in the size of the labor force, and increased participation in labor force." The conclusion of the foregoing study and the responses to Dr. Clemente's survey document the important role of electric power and its growth in maintaining the economic health of the region.

Public Service Company of Indiana, Inc. (PSI) participated in many ORBES activities and availed itself of the opportunity to provide periodic inputs and objective comments throughout the duration of the ORBES Project. The ORBES Project Team's determined reluctance to accept and/or incorporate data which was not totally compatible with its views, has now resulted in what we believe to be a grossly erroneous and scientifically unsupportable ORBES Main Report. Therefore, PSI and its Chairman, Hugh A. Barker, who served as an Advisor to ORBES, at this time disclaims the accuracy of the contents and quality of the ORBES Main Report.

PSI supports the positions expressed in the pooled comments on the Main Report by the utility industry advisors to ORBES. In addition, there are two specific issues on which PSI would like to comment. In reviewing the mandate for the study, the ORBES Main Report emphasized that it was "to assess the potential environmental, social, and economic impacts of a proposed concentration of power plants" (page 45). The Report further stated "In late 1974, Public Service Indiana announced that it would build a nuclear fueled facility, the Marble Hill plant, on the Ohio River between Louisville and Cincinnati. Citizen concern intensified" (page 46). The Report assumed that under the nuclear scenario about 145,000 MWe of capacity would be installed by the year 2000 (page 10). Yet the Report concluded that the nuclear substitution case would reduce sulfur dioxide emissions only 3% over the base case with coal fired generation (page 34). The Main Report grossly underplayed the resultant vast improvements in air quality under the nuclear scenario. Also, the ORBES Project Team for some unexplained reasons expanded its Congressional mandate of 'proposed concentration of power plants' to a series of arbitrary scenarios which emphasized existing sources.

In discussing Section 126 of the Clean Air Act, the Main Report commented on the Gallagher Generating Station hearings. It stated that the problem may be linked to the Clifty Creek Station and that emissions from Clifty Creek may contribute to air quality degradation in the vicinity of Gallagher (page 224). However, such a claim was not substantiated in either the Main Report or its support documents. In its 'Air Quality and Related Impacts' document, the authors zealously attempted to demonstrate violations of the NAAQS for SO_2 in 1977 in Floyd County, Indiana (page 6). A CAAP (Continuous Aerometric Acquisition Program) site in Floyd County, operated by the Indiana Air Pollution Control Division and the county's only quality assured monitor, demonstrated that in 1977 Floyd County complied with the NAAQS for SO_2.

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Overall Comments

My first reaction on reading the Main Report is one of admiration: so much information summarizing those forty-odd Phase II publications listed in Appendix B is organized and presented in so smooth-flowing a style. In this aspect it is a tour de force, irrespective of the validity of the data.

One has to recognize that these distillations of research belong on library shelves. They will not gather dust there, for they will represent a carefully planned data base. The plan may look easy now, but was surely not easy to make in the beginning.

Such a data base is badly needed in ecology and energy areas today. This is for two reasons: one because of the confusion and actual misunderstandings that are prevalent as in the public relations utterings of some interests; and two, because of the difficulty of preservation of basic data in a field that is developing so fast as to lose perspective and historical lessons from its past.

An example of serving the first need is the careful laying to rest of the myth that nuclear generation provides cheaper electricity than coal generation does [pp. 274ff].

An example of serving the second is the case of natural gas. Most of the work on natural gas use is already outmoded (see below), but at least one can learn from this the effects of deregulation on an energy source. There is, on p. 39, a parenthetic bow to the facts in the case.

Specific Comments

These probably do not exhaust the possibilities for specific comments. However, I have tried to ensure against serious omissions in the General comments, below.

1. Granted the major emphasis on coal, it is encourag-

ing to see the very minor attention given to nuclear as an energy source: it constitutes of the order of 1.5% or less of our energy needs and deserves relegation to minor attention, even though excessively capital intensive.

2. One rather serious error, in my estimation, is the blithe assumption that "RNSPS Units already are very clean units, removing approximately 90 percent of their potential sulfur dioxide emissions." [p. 156]

This statement may be true for oil-fired and low-sulfur-coal units with scrubbers, where removal of sulfur dioxide is not so important. At the same time there is not one unit of large size, greater, say, than 100 MW, burning high sulfur coal, which operates reliably. And I suspect that in the nature of things, large units can not operate reliably with scrubbers. Thus the "already" is in part false.

The quoted statement seems to reflect the EPA official position. But this position is based on the institutional crystal ball. The credibility of much of the air-pollution data suffers seriously because of this assumption, and the overall effect is to draw unrealistic conclusions. I suspect that EPA has been led astray by too much reliance on LG&E reports.

3. Statements such as that in the first full paragraph on p. 26 suffer seriously, in my opinion, because no mention is made of the effects of "price elasticity" in changing demand. Failure to take account of this phenomenon may blind one to the considerable decreases in demand for energy that have already occurred. The statements such as that on p. 39 ". . . conservation could make significant inroads. . ." and that on p. 54, paragraph 4, where the quoted statement is repeated, should not be in the conditional. Already some of the problems of demand and wasted energy are being solved under the impact of price increases. The ill effects of this omission are slightly mitigated by the discussion on pp. 224ff.

4. One very serious omission, it seems to me, is the problem of sludge. This goes along with the lax acceptance referred to in item 2, above. Some 600 lbs. of sludge is produced by a scrubber for each ton of high sulfur coal burned. The impact of sludge disposal on local water quality is poorly understood and surely deserved careful discussion, along with sulfur-recovery alternatives and coal beneficiation.

5. It seems to me that considerable effort should have been made to emphasize the gross over-building of power plants in the ORBES, and indeed the national, area. The overcapacity presently existing for which utility customers have to pay would seem to be excessive, and suggests that Managements of the involved utilities have not been responsive to changing conditions, and to their statutory responsibility to serve the public

6. My last specific comment is that the quality of the content of a number of sections of the Main Report would have been not only improved but also made more up-to-date had more attention been paid to the highly professional, competent and objective contributions of Mr. Fred Hauck. Indeed, had such attention been paid sufficiently for his information to issue in the Report my criticisms in the five areas above might not have been necessary.

General Comments

These comments are legitimized by the ". . . and, indeed, on any aspect of the ORBES project. . ." in the covering letter of December 17, from Drs. Stukel and Keenan, They are necessitated by the directive of the Senate Appropriations Committee when it "directed EPA to conduct a study 'comprehensive in scope, investigating the impacts from air, water, and solid residues on the natural environment and [on the] residents of the region. . .'" [Executive Summary, p. 3].

It has become more and more evident in the last three hundred years of the Industrial Revolution that to the classical three material necessities of mankind--food, shelter, and clothing--we must add energy. Of course, energy was always there, largely implicitly at first. But now the necessity is explicit.

The problems that arise because of this explicit necessity have increased with the burgeoning of technologies. One begins to see as a serious problem whether people will continue to control technology in this increasing energy demand, or technology people.

The problem should not be trivialized by treating it as a species of legal game.

> There is nothing more difficult than to become critically aware of the presuppositions of one's thought. Everything can be seen directly except the eye through which we see. Every thought can be scrutinized directly except the thought by which we scrutinize. A special effort, an effort of self-awareness, is needed: that almost impossible feat of thought recoiling upon itself--almost impossible but not quite. [E. F. Schumacher, A Guide for the Perplexed. Harper and Row, New York, 1977, p. 44.]

Nor should the problem be ignored entirely, as it seems to be in the Main Report. We need some discussion of philosophical alternatives to complement the possible scenarios. I do not propose to remedy this, as it seems to me, defect; nor would I feel entirely competent to try. At the same time I would like

to indicate the directions that such discussion might have taken.

Present thinking in this area of pollution production and control may attempt to deal with issues raised in this Report by economic theory using the concept of "unpriced values." The value called, for example, "quality of life," not having a market price, resists quantitative approaches. [For an extended discussion see John A. Sinden and Albert C. Warrell, Unpriced Values. Decisions Without Market Prices. John Wiley & Sons, New York, 1979.]

The term "pollution" may require unorthodox analysis. Pollution is what someone does not want. For this reason it is never unilateral. This fact can be the genesis of conflict or preferably of rational compromise.

For example, some of the people of my Valley of the Ohio River find sulfur oxides and particulates polluting in respect of their effects on the 'quality of life' and, more specifically in respect of their effect on health. Local physicians agree with us. But to the utility our demand for clean air is polluting since it would prevent them from the reasonably legitimate activity of getting rid of their waste products inexpensively.

A modern approach suggests that both sides should pay for their privileges: the one for getting purer air the other for using the environment their way. Negotiated prices would then presumably permit market forces to operate. Values then may take on prices. This may be called the hard-boiled, or mechanistic, or tunnel-vision approach to the environment. It ignores those values on both sides that are literally priceless.

It seems clear that overt response of people to pollution follows a probability distribution such that at any given level of a pollutant there will be a certain number of people who will be hardly affected, a number of people subclinically affected, and some who will be clearly sickened by the pollution. It may be accepted objectively that for the last of these the pollution is bad to an extent measurable in part by hospital costs and undertakers' charges. The pollution may be acceptable to the majority of people. Perhaps they have grown up all their lives in polluted air. There must be thousands of people who have never breathed pure air. The pollution is irrelevant to the first group except as it destroys clothes and finishes on cars or houses, or produces such non-health costs. That life expectancy and illness in the neighborhood of the polluter may be affected relative to the State average may not be known to, or perhaps even considered important by, the majority of citizens.

An example pertinent to this point is that of the Youngs-

town area Save Our Valley members who wish "to 'save' jobs from being lost by the closing of steel mills in the area" [p. 295].

In any event, it seems likely that the values perceived by the three groups will differ, and may even appear irreconcilable.

At the same time, the source of the pollution--let's say a power plant--will assign to its right to rid itself of its sulfur oxides and particulates a value related at least in part to the cost of scrubbers and precipitators to remove a specified percentage of the waste material.

Here, then, in a situation typical of all--certainly at least, most--pollution problems: a mix of values some of which have rational price tags; some of which are and must remain unpriced. Further, the analysis is relativistic. Strong biases are likely to be imposed.

If a just solution of any of these problems is to be reached then the protagonists: the citizens' group, the utility, and the regulatory agency must be prepared to recognize and agree on boundary conditions set by the nature of the case.

For example, is the health of the affected people overriding. It may be that some other value such as jobs may be thought overriding by the affected people, as in the Youngstown example cited above. Here health must take a secondary position.

In another example, as reported in Business Week, February 2, 1976 "Heart disease deaths per 100,000 population: Ohio, 382; Steubenville, 500.5; nearby Mingo Junction, 606.2." Bronchitis deaths at Steubenville double the average for Ohio; at Mingo Junction almost five times as many as the Ohio average. Only the ill move away from this polluted area--under the advice of physicians.

Another boundary condition is demographic. For example, there has been an out-migration of people from this area, as well as a fall in the birthrate, so it may be that job demand will continue to fall unless some artificial stimulus is applied--assuming that the people would benefit therefrom. This implies a decreased need for more generating capacity in the near future.

One important boundary condition that needs to be settled on is the issue of growth. To reject a new power plant on the ground that it is not needed is to be tagged an exponent of "no growth." The issue is so heavily loaded with emotion that it becomes a major challenge to obtain a hearing for someone who

would ask whether growth in one direction might not profitably be replaced by growth in another. For example, the mental and physical energies released by not building an unneeded plant may find profitable constructive growth in an area of imaginative, improved services and increased efficiency of the existing utility. Then, everyone profits.

This "jobs" issue is so persistent, and apparently so impressive to the unthinking listener or reader, that it seems worthwhile to recall an ERDA-financed study by the Lawrence Berkeley Laboratory which concluded that "a dollar spent on electricity produced fewer jobs than almost any other option." For example, "one million dollars spent buying electricity produced about 44 jobs. On the average, one million consumer dollars produced 80 jobs. Buying more efficient household appliances produced 96 jobs per million dollars." [Ron Lanoue, Nuclear Plants: The more they build, the more you pay, Center for Study of Responsive Law, 1976, p. 15.]

Still another boundary condition has to do with need. Because a utility asks the Public Utilities Commission for the go-ahead to plan and build another power plant does not by any means certify that it will be needed. The average citizen finds this hard to believe. However, several recent studies have exposed the tax incentives that make it highly profitable to build, and that even encourage building, more and more plants. (See, for example, Duane Chapman's Report in the ORBES series.)

If these (and there are other) boundary conditions can be agreed upon by the negotiators the source of controversy may well disappear, and with it ill-feelings and recriminations. For example, if thorough analysis shows that a plant is not needed, then there is no problem about what to do with its proposed pollution. Such an analysis by Fred Hauck [consulting engineer and President of Save The Valley] in the case of PSI has provided a paradigm case. In 1973 PSI forecast that in 1985 their peak demand would be 7120 MW. This was during their pleading for permission to build Marble Hill. Mr. Hauck, invoking the rational constraints and boundary conditions I have indicated, set their forecast 1985 need at a maximum of 4450 MW. Since then their annual forecasts have steadily declined: by 1976-7 it had been projected at around 6000 MW. The quarterly report of the end of June, 1980 estimates the 1985 need at 4650 MW! Gibson Unit #5, deferred, is yet to go on line. Thus, without Marble Hill PSI is likely to reach around 50% excess capacity by 1985.

Having agreed that a new plant is not needed, the negotiators may turn to the matter of jobs since it is desirable to replace a negative with a positive. Here it may well be possible to show that there are plenty of opportunities in service areas that can open up new job opportunities. Further, there

are industries that are practically non-polluting that can move into an area where the pollution limit has been reached, and furnish jobs. There is always the possibility of work to decrease pollution.

In the present situation in our Valley it is the citizens who suffer when environmental pollution is increased. The power company management often live at a distance. Actually, it seems that these companies are run by accountants, whether they are presidents of the company or lesser cogs in the organization. Decisions are made on even the narrowest margin of the "bottom line." I have suspected that the person who really runs the company is the person who programs the computer. He tells it what to say, and its word may too often be accepted uncritically as a pronouncement from on high.

The fact is that uncertainties are bound to enter into any judgment--which is one reason for management, of course. These may be hidden in data which appear sharp and clear because couched in numbers. But uncertainties may also hide in unrecognized variables, in human error and in human intransigence.

In earlier times a manager might rely upon his knowledge of human nature. If the bottom line yielded him less profit than he could get by screwing the clamps on his customers, he might accept it in the conviction that in the long run all would be better off. But the larger the organization, the more difficult to operate this way. For with a half-million customers a tiny margin per customer multiplies to a too-tempting number. Besides, a policy decision based on the bottom line saves decision and furnishes a firm legal base in case things go awry. Rigidity is tempting, but may be self-defeating in the long run.

I have tried in these few general comments to show the type of discussion which in my opinion would have strengthened the Main Report. At those working sessions I was able to attend I gained the impression that there was strong opposition to including this kind of philosophical-technical-boundary condition type of discussion in the Report. It seems to me that such discussion would have been of signal benefit to all sides in this complicated network of issues.

I wish to end on the positive note that this monumental effort by the Core Team and the Project Management Team deserves to bear fruit. It has given us a remarkable example of the value of openness and rational discussion in attacking many difficult and emotionally laden problems.

Tom Duncan
President
Kentucky Coal Association
Lexington, Kentucky

This comment should be prefaced with the statement that Dr. James J. Stukel and Dr. Boyd R. Keenan, project co-directors, have performed well and fairly in a difficult situation. They and a number of the Core Team, as well as many support researchers, have been willing to hear with open minds dissenting or challenging comments from advisory committee members and others.

But the fact is that, whether from the very real, if subtle, influence of the Environmental Protection Agency role, or the obvious biases of many of those involved in the ORBES project, or both, some strong prejudices permeate the Main Report. Indeed, this was almost inevitable, given the approach and nature of much of the preliminary work, unless the authors were to repudiate much of that work. I think that should have been done, although recognizing how quixotic such thoughts are in these circumstances. Without knowing the inner workings of the final drafting process, one would think only an awareness of such prejudices and a sense of fairness could lead to such statements as that found in Section 6.1 on page 141:

"MORTALITY. As discussed in section 4.6, substantial controversy exists about the quantification of deaths related to air quality. Some researchers believe that only total suspended particulates can be related firmly to increased morbidity and mortality and then only to cardiovascular disease, not to respiratory disease. Many other researchers believe, however, that a growing body of epidemiological evidence exists to support the hypothesis that the annual average exposure to sulfates--or something closely related to them--results in an increased mortality rate."

How, pray tell, can anyone grapple with a statement that "Many...believe...a growing body of epidemiological evidence exists to support the hypothesis that...exposure to sulfates---or something closely related to them---results in an increased mortality rate"? But the report seeks to use such a shaky reed as a springboard to projections of "sulfate-related deaths"

through the year 2000. These projections are sprinkled liberally throughout the report. Unfortunately, the caveat is not so well emphasized.

Indeed, the picture painted by the report might well be in much better focus if several caveats sprinkled through it were boldly set forth at the start, perhaps in a special section. For example:

(In Section 2.6, page 55) "The most troublesome methodological problem, but an unavoidable one, is the argument from ignorance....Several examples illustrate this problem in the case of ORBES....the health benefits from electricity---such as its use for life support systems and air conditioning---are not entirely clear....Nor is there information about what would occur if this electricity were not generated. In addition, whether utility expansion contributes to overall economic growth is unknown...."

(In Section 4.7, page 104, footnote 39) "The most recent data were used for each of the social measurements discussed in this section. In some cases, however, data from 1970 constituted the only available information. It is recognized that updated information could change some of the conclusions in this section."

(In Section 5, page 117) "Among the coal-dominated scenarios, environmental standards are assumed to be the same for the base case, the high electrical growth case, and the electrical exports case....The controls for land reclamation are derived from federal standards prior to the 1977 Surface Mining Control and Reclamation Act." (In view of that, it is startling to read in the same paragraph the statement that "With regard to environmental protection of air and land quality, then, the base case, the high electrical energy growth case, and the electrical exports case reflect the full implementation of current policies.")

(In Section 15.2.3, pages 288-289) "It also should be noted that the harvesting of biomass resources in logging and agriculture could lead to a higher incidence of occupational injury than the extraction of conventional fossil fuels, including coal mining."

Since a portion of our comment on the preliminary draft of the report was directed to the lack of such caveats as quoted above, this is not an attempt to belittle them. But an open-minded reading of the report will, I believe, clearly show underlying biases that simply cannot be overcome by a few token disclaimers. The biases, I believe, are primarily anti-growth and anti-coal. Although only a page-by-page analysis would make the case fully, I will try in the space allotted to point out

some reasons for that belief.

It is interesting that, at a time when the EPA, which contracted for this study, was attempting to make "acid rain" or "acid deposition" its new battle cry against coal-combustion emissions, the report would conclude (page 296):

"The single issue within the broad context of continued (and perhaps increased) reliance on coal that could produce the most conflict is the long-range and transboundary movement of air pollutants across state lines. Since ORBES began in 1976, this issue has become perhaps the most prominent one in the region. It affects employment levels in the coal-mining industry as well as industry in general. It triggers emotions that are easily translated into political controversy. Some feel that such political controversy, both intrastate and interstate, could threaten the stability of the American federal system."

That strong assertion must be taken along with the statements (in Section 12.1.2.2, page 229) that "Although the acid rain phenomenon is not understood fully, it is clear that long-range transport plays an important role"; and (page 236) that "The policy debate that will take place in the upcoming Clean Air Act review will include at least three distinct points of view. The first argument, whose proponents will include many leaders from the ORBES coal-producing states, is that present energy needs and associated national security matters are so serious that additional attention cannot be paid to questions of transboundary air pollution...." Not being equipped with such mind-reading powers, I cannot flatly refute the prediction in the latter statement. But its apparent implication that the coal industry will take such a stand is absurd at best. The coal industry has encouraged attention to the question, in fact has sought to get the EPA to leave the pulpit and go into the scientific arena on the issue, and is cooperating in an effort to get reliable data, which the EPA and others seeking precipitate action seem strangely reluctant to compile.

In the report's various treatments of deaths and injuries (for example, Table 7-3, page 173), a basically straight-line projection seems to have been made. On the other hand in Section 15.2.2, page 286, after discussing problems with wind energy conversion systems such as the occasion when an eight-ton blade was thrown 750 feet, the report casually assumes that "Ultimately these issues will be resolved by technological improvements in wind turbine systems." Throughout the report there is a tendency to assume that problems associated with coal will continue or compound, while problems associated with other energy sources or with lack of growth are discounted, ignored or acknowledged only with a disclaimer that information wasn't available.

Information obviously must be limited even in a four-million-dollar study. But, as stated earlier, the course charted at the start of the study fairly well determined the final dilemma, despite all the computer models, statistics and technical arguments generated in the meantime. A preliminary report mentioned, I believe, only in footnotes and Appendix B in the main report is a case in point. It is "David S. Walls, Dwight B. Billings, Mary P. Payne and Joe F. Childers, Jr., University of Kentucky, A Baseline Assessment of Coal Industry Structure in the Ohio River Basin Energy Study Region, Subcontract under Prime Contract EPA R805588." Its bias against the coal industry is such that the only positive factor mentioned is wages paid, while negative factors were pulled from secondary and remote sources or, on occasion, apparently invented since the cited source certainly did not reflect the same picture. But the point is not just the unrealiability of the preliminary report, it is the position in which it places the authors of the main report---they are left with practically nothing good to say about the coal industry except in terms of jobs. And that seems generally to be placed in the context of the danger of creating "boom town" effects. It is interesting that one positive statement on employment comes in the context of using scrubbers (Section 8.4, page 186): "The slightly higher labor demand under the strict control case as compared to the base case is interesting in light of the dispute over the use of scrubbers. Such higher employment benefits, plus the fact that the high-sulfur coals in the ORBES region would be more competitive and keep more miners employed, are a tradeoff with the costs of building such systems." But what is really puzzling to the non-academic mind is how the question of jobs relates to the flat statement regarding coal-dominated scenarios that (Section 5, page 116) "Also common to all the scenarios is the assumed regional economic growth rate: an annual average rate of 2.47 percent between 1974 and 2000." If, in fact, that is saying that none of the various scenarios would change economic growth, surely something is missing; and if it is saying that such mundane matters were of no concern or not enough concern to warrant pursuing, than I say the four million dollars for the study went in the wrong direction. But, on that, I suppose I'm just being repetitious.

The biased approach comes through in little ways, too. In Section 3, pages 7 and 8, we find, "In general, the reclamation of surface-mined land for permanent land use tends to be a slow process. Data are available for only a quarter of the region's 1.6 million affected acres. These data show that this portion has been affected for 10 years and has not yet been fully reclaimed." Unless "these data" came from lists of abandoned lands or those with bonding problems, they are a bunch of junk. And, if better information wasn't sought, this is again the case of ORBES' taking the convenient route to disparage the coal industry.

The fact is that all too frequently negative data seemed perfectly acceptable, no matter how fragmentary, while great efforts were made in the other direction, such as the projections of crop losses because of emissions, certainly on grounds only slightly firmer than the "sulfate-related deaths." And, just as with mortality projections, there is no attempt to put a value on losses that would occur if the electricity were not generated and available. In this connection, one might note that the Associated Press in an October 16, 1980, story said that the National Oceanic and Atmospheric Administration reported that "The final toll from this summer's heat wave is 1,265 deaths....Most of those who died from the heat were either elderly or poor and lived in homes or apartments that were not air-conditioned, said the agency." It also said that "electrical energy use was 5.5 percent above normal, a record." Certainly this information came late for use by ORBES. But after watching a good bit of the ORBES activity, one could have some questions whether such pedestrian figures as deaths---or production losses---linked to the lack of electricity, whether because of costs or capacity, somehow don't have the attraction for computer-equipped, EPA-funded researchers that they find in projecting deaths, injuries, illnesses and losses "caused" by familiar targets like the coal and electric utility industries.

One question that perhaps would be answered in the preliminary research report, still could use some treatment in the main report. It involves the statement (in Section 14.2, page 259) that "Under the natural gas substitution case, total revenues collected from consumers between 1976 and 2000 would be lower (by about 26 percent) than the total revenues collected under the base case between the same years." The question is what consideration, if any, was given to partial and/or full decontrol of natural gas prices at the wellhead. Developments on that line could make these calculations wrong, not just shaky.

With all these questions and criticisms, it would be unfair not to point out specifically one finding of some comfort to the coal industry (in Section 15.1, page 275): "One key finding is that, under the current fiscal and regulatory schemes prevalent in the ORBES region, coal-fired units have a slight cost advantage over nuclear-fueled units. Perhaps even more significant for future energy policy and development is another key finding: without present federal tax and other fiscal policies that favor capital-intensive production (including the nuclear industry), the cost advantage of coal-fired over nuclear-fueled generation would be substantially greater...."

But such crumbs are precious few. The main report, built on the unsound foundation of "studies" involving too much bias and over-reaching, cannot stand, despite ameliorating language sprinkled through it in an apparent attempt to salvage a semblance of objectivity and reliability.

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These comments on the Ohio River Basin Energy Study (ORBES): MAIN Report have been prepared in response to the project office invitation. Prior to presenting comments, we want to point out that our Company being represented on the ORBES Advisory Committee is not to be interpreted that we agree with methods used or the results indicated in the report. Further, we find several aspects of the project that make the objectivity of the results of the ORBES effort questionable. These aspects will be described in our comments.

Institutional Considerations

It is not reasonable that comparative coal and nuclear costs should be discussed in this section of the report. A coal versus nuclear comparison does not appear to be in the directive mandate from Congress. The discussion of the comparative economics shows a bias on the part of the authors and editors. This analysis was performed by an individual from outside the ORBES region who is known to have a definite anti-nuclear bias. The region is rich with nuclear expertise and has many operating and soon-to-be-operating nuclear units. The comparative analysis considers the Southern Indiana area of the region. Southern Indiana currently has no operating nuclear units. Yet, this area is identified as being "typical" of the region.

The basic argument in the nuclear versus coal comparison centered on taxes and tax subsidy provisions. These provisions were created by legislation to help stimulate economic development. What is not presented is the total impact on income and outflow to every customer if their provisions are not in place. The basic assumptions and methodologies described in the support research are questionable and without sufficient documentation within the referenced report to support the conclusions. For example, the analysis compared coal and nuclear units installed in different time periods, thus reflecting a lower installed cost for the earlier installed coal plant with resulting lower tax subsidies. Also, the widely differing construction periods between coal and nuclear installations result in benefits to the coal alternative.

Fuel Substitution and Conservation Emphasis Scenarios

The fuel substitution and conservation emphasis scenarios are compared with one another. The only common factor in the comparison is the economic growth rate. We question whether or not there may be other assumption(s)

that may also be controlling the model and whether or not other growth rates are valid for a proper comparison between the scenarios.

We also question why the natural gas substitution scenario is the only scenario where consumer costs are calculated. By not presenting the consumer cost for all of the scenarios the authors show a lack of thoroughness and create the impression of bias.

Of particular concern is the calculation of consumer costs for the natural gas scenario. Not defined is whether the total revenue impact is calculated for all areas of the ORBES economy or only for the electric utility industry. Thus, the costs to other industries and the final impact to the consumer may not be properly reflected. It is also questionable to imply that large quantities of natural gas will be available in the future for the generation of electricity.

General Concerns

An overall direct concern in the Main Report is the manner in which the authors and editors utilize some of the conclusions of the support research efforts. Throughout the Main Report conclusions are presented as if they are undisputed facts rather than presenting the results by saying "support studies indicate". Misleading to the reader is the use of words like "substantially," without being quantitative, and "assuming," when subsequent conclusions and results are stated without reminding the reader that they are based on assumptions. The authors also point out to the reader that certain areas are controversial. The authors then frequently only present results and findings only from one side of the controversy.

We contend that the USEPA failed to maintain objectivity or adequate control in managing the subject study. USEPA paid for a large percentage of the Teknekron work on air modelling outside the grant arrangement for the ORBES project. The Teknekron work was supplied to ORBES and provides the basis for the air quality analyses promulgated in the ORBES final report. The Teknekron models and theories have not been subjected to peer review to any degree. To the degree that the Teknekron work has been reviewed, it has been subject to question. Whether the Teknekron work is valid or not, and we do not believe that it is, it was not objective of the USEPA to introduce this material into the ORBES effort as though it were independent research.

Many of the ORBES project conclusions have been released to the press before the report was finalized and subjected to peer review. See the UPI article appearing in the February 4, 1981 Washington Post as an example. USEPA should not have allowed their grant recipients to perform in such an irresponsible manner. Leaking such potentially inflammatory, unreviewed, and draft material to the press certainly strikes of questionable objectivity and confirms our belief that the scientific bases of the conclusions of the report are so weak that flamboyant headlines are required to gain attention.

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The Ohio River Basin Energy Study (ORBES) was undertaken to describe the effects of various energy futures in the Ohio Valley. The final report will be of interest to all citizens and policy makers concerned about the social, economic, and environmental aspects of energy development, particularly for coal-fired electric power generation. The study was commissioned by the U.S. Senate in response to citizen concern about utility plans to construct additional electric generating units on the Ohio River. The work was funded by grants from the U.S. Environmental Protection Agency. The research was carried out by over 100 university faculty members at 8 institutions, including the University of Kentucky and the University of Louisville.

Encouragingly, under a number of different energy futures (including business-as-usual, strict environmental, strict conservation, and high electricity growth) the environmental effects of the utility industry in the year 2000 will be substantially less than those in 1976 - even with significant growth in electricity production. This is most notable in the decreases projected for utility sulfur dioxide and particulate emissions, which should result in fewer adverse effects on air quality. In many cases, only slightly different impacts were predicted for scenarios based on strict environmental controls or strict conservation measures. This is partly due to the fact that environmental controls on new plants are already quite strict and the replacement of older plants with newer, better controlled plants leads to lower overall environmental impacts.

The positive nature of these findings was obscured by the emphasis the report placed on cumulative (thus magnified) differences among the scenarios. Thus, for example, nowhere in the report is it pointed out that in all scenarios - except where environmental laws are ignored - the deaths alleged to result from air pollution will be significantly lower in the year 2000 than in 1976.

Possibly the major criticism of the report, however, is the lack of distinction made for the readers between findings which are highly certain and reasonable and findings which are highly speculative, controversial, and admittedly imprecise. The latter would apply particularly to conclusions reached concerning sulfate-related mortality, ozone-related crop damage, and "boom-town" social conditions. The authors pointed out some of the shortcomings of their data, but this did not restrict their conclusions. These problem areas are discussed in some detail below.

Sulfate-related Mortality - Atmospheric sulfate is formed from sulfur dioxide, which is released into the air during the combustion of fuels, the largest source being oil and coal burning power plants. The report concludes that "a growing body of evidence supports the hypothesis that the annual average exposure to sulfates - or something closely related to them - results in an increased mortality rate." Furthermore, the report assumes that the actual mortality rates can be calculated from known or projected sulfate levels throughout the region. Such calculations indicated that exposure to this single air pollutant was responsible for up to 11% of all the deaths which occurred in the ORBES region in 1975, which would make this far and away the greatest health concern of any aspect associated with energy generation. By comparison, the report suggests that the mortality associated with sulfate exposure resulting from a coal-fired power plant is 100 to 1,000 times greater than all the possible deaths associated with a nuclear power plant of the same size. Based on this difference, it must be considered surprising that the study did not recommend a rapid shift from coal to nuclear electric power generation.

One might ask, how reasonable is it to assume that large numbers of the general public are dying each year from sulfate exposure? Not very. All of the numerous scientific panels that have examined the available evidence have concluded that there simply is no justifiable basis for any sulfate standard or for any claim that sulfate levels are, in fact, related to mortality. These include reviews by the National Academy of Sciences, the scientific review panel for the U.S. Environmental Protection Agency, the National Institute for Environmental Health Sciences, and the World Health Organization, to name a few.

Claims of sulfate-related mortality have been based solely on statistical analyses and the above groups, as well as many others, have found this work to be seriously flawed and the conclusions unwarranted. Statistical analysis is full of pitfalls and correlations cannot be viewed as cause-and-effect relationships. The studies have been characterized by poor data, uncontrolled variables, and internal inconsistencies; for example, some of the correlations suggest that pollution is good for people. In spite of this, such work continues to be used by some people to "estimate" the effects of sulfate exposure on mortality. The uncertainty of the estimates is acknowledged by setting the bottom limit on mortality at zero deaths. Thus, we see in the ORBES report a mortality estimate ranging from 0 to 489,000. The next step was to determine a "best estimate", which was one-third of the maximum of 163,000 in the above example. At this point the zero death possibility was dropped from the discussion. The fact is, there is no justification to assume that 163,000 is more reasonable number than zero.

The limitations of such analyses may have been apparent to the authors of the ORBES report, but they certainly are not apparent to many readers and reviewers of the report. The following quotation from the Louisville Courier-Journal (February 2, 1981) is not untypical:

> "Under all five coal scenarios, the impact on the region's health would worsen. . . . .the report estimates that 163,000

people could die between 1975 and 2000 because of sulfate-related diseases. If stricter environmental rules were adopted, that number could be reduced to 109,000."

Such an assertion is absurd and surely not intended by the ORBES authors. How could one attribute any significance to a difference of 54,000 between two numbers when one number could be 0 to 489,000 and the other 0 to 327,000? One could not.

This lack of objective and responsible scientific reporting detracts from an otherwise credible review of the health effects related to coal use. It is certain that many unwarranted and irresponsible conclusions will be drawn from this report. It is unfortunate that the report did not rely on the conclusion reached by Dr. Edward Radford in a support study carried out for ORBES. Dr. Radford, an environmental epidemiologist at the University of Pittsburg, reported that the effects attributed to acid derivatives of sulfur dioxide (sulfates) were unreliable and that all air pollution mortality together is only a small fraction of that suggested by the statistical studies, concerning which, Dr. Radford wrote:

> "Allegations of much more significant health impacts from urban air pollution, which are based on multiple regression techniques, simply display the clear inadequacy of this method for evaluating health effects in complex social groups where major confounding variables such as cigarette smoking cannot be taken into account." - Impacts on Human Health from the Coal and Nuclear Fuel Cycles and Other Technologies Associated with Electric Power Generation and Transmission, prepared for Ohio River Basin Energy Study (ORBES), July, 1980.

To return for a moment to the initial statement that "a growing body of evidence" supports the theory of sulfate-related deaths, it should be pointed out that there is little - if any - new evidence, only new studies which continue to count tremendous numbers of sulfate-related disease deaths (although none are known in the medical profession) and which continue to document their results by referring to the same earlier, discredited work.

Crop Damage - The ORBES report concludes that current levels of ozone and sulfur dioxide throughout most of the region are causing significant crop losses, even at levels well below the air quality standards. In 1976 the crop losses in the ORBES region attributed to the utility contribution to ozone were estimated to be 14% of the soybean crop, 8% of the corn crop, and 6% of the wheat crop. Although power plants do not emit ozone, they were estimated to be responsible for 40% of the atmospheric ozone levels indirectly, through emissions of nitrogen oxides.

The predicted losses were said to be occurring in the absence of any visible damage to the plants. Since small losses in the absence of visible injury are, for practical purposes, impossible to prove or disprove, this is and has been a subject of some controversy. For the many farmers who will read or read of this report, the implication is that a major study has provided new evidence that air pollution from power plants is causing significant

crop losses amounting to several hundred million dollars per year in the ORBES region. Nothing could be further from the truth. The Institute for Ecology, which provided the study, did not obtain any new evidence at all nor did they carry out any experiments on crops. As with the mortality studies referred to above, the authors merely reviewed the available literature and withdrew selective data bearing on their hypothesis.

The most questionable aspect of this study lies in the derivation of equations for predicting crop damage which are based on the assumption that crop losses are proportional to cumulative ozone exposure. In other words, exposure to high ozone levels for a short period is assumed to be equivalent to exposure to low levels for a long period. Such an assumption can not be supported by the data cited in the report. In fact, in the author's data for soybeans, at equal cumulative exposures, a high concentration of ozone (0.07 ppm or parts per million) gives much higher damage than a low concentration (0.02 ppm). Thus, it is seen that cumulative exposure overestimates the damage at low concentrations - by nearly 3 times in this case. The yield data is so poor that one cannot always find a relationship between the duration of exposure and crop loss: exposure to 0.1 ppm ozone for 258, 552, and 798 hours gives reductions of 66%, 55%, and 66% in plant fresh weight, respectively. Data such as this from several studies were combined and the authors deduced a "statistically significant" damage function by a best fit of the data. No best fit was obvious; thus a regression analysis was applied. Since the fit was still not good, further data were arbitrarily thrown out to make the function "more statistically significant". In truth, there is nothing significant about the damage function except the statistics.

The most surprising finding after all of this analysis was not mentioned by the authors: that is, that crop losses in 1976 due to background levels of ozone (0.03 ppm, the level found in pristine, unpolluted areas) exceed those due to the ozone levels which were attributed to utilities.

The next area of certain controversy, but uncertain accuracy is the large proportion of ozone that was attributed to utility nitrogen oxide emissions. There is no evidence that ground level ozone in rural areas is largely due to power plant emissions. Researchers are working on methods to determine ozone concentrations from nitrogen oxide and hydrocarbon emissions, but none are presently available. Levels of hydrocarbons were not considered in the report to be important determinants of ozone levels (power plants do not emit significant amounts of hydrocarbons) - an assumption contrary to present scientific opinion in this area. The most significant sources of ground level ozone precursors are known to be urban sources of hydrocarbons and nitrogen oxides (predominately mobile sources). The authors speculated that urban nitrogen oxides might be scavenged by plants - this speculation is unsupportable. The authors judged that 40% of the regional ozone levels in 1976 were due to utility nitrogen oxide emissions. This figure is based on a long list of assumptions rather than calculations. Taken all together the entire argument for ozone-related crop losses is a "house of cards", which can be shaken to the ground by the slightest breeze.

Boom-Town Social Conditions - The major social consequence of an expanded utility industry in the ORBES region would be due to the increased production

of coal and the increased employment of coal miners. The study predicts "boom-town" effects for at least 79 to 88 of the 152 ORBES counties with coal mining. This conclusion is clearly erroneous and based on a parameters which is not related to community growth problems - namely, a growth of over 200% in coal mining employment between 1976 and 2000. In other words, if a county had 100 miners in 1976 and 300 in the year 2000, boom-town conditions would be predicted. Coal production was predicted to nearly double in the ORBES region by the year 2000 - a growth rate that results in a 2.3% annual increase in coal production. Coal production in Kentucky increased at an annual rate of 5.1% between 1965 - 1975 (or over twice the rate predicted by ORBES). A number of Kentucky counties grew at even greater rates during that decade, with no evidence of any "boom-towns".

The ORBES project was an experiment - an experiment which produced some worthwhile results. The possibility of continued growth of the electric power industry in the ORBES region needed to be examined. The ORBES team did a credible job of describing a number of alternative energy futures for the region. Assessment of future impacts, always difficult to judge, was handled with considerable objectivity and with appropriate scientific expertise for the most part. It is important to point out, however, that several major conclusions reached in the report can not be substantiated.

1. There is no evidence that exposure to air pollution in the ORBES region is responsible for large numbers of deaths each year.

2. There is no evidence that widespread crop losses are occurring in the ORBES region because of exposure to ozone derived from utility emissions.

3. Future growth in coal production at less than past rates is not likely to result in any boom-town conditions in the ORBES region.

In conclusion, the ORBES report, while providing many useful findings, will actually further the controversy in the area of air pollution effects on health and crops. While providing little in the way of new analysis and no new data or evidence bearing on these subjects, the report will carry with it a certain authority based on its Congressional mandate, the prestige of some of the ORBES team members, and its $4 million price tag.

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FUNDAMENTALS THAT THE ORBES STUDY SEEMED TO HAVE MISSED

- that United States electrical generation reserves are now at an all-time high of at least 43% (see "Electrical World", September 15, 1979).

- that ECAR electrical generation reserves are also at an all-time high of 45% (see DOE's "Electrical Power Monthly", August 1980).

  If present trends continue, both of the above figures are certain to surpass 50% well before 1985!

  Maintenance of these excessive reserves (greater than 20%) is costing U.S. consumers a great deal of money. Our own figures indicate a money penalty of more than $12 billion annually, or at least 12% of every consumer's bill!

  Duane Chapman's ORBES study has outlined in meticulous detail, the money incentives that "persuade" both the utility and its executives that excessive growth is good for all. Chapman's "Conflict of Interest" conclusions should be widely publicized!

- that electric energy, even in the excessive amounts being used, constitutes but 12% of all energy reaching the point of of use. Nuclear generated electricity is but 11% of this figure. Thus, nuclear energy is presently filling 12% times 11%, or only 1.3% of our total energy needs! Even in 1990, when nuclear installations might conceivably grow to 110 facilities, the atom will still supply less than 3% of all energy needs! The stress on nuclear energy seems to be much ado about very little.

- that the real-dollar cost of electricity seems to be increasing more than 5% annually. This cost increase in itself is a powerful suppressant to the growth of electricity use. Further, when the Public Utility Regulatory Act's (PURPA) time-of-use pricing is finally put into use, peak growth could be stifled for a decade or more. Both "Ripple Control" and "Radio Control" are currently being used effectively in experimental areas to regulate daily and seasonal peaks.

I feel that the ORBES study, while it was most carefully planned and carried out, lacked the boldness needed to be truly effective. Only Cornell's Duane Chapman had the audacity to point out the fundamental weaknesses of allowing the electric utility industry to act as "the expert" in deciding its own growth policy.

Fred Hauck

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ORBES represents an excellent start toward developing the information needed to make rational energy-related policy decisions in the Ohio River Basin. The predictions presented in ORBES appear to be based on reasonable interpretations of the best information currently available. The major limitation of the ORBES report, in my opinion, is that some important factors were not developed for several of the scenarios studied. Because of this, a comprehensive comparison of the various energy and environmental policy alternatives cannot be made.

The most complete comparison which can be developed from the ORBES data is that between several alternative approaches for dealing with the controversial issue of sulfur dioxide emission limits. A comparison of the most significant impacts of these alternatives indicates the following:

1. Converting to Least Emissions Dispatching. At an increased cost of 1% to electricity consumers, annual sulfate is reduced 2.1 micrograms/m^3, resulting in about 20,000 fewer premature deaths.

2. Tightening Air Pollution Standards. At an increased cost of 1.5% to electricity consumers, annual sulfate is reduced 1.6 micrograms/m^3, resulting in 54,000 fewer premature deaths.

3. Reducing Power Plant Life by Ten Years. At an increased cost of 3% to electricity consumers, annual sulfate is reduced 2.1 micrograms/m^3, resulting in about 20,000 fewer premature deaths.

4. Using More Natural Gas. At a savings to electricity consumers of .2%, annual sulfate is reduced .3 micrograms/m^3, resulting in 34,000 fewer premature deaths.

5. Relaxing Air Pollution Standards. At a savings to electricity consumers of 4%, annual sulfate is increased 2.7 micrograms/m^3, resulting in 55,000 more premature deaths.

Assuming that the majority of consumers are willing to pay a little more for electricity in exchange for air quality that reduces health risk, the most attractive option would appear to be a conversion of power plant networks to a least emissions dispatching system. Additional air pollution relief could be provided by converting to natural gas where practical, and also having certain power plants either shut down ten years early or install

air pollution controls. The selection of those plants should be based on their relative economic efficiency for reducing air pollution emissions.

Expansion of this ORBES data base would allow for a much more complete analysis of air pollution control alternatives. For example, the following questions could then be examined in great detail:

- Should future power plant siting in the region be concentrated or dispersed?
- What are the incremental costs and benefits of relaxing or tightening air quality standards?
- What is the most efficient SO_2 control strategy utilizing all available considerations, including low sulfur coal, cleaned coal, flue gas desulfurization, least emissions dispatching, reduction of power plant life, energy conservation, use of more natural gas, solar energy, new plant siting, and stack height.

An unfortunate aspect of ORBES is that only a very incomplete analysis was performed on several scenarios. It would have been very helpful to develop information on at least sulfate concentrations, air pollution mortality, costs to the consumer, employment, and crop damage for all scenarios. This would allow much better answers to questions such as the following:

- Is it in the ORBES region's interest to export power?
- Is investment in energy conservation or alternative energy sources worthwhile?
- What are the implications of increased energy growth?

Another limitation of ORBES is that data for a number of important impacts was not developed at all. This results in a very incomplete picture of some scenarios, allowing for misleading comparisons. The best example of this is for nuclear power where the critical impacts of the nuclear fuel cycle, normal radioactive plant emissions, and the risks of a nuclear accident are not quantified. For the conservation, alternative energy, and natural gas, the total employment impacts and total cost to consumer could have been presented. ORBES only looked at costs and employment attributed to the centralized generation of electricity. Two other important, but overlooked, factors in ORBES are acid rain and morbidity caused by air pollution.

One last issue not analyzed by ORBES is alternatives for managing peak electrical demands. Peak load pricing, pumped storage projects, and new power plants, are all under consideration in the region. ORBES could have been very helpful in clearing up some of the controversy surrounding this issue.

Despite the limitations of the final report, the ORBES approach appears to be the best hope for developing sound energy and environmental protection policies. ORBES shows that our current plant-by-plant approach for deter-

mining these policies is totally inadequate. A much more sophisticated, regional approach toward planning is clearly called for when making energy and environmental decisions of regional impact. Unfortunately, political realities may dictate that such a rational decision-making approach to these complex issues will not be developed.

In conclusion, I would state that the ORBES approach toward our energy problems is helpful and does work. A major follow-up study is now needed to further develop and refine the data needed to make rational energy and environmental policy decisions in the Ohio River Basin.

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Comments on ORBES MAIN REPORT

1. The ORBES main report mentions the impacts on land from coal mining and electrical transmission lines, but does not mention large land requirements of solid waste from fly ash and from air pollution control devices unless it considers these to be a part of power generation land requirements. This couldn't be determined from the report. There should be a notation that there are some significant land requirements from waste disposal.

2. The impact discussions in the report are too general and not site specific.

3. The report emphasized heavily on coal energy and the impacts on various scenarios of the coal energy production have been thoroughly discussed. However, the impacts on the other alternative energy are not adequately addressed.

4. Synfuel plant development is a coal related development and is a very important energy development in the Ohio River Basin. However, it was only briefly mentioned on page 237 in the report. We feel that more information and the impacts discussion concerning the synfuel plant development should be addressed in the report.

5. The report emphasized the discussions of air quality and water quality impacts. However, very little water quantity impacts were discussed. For example, the quantity problem in the Monongahela River as a result of future energy development was totally neglected. We feel that the report should be further revised to describe problems and potentials of energy development more specifically, and the impact discussions, especially on the water quantity aspect should be addressed more adequately.

6. From an Air Quality standpoint, the study is particularly significant to Pennsylvania in that it conclusively documents the existence of long-range interstate transport and demonstrates the significance of utility SO_2 emissions on ambient SO_2 air quality, on total suspended particulate concentrations (through sulfate formation) and on acid precipitation. Because we must burn more coal in the future and not less if we are to solve this country's current energy-petroleum crisis, recognition of the importance of long-range transport and transformation of SO_2 is a key to assuring appropriate energy development in the ORBES area.

7. One significant problem does exist with the air quality analysis as presented. The implication is that we are following the base case scenario. This was a valid assumption in 1976 when the study was originated. Since then, however, a shift in EPA's attitude has promoted maximizing SO_2 emissions while ignoring long-distance transport. This shift has been justified by the source by source control method outlined in the Clean Air Act for existing sources which tends to overlook the cumulative effect of pollutant emissions. This shift has caused massive relaxations of SO_2 emission limitations throughout the ORBES area as cited in "Petition of the State of New York for Disapproval of Proposed Revision of State Implementation Plan and Comments." Thus, we are in fact following the non-compliance case more closely than the base case. We recommend that the 1980 SO_2 emissions for the ORBES area be added to the report graphics to verify this assumption including a statement as to the significance of this assumption.

The main report states "the immediate benefits of SIP compliance are clear: utility SO_2 emissions could be reduced by one-third by 1985." It also indicates that in the year 2000 SIP units will dominate in emissions, but will represent only 28% of the electric generation and will emit five to six times more sulfur dioxide than those units regulated by new source performance standards. This indicates that following the non-compliance scenario will have a significant impact and the readers should be aware of the direction or a scenario that the ORBES area is following.

8. One economic consideration which has not been adequately considered in the report is the problem of inequity of emission limitations throughout the ORBES area and their impact on a state's air quality and their economic development. This is of greatest significance to Pennsylvania as the "last downwind" state in the study area. You may wish to refer to a recent draft study entitled "Economic Consequences of Long-Range Transport and, Additional Costs of Sulfur Dioxide Control in Southwestern Pennsylvania Due to Long-Range Transport."

9. The report states that ORBES Region Power Generating Units produce about 80 percent of the regional sulfur dioxide emissions and 47 percent of the regional nitrogen oxide emissions. The report further states that long-range transport of these acid rain precursors is an important factor, with effects from emissions in the lower region appearing in the upper region -- Eastern Ohio, Pennsylvania, and West Virginia. Long-range transport from this region may also affect southeastern Canada. With the current awareness of the acid percipitation problem and the potential for long-term environmental damage, the emissions caused by increases in power generating capacity or coal conversions must also be taken into consideration. The report does this by considering various scenarios. Necessary controls should be placed on both existing and new power generating plants to prevent a worsening of the acid precipitation problem.

10. Finally, it is critical that this report be regarded only as a first step identifying the existence of the problem. As cited in the main report, the greatest danger for the ORBES area is inaction and lack of a coherent method for decision making. The need for interstate air resource management is a necessity if the ORBES area is to have a sound economic/environmental future.

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Inexcusably, there is no way in which the ORBES study can be viewed as an action report. It is, in fact, no more than a magnificent example of statistics gathering, dedicated to and destined to be used thoroughly by the utility industry. It will serve only to confuse our so-called political decision makers who will be forced to react only to the demands made by each one's specific constituency.

It is deplorable that this study, costing in excess of $4 million, was not designed to produce a recommendation on what should be done. The information was gathered by faculty members of some of our greatest universities in an outstanding and imposing example of in-depth and critical research. Who, better than this group of over 100 investigators could be in a position to make a sound recommendation for the future?

The writer, together with many other citizens, complained years ago to the Environmental Protection Agency about the threat of deteriorating air quality in the Ohio Valley. After months of hemming and hawing, EPA finally decided to "look into the matter" and soon the ORBES study was underway. It is now revealed officially that an increasing number of deaths will occur by 1990 under certain scenarios studied. It is also revealed officially that there is a cascading effect up the valley resulting in a "trans-boundary transport" of various pollutants. These are only two of the many terrifying facts that have been investigated and verified in the study. With such a commanding array of evidence that there is "trouble in the Valley", it is almost beyond belief that a specific set of far reaching recommendations in setting limitations on numbers of plants, in setting limitations on emissions, siting and political arrangements should not have been required before allowing this group of investigators to disband.

The report casually mentions that "It is not our responsibility (the ORBES researchers) to recommend which path should be followed". It is only their resposibility to "warn that inaction could result in economic stagnation and accompanying social problems capable of draining much-needed vitality from the region and from the nation at large". We submit that these

two statements truly point out the most glaring deficiency of the entire report. All the investigators were aware of each piece of research developed, and each piece was discussed. Whether the information was scientifically, socially or politically oriented, it was thoroughly discussed in open sessions. How could they be denied the authority and the responsibility to make carefully authenticated recommendations to solve an admittedly severe problem?

As a member of the advisory group, I was pleased by the manner in which research reports were critically appraised before acceptance by the group. I am not pleased by the action of EPA in stifling open recommendations for corrective and preventive action. To be sure , they would not be binding on any political entity but they would constitute an exposition on collective action which is so desperately needed. But what do the "decision makers" have now? Nothing but a host of truly valuable but disconnected statistics with no starting point spelled out for an attack on a devastating problem.

Ralph Madison

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Before beginning my substantive comments on the final report of the Ohio River Basin Energy Study (ORBES), I would like to congratulate the Management and Core Teams, Support Researchers, and Project Office Staff on the quality and objectivity of the report. An overwhelming amount of data and analysis have been pulled together into an extremely readable document. Moreover, the research has been summarized in a manner that highlights the major points of view on the issues surrounding energy development in the Ohio River region without emphasizing any one perspective over the others.

The ORBES final report is relevant to the interests of the Office of Technology Assessment (OTA)--and of the Congress as a whole--in several respects. These include the ORBES experience in technology assessment as well as the study's contribution to discussion of the issues related to energy development and the environment--issues addressed in previous and ongoing OTA studies and likely to be the focus of lively debate in the 97th Congress.

As one of the few formal institutional mechanisms for conducting policy-oriented technology assessments, OTA has a continuing interest in the approach to and progress of such assessments. In this context, I have been interested in the ORBES methodology for dealing with regional-based issues and in the general management of such a broad study in the face of widespread public interest. Of particular interest have been the analytical methods used to disaggregate national- or state-based data to the regional level; the problems involved in coordinating the activities of a large number of geographically dispersed participants representing a wide array of disciplines and interests; and the conduct of such a study under constant scrutiny from the parties-at-interest and the media. These aspects of ORBES contribute significantly to the body of experience with policy-oriented technology assessments.

Moreover, many of the issues addressed by ORBES are of interest to OTA and the Congress as a whole, especially those concerning the relationships among air quality, the economy, and energy development, and the implications of those relationships for the utility industry and for the upcoming Congressional review of the Clean Air Act, the synthetic fuels program, and other legislative proposals related to energy development and the

environment. I would like to briefly review some of the ORBES findings with respect to these issues in the context of previous and ongoing OTA studies and the agenda of the 97th Congress.

Among the most significant ORBES findings are those on air quality. The ORBES analysis has demonstrated the sensitivity of air quality--whether measured as emissions or as ambient concentrations--to such factors as state commitment to SIP compliance and enforcement; utility plant siting and operating procedures; and financial considerations. These, in turn, have been related in the ORBES analysis to consumer costs, agricultural productivity, and public health. In terms of previous OTA studies, many of these findings are directly in agreement with the conclusions of The Direct Use Of Coal (OTA-E-86, April, 1979). For example, both studies addressed the human health effects of pollutant loadings from coal combustion. Although researchers in both studies felt that substantial controversy surrounds the quantification of human health effects, they also felt that the evidence does support the hypothesis that human exposure to some pollutants (particularly TSP, SO_x, NO_x, and their transformation products such as sulfates and nitrates) contributes to an increase in morbidity and mortality. The Clean Air Act, which mandates standards for TSP, SO_x, and NO_x, is to be reviewed by the 97th Congress. Although much additional research must be done before the effects of air pollution on human health can be determined conclusively, the ORBES findings become especially significant in light of widespread pressure by special interest groups to relax the Clean Air Act standards.

The ORBES research on air quality also is relevant to an ongoing OTA study of acid precipitation. In several respects, most notably the modeling of long-range transport of air pollutants and the calculation of economic damage functions from air pollution, the ORBES work is among the most comprehensive to date. Although much basic research remains to be done in the chemistry of pollutant transformations and in the effects of pollutants and their transformation products on terrestrial and aquatic systems, the ORBES results provide valuable background information for OTA's examination of air pollution and acid precipitation. And, as with the ORBES findings on the human health effects of the pollutants from coal combustion, the study's research on long-range transport and on the economic impacts of air pollution becomes increasingly important in light of Congressional review of the Clean Air Act and the proposals for regulating trans-boundary air pollution and currently unregulated air pollutants such as sulfates.

The ORBES findings on employment-related impacts also are in accord with those of OTA's study The Direct Use Of Coal. That is, that although the resulting stress on community services is not so pronounced in the ORBES region as it is in the Rocky Mountain areas, it still is potentially severe. The difference is that in the West such services have been adequate but break down when confronted with rapid population growth, while in many of the coal-mining regions of the East such services have historically been below par and can only be strained further by population growth. These findings should contribute to informed debate on legislative and other initiatives to encourage the greater use of domestic coal (especially for the replacement of oil and gas in electric generation and for the production of synthetic fuels) as well as those to reduce the level of Federal support for community services.

The ORBES report also highlights a number of issues related to utility operations that are relevant to an ongoing OTA study that looks at possible future paths for the utility industry in the context of cogeneration and other on-site electric generating technologies. Of particular interest to OTA here are the financial and economic implications to utilities of various strategies for pollution control, including capital investment in control technology, least-emission versus least-cost dispatching, plant retirement schedules, and the alternatives to central station coal-fired electric generation. Again, in a time when Congress is likely to be asked to deal with inflation, the costs of environmental protection, and the future regulation or deregulation of electric generation, these issues are very timely.

Finally, I would like to comment on the policy-oriented aspects of the ORBES assessment. One of the most difficult tasks for the ORBES researchers was to suggest mitigation strategies for the adverse impacts posed by their energy development scenarios. In part, this task was difficult because of the breadth of the issues they addressed. Thus, a mitigation strategy for air pollution also had to deal with any resulting economic, social, institutional and other effects. For the most part, however, the task of devising mitigation strategies was difficult because of the wide range of parties-at-interest (e.g., utilities and utility organizations, labor, state and local governments, consumers, industry, environmentalists) who were invited to participate in the ORBES project. Although the range of participants made debate difficult at times, it also contributed a richness to the study that made it possible for ORBES to investigate policy options that transcend traditional jurisdictional boundaries, such as those of state and local governments or utility service areas. This added richness also enabled the ORBES researchers to examine strategies outside the conventional policy realms of legislation and regulation. In this light, I found strategies for least-emission dispatching and for regional coordination among utilities and governments to be especially intriguing, and ones that are likely to stimulate and enliven the debate on regional development for some time.

Jack Schramm	Rebecca W. Hanmer	Valdas Adamkus, Acting
Regional Administrator	Regional Administrator	Regional Administrator
U.S. EPA, Region III	U.S. EPA, Region IV	U.S. EPA, Region V
Philadelphia, PA.	Atlanta, Georgia	Chicago, Illinois

These comments on the Ohio River Basin Energy Study (ORBES) Main Report are compiled by the EPA Regional Administrators from Regions III (Jack Schramm), IV (Rebecca W. Hanmer) and V (Valdas Adamkus, Acting). They reflect a multimedia review from Regions III and IV and an air review from Region V. As Regional Administrators, we would like to express our appreciation to the Senate for the foresight to commission this study. We also commend Professors Stukel and Keenan for their capable leadership which inspired the diligent efforts by the Core Team in the development of this comprehensive study. This report will be an invaluable tool for Congress and the EPA because it provides a comprehensive review of factors which should be considered in the selection of energy and environmental options for the future of the Ohio River Valley.

We acknowledge that in any study there are necessarily tradeoffs between the number of issues examined and the detail with which each is examined. We sympathize with the fact that because the ORBES was intended to be so comprehensive in scope, it was difficult to adequately condense the many specialized projects in one document. The Main Report alludes to some of the basic methodological limitations in so broad a study (Section 2.6, Underlying Methodological Issues, p 55), and repeatedly cautions against utilizing the data as if they were meaningful in the absolute sense (see pages 57, 102 and 142). The report does generate data that can be utilized to compare the various futures. We feel this is consistent with the Congressional mandate to assess the potential environmental, social and economic impacts of a proposed concentration of power plants in the Ohio River Basin. This report provides a synthesis of opinions (some of which are supported with varying degrees of technical analysis) relating to the potential impacts which could occur under a variety of futures, and thus has satisfied the objectives of the study. However, because of the

methodological limitations, we are of the opinion that the report should not become the basis for regulatory or legislative development but can serve a useful purpose as a background document.

We have listed below, several issues that concern us:

1. The report does not address health impacts in as great a detail as we desire; however, we are sympathetic to the problems of the researchers since the state of the art for measuring health impacts is not very advanced on a local scale. It is understandable that a study such as this, which attempts to identify health impacts on a regional scale, encounters difficulty in quantifying health impacts in such a way as to compare with control costs. The ability to quantify health effects is also limited by the state of the art of long-range transport modeling techniques.

2. The report did not adequately address acid precipitation in the northeastern U.S. because the impacts are outside the Ohio River Basin. Although there is not sufficient information currently available to quantify the effects of acid rain, to develop a meaningful cost/benefit consideration would require some investigation of impacts beyond the ORBES region.

3. We note that the report does not examine in any detail the impacts of developing alternative energy technologies. We agree that within the next 20 years (the ORBES time frame), these technologies will probably not make a significant contribution. However, after the year 2000, they may begin to make a significant contribution; hence the reader should use caution in extrapolating findings beyond the study period of the report.

4. The report did not adequately consider NO_x controls. Throughout the report NO_x was assumed to be proportional to the generation of electricity. Since NO_x controls utilizing staged combustion techniques appear to be feasible and relatively inexpensive for new construction, it is unfortunate that a low NO_x scenario was not examined. Because of the chemical relationship between NO_x and ozone, and because ozone is such an important factor in crop damage, a low NO_x scenario may have provided some useful additional information.

In spite of the methodological problems, we are of the collective opinion that the ORBES is a relevant and highly useful study. Among the considerations which led to this opinion are:

1. The ORBES is comprehensive. We know of no other study which has examined such a broad range of issues in such detail. The reports generated by this study have made a significant contribution to our understanding of the myriad of factors affecting, and influenced by, power generation and have indicated directions for future study by EPA.

2. ORBES has succeeded in striking a reasonable balance between main issues and peripheral issues in the development of its conclusions.

3. This report is readable. Perhaps the most difficult task in any study is to report the findings in a manner that will be understandable to a broad readership. The ORBES report has succeeded in presenting an extremely broad range of considerations in a manner that is understandable, and should make interesting reading for the Congress, the general public and the scientific community.

In conclusion, we hope that this report will reach the broad readership for which it is intended. We agree with the finding that a clean environment and economic growth are not incompatible goals. However, the readers must recognize the limitations of the assumptions in this report when interpreting the findings.

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The ORBES Main Report, despite considerable improvement on the draft version in terms of organization, remains a classic example of (i) very bad science and (ii) a one-sided approach to highly complex and controversial subject matters. These two general defects are so fundamental and so infect the entire Main Report as to render it worse than useless as a policy tool--worse than useless in the sense that the Main Report is misleading in many respects. The infirmities to which the Utility Industry Advisors refer are catalogued and spelled out in some detail in our following comments. Because the Main Report is so scientifically defective and so warped, we urge that it be withdrawn and discarded. Alternatively, we urge that before the Main Report is permitted to infect public policy, it be subjected to rigorous peer review by the Science Advisory Board (SAB) or the National Academy of Sciences (NAS). We are confident that the Report's numerous technical weaknesses will not withstand competent peer review and that the SAB or NAS will recommend that it be scrapped or entirely redone.

In our view, some of the failings of the Report are:

1. Unsupported Findings. Many of its startling conclusions are unsupported by the Main Report itself or its underlying documents. This seriously detracts from its role as a reliable piece of work. It does little good to state that "many judgments were made based on inadequate data" in a "research exercise" (p. 56) and then to state serious and frightening conclusions about the consequence of an extrapolation of such judgments. Such conclusions involve the effects of power supply facilities on air, water, crops, land, society, and human health.

2. Negative View of Power Supply. The ORBES Main Report is based on an exceedingly negative treatment of all power supply facilities. The Report's failure to treat the positive aspects of energy supply in any way or, alternatively, its failure to address the impacts of a lack of energy supply on society is counter to the original charge of the Congress. That charge was for "an assessment of the potential environmental, social, and economic impacts of the proposed concentration of power plants in the Ohio River Basin".

The Foreword of the ORBES Main Report speaks (p. 3) of the "potential beneficial and adverse impacts on the environment, society, the economy and public health". (Emphasis added.) Yet nowhere in the document is there any mention of the beneficial effects of energy supply facilities on such matters. Likewise, as stated in the executive summary (p. 81 of Main Report), the intent

of the project was to investigate "possible impacts of an expanded generating capacity in the context of a number of issues". Instead of examining the positive effects of energy as well as the negative effects, a number of researchers have consistently portrayed speculation, hypotheses, and innuendo as "findings". This is hardly an objective guide for policymakers. Available empirical data suggest that the positive effects of energy facilities far outweigh the adverse impacts and that such facilities have a beneficial effect on the quality of life in general. Research surveys recently conducted in communities with power plants demonstrate overwhelmingly favorable individual perceptions of beneficial impacts upon such sectors as property owners, young adults, schools, housing, medical facilities, the local economy, employment opportunities, and personal incomes.

The ORBES Main Report is focused on the environmental, social, and economic costs of <u>having</u> electricity. However, no examination has been undertaken of the pervasive costs and effects of <u>not having</u> an adequate and reliable supply of electric power. In other words, what would be the implications for the well-being of the Ohio River Basin region if necessary energy development were not pursued? In our judgment, an enormous shortcoming of the ORBES Report is that it stopped short of addressing the consequences of a failure to meet electricity demands. The benefits of continued ability to meet such demands can be conceptualized as the avoidance of costs of power interruptions. Among the readily identifiable potential costs of power interruptions, which we believe should have been evaluated by ORBES, are safety risks to populations, health impacts upon the elderly and the disabled, social disorganization, and out-migration of inhabitants and industries from the ORBES region. Each of these specific areas, which should have been thoroughly evaluated, were not considered at all. For example, the Main Report (p. 55) states that "the health benefits from electricity--such as its use for life support systems and air conditioning--are not entirely clear." What a patently absurd statement! The health benefits from electricity are obvious and overwhelming. Just ask someone on a life support system if he or she is receiving a health benefit! As for air conditioning, recall last summer when more than 1,000 Americans died as the result of one of the worst heatwaves in our nation's history. What would the death toll have been if our nation's power plants had not been able to supply sufficient electricity to keep home and office air conditioning systems running! There can be no question but that the health benefits alone from electricity are enormous. The magnitude of those benefits may, however, present problems of quantification--but this certainly is no reason for discarding or ignoring those benefits.

Coupled with this, there is insufficient recognition throughout the Main Report as to the manner in which reliable energy supply affects the capacity for reasonable economic growth in the region. Along with this overall disregard of reliability, there is an apparent lack of respect for "growth policies" adopted by several states which represent a coordinated effort by those states to balance environmental concerns with growth and energy availability.

3. <u>Unrealistic Scenarios</u>. The alleged impacts reported in the ORBES Main Report are based on fictional scenarios which bear little resemblance to reality. This end result of three years or more of research contains little information of practical value either to the policymaker or to the public

which ultimately bears the cost of the effort. For example, all the scenarios (Table ES-1) assume a constant economic growth rate of 2.47% with a variable energy growth rate of 0.1% per year to 1.73% per year. This is entirely unrealistic and totally ignores the relationship between adequate energy supply and economic growth. A supporting document (Page, Gilmore & Hewings, An Energy and Fuel Demand Model for the Ohio River Basin Energy Study Report, p.73) confirms that the basis of the ORBES assumption is absurdly simple and naive. It states that the annual rate of growth is based on the assumption "that labor productivity has increased in such a manner to allow an annual average growth rate of 2.47 percent per annum. Besides the fact the people are assumed to be better workers in the year 2000, we have essentially assumed that input material requirements are the same as that in 1974."

Also, choosing a scenario labeled "non-compliance with state implementation plans" is quite inappropriate, since it assumes an absence of federal and state enforcement sanctions. Utilities are not exempted from compliance with the law. This scenario suggests that they are.

The conservation scenario emphasizes two factors which, supposedly, account for the low energy consumption. These are the achievement of "maximum practical end use efficiencies" and the adoption of cogeneration on a wide scale throughout the ORBES region (pp. 251-252). The first factor was not quantified for the purposes of ORBES (p. 252 and p. 293). Therefore, all conservation effects are apparently the result of cogeneration. The summary of resulting pollutants under this scenario (p. 255) shows a small decrease in sulfur dioxide and particulate emissions and a significant decrease in NO_x emissions. However, the Report also notes that any possible improvements in air quality resulting from cogeneration are dependent on the fuel utilized (p. 294). No details on the fuel to be utilized by the cogenerators are given. Based on our knowledge of fuel availability and costs in the Midwest, it seems unlikely that cogenerators would use anything but coal, with a resultant deterioration rather than improvement in air quality.

The export scenario of high electrical generation in the ORBES region unrealistically assumes a substantial delivery of power to the Northeast. To the best of our knowledge, there is no intent or plan to install an additional 20,000 megawatts of generating capacity in the ORBES region for transmittal to the Northeast--even if the financing capability existed to do so, which it clearly does not. This is another example of the ridiculous nature of scenario assumption. Incidentally, the Report presents a confusing and contradictory position on the exporting of power from the region and demonstrates a lack of knowledge on the part of the authors as to how bulk power systems are planned and how power flows on the interconnected network. It notes (p. 67) that a large amount of the electricity generated in the region is exported and implies throughout the Report that there is something wrong in doing so. During the course of the study, the ORBES Core Team was apprised of how systems were planned and why there was power flow over widely separate portions of the ORBES boundary. It was pointed out how significantly the so-called "export" changed when the boundary of the Phase I Study was expanded for the Phase II Study. A statement (p. 227) that exports of power might be from nuclear-fueled rather than coal-fired units indicates once again the authors' lack of understanding of power system operation. Nuclear units with their

low fuel cost would inherently be dispatched first to satisfy the regional load and provide lowest cost to the regional customers. Any exports would be from generation available byond the nuclear capability.

4. Institutional Mechanisms for Plant Siting. The ORBES Main Report states that "existing institutional mechanisms are inadequate to ameliorate air quality impacts, many of which transcend political boundaries" (p. 30) and that "voluntary cooperation among utility companies...may not be realistic" (p. 32) as a viable alternative for reconciling conflict. Although various organizational approaches in facilitation of the siting of electric power generating plants should be studied, it should be noted that the interstate compact approach (p. 32), as represented by the Delaware River Basin Compact (DRBC), has been judged a failure by several distinguished public policy analysts, including Dr. Aaron Wildavsky, of the University of California at Berkeley, (Wildavsky, A., in Speaking Truth to Power: The Art and Craft of Policy Analysis) and Bruce Ackerman (Ackerman, B. et al., The Uncertain Search for Environmental Quality), among others. The Ackerman and Wildavsky works indicate that the planners, in their zeal, effectively foreclosed certain political options. Further, it is argued that the goals of DRBC were "fundamentally misconceived" and did little to "reconcile in satisfactory fashion the inevitable tensions between industrial man and nature". And if, as the Foreword from the US Environmental Protection Agency suggests, ORBES is to serve as a guide to policymakers, care must be taken to see that an excess of such zeal in technocratic analysis does not have the same effect here.

However, none of the foregoing is intended to reflect unfavorably on the study of an interstate agreement that, unlike the DRBC, is a state-initiated regional effort, without the federal government as the lead partner. The study entitled "Siting of Major Energy-Related Facilities Along the Ohio River" now under way by the Ohio River Valley Water Sanitation Commission (ORSANCO)--with the Council of State Governments as contractor and funded by the John A. Hartford Foundation--has its genesis in state action, consistent with the National Governors Association's urging "action to expedite and encourage, but not mandate, regional arrangements of states" with regard to siting. ORSANCO seeks a comprehensive study of institutional mechanisms for siting designed to promote a balance between environmental concerns and goals for necessary economic growth. Consistent with the spirit of that sentiment, we are inclined to view this alternative as generally promising, given safeguards for avoiding the DRBC experience.

Not to be ignored, however, is the option of voluntary, industry cooperation in the region with respect to siting coordination. Reliability councils, such as ECAR, can have valuable influence on resolution of many concerns in this regard. ECAR has developed a plan for siting coordination. We agree with the need for coordination, but we suggest a voluntary mechanism in preference to the creation of another layer of government regulation. However, one must bear in mind that the power plant siting process employed today is far from arbitrary. It is utility site specific, with alternative site analysis required by the National Environmental Policy Act in environmental impact statements. Both federal and state licensing processes provide substantial input to the ultimate determination of a site.

5. Socio-Economic Considerations. The Main Report's treatment of social values (p. 107) is largely based on H. R. Potter's support research document (Potter, H. and Norville, H., "Ohio River Basin Energy Study: Social Values and Energy Policy," Purdue University). In this document, Dr. Potter indicates a major shortcoming in his own research: "One of these limitations often is the adequacy of the data for the specific problem. That is, indeed, a limitation in this study since no original data were collected, and that which was available for secondary analysis was not uniform across the study region." (p. 2). As a result, Potter's study contains little in the way of basic scientific or original empirical information to establish the basis for policy analysis.

The ORBES Main Report states: "In general, the ORBES region has a worse health status...than does the nation." (p. 96) Two pages later (p. 98) it continues by saying that "the use of coal for electrical generation by utilities results in potential health impacts in the ORBES region", i.e., coal mining deaths, injuries, etc. As such, there is a strong implication that increased levels of coal consumption are responsible for the region's dubious health. The question one must raise is whether health conditions are directly resultant from coal development and burning or whether they might at least be partially attributable to the fact that the region's per capita gross product is considerably less than the nation's (p. 69).

A major shortcoming of the ORBES Main Report is the statement "whether utility expansion contributes to economic growth is unknown" (p. 55). Thus, ORBES researchers--for whatever reason-- consciously decided to ignore the possible beneficial impacts of adequate energy supply which, despite their assertions to the contrary, are well documented. For example, a study prepared by the Academy for Contemporary Problems ("Stimulating the Economy of the Great Lakes States: A Survey for the Committee for Great Lakes Economic Action") gives credence to this premise by placing the contributions of the manufacturing sector and energy supply into clear focus. It concludes, among other things, that: "uncertainty about energy supply" represents one of the "impediments that must be overcome if new growth in the regional economy is to be stimulated" (p. E-3); "heavy manufacturing, which long undergirded this region's economic dominance, is growing slowly in the United States, still more slowly in the region" (p. E-2); and "nonmanufacturing jobs in the region are not growing fast enough to absorb those displaced by the substitution of capital for labor, absolute losses of employment in some basic industries, natural increase in the size of the labor force, and increased participation in the labor force" (p. E-2). Even the Main Report Foreword (p. 2) itself demonstrates a certain degree of inconsistency by attributing the decline in electricity demand growth rate to several factors, including "changing demographic and economic conditions".

6. Coal Use and Energy Independence. The ORBES Report ignores entirely the strategy of encouraging the use of coal in the interests of this nation's energy independence. By stressing only the negative effects of increased coal use, the Report implies, for example, that end-use substitution of natural gas in one scenario would be preferable to increased use of coal for electricity generation. The support documents, however, recognize a benefit to be obtained from the substitution of more abundant fuels for scarce fuels.

The aforementioned Page support document states (pp. 51-52): "The 'push to coal' scenarios assume a widespread use of heat pumps for space heating. Since the net energy cost of space heating via heat pumps is approximately the same as the energy required in space heating by direct combustion of fossil fuels, the use of heat pumps would promote energy efficiency and would decrease dependency upon fuels that are more scarce."

In addition to national security, reliance on coal lends itself to greater prosperity and serves as an economic stimulus, particularly in the very region which is the subject of this study. Those portions of the Report that deal with the public health-morbidity/moribundity effects of coal burning in the ORBES region constitute additional examples of "bad science". For a detailed critique of these matters, refer to "Utility Industry Advisors' Comments on ORBES Air Quality Analyses". However, we would like to note that here again the ORBES Report is totally one-sided, focusing only on the negative effects of coal burning. For example, what about the new hospitals in rural Appalachia which heretofore did not exist, or local miners who now are able to afford medical care? We ask, "Why have positive effects been disregarded?"

7. Air Quality Impacts. The ORBES Report fails to provide the facts on air quality necessary to support its key findings. A detailed critique of this area is contained in "Utility Industry Advisors' Comments on ORBES Air Quality Analyses".

8. Agricultural Impacts. Projections of crop losses have been arrived at by ORBES researchers, to our knowledge, without the introduction of adequate scientific data from actual field studies around coal-fired power plants. Extensive bio-monitoring and vegetation field surveys conducted for over nine years have failed to detect significant injury and productivity losses attributable to SO_2 emissions from generating facilities. Statements such as "Crop gains that could have been achieved from complete abatement of sulfur dioxide concentrations (ranging from 867,000 bushels to 6.1 million bushels)" represent nothing more than a mere statistical extrapolation. Detailed comments on crop losses are included in "Utility Industry Advisors' Comments on ORBES Air Quality Analyses".

9. Water Quality Impacts. Once again, an evaluation of the ORBES Main Report is complicated by the fact that some references cited are documents produced during other phases of the ORBES project and, as such, may not provide the original source of the information. For a scientific work of the magnitude of the ORBES Main Report, the location of the data and standards used to draw conclusions should be clearly cited.

A general assumption of no strict effluent controls on the water discharges from power plants was made for all scenarios except that of strict environmental controls. This assumption comes dangerously close to making the ORBES Main Report invalid on its face. Water discharges from power plants are perhaps the most strictly controlled of all water discharges. Specifically, the references (p. 7) to stream desiccation and fish kills are inappropriate. During the past ten years there have been no fish kills in the ORBES region due to 7-day - 10-year low flow (7Q10 flow), as theoretically assumed for 1976, or due to ambient water quality. Fish kills have occurred during this

time period--but only during an emergency event such as a toxic chemical spill. Also, it is inconceivable that the majority of rivers in the ORBES region could experience any eutrophication even during a 7Q10 flow event. Both current and navigational traffic would prevent eutrophication. Also, the study fails to take into account the beneficial effects of the water treatment systems, such as settling ponds, used by power plants. These systems act in a cleaning capacity for large streams in the region such as the Ohio Main Stem and Mississippi. This effect is also evident on smaller, heavily industrialized rivers like the Kanawha. There appears to be an error (p. 89) in the number of streams classified in either the A or B category. Only 24 streams were classified, yet 18 were designated A and 8 designated B. This does not equal 24 streams. The postulated impact on aquatic life (p. 95) implies that these projected impacts result from power plant operations. The third paragraph on page 96 indicates that this is not so and that high background pollutant levels associated with the 7Q10 flow are the primary factors. This fact was not stressed strongly enough. The impacts of entrainment and impingement are greatly overstated (p. 217). With the introduction and use of new intake design technology, such as slotted pipe and small mesh screen intakes, the "devastating entrainment-impingement impact on the main stem" will not occur. These types of intakes have been installed and are operating successfully at several power plants on the Ohio River Main Stem.

Another fundamental shortcoming of the treatment of water quality impacts involves the selection of the reference concentrations of pollutants. One reference concentration was selected for each of the 20 pollutants examined. EPA criteria, ORSANCO standards, and individual state standards were reviewed and, in general, ORBES researchers adopted the most stringent criteria as the ORBES reference concentration. These reference concentrations were assumed to apply to all water bodies in the ORBES region. No single ORBES reference concentration can be used to assess the water quality impacts of the region's water bodies. The natural variability among aquatic systems, or even within a single aquatic system, cannot be identified with a single numerical value. Factors such as hardness, pH, sediment characteristics, and types of aquatic organisms present often impact on the pollutant's effect on the aquatic environment. A water quality standard consists of <u>two</u> parts: 1) a designated use and 2) numerical or qualitative criteria developed to attain the designated use. Each state is delegated the responsibility of adopting water quality standards to ensure protection of state-designated uses, e.g., industrial, agricultural, public drinking source, fisheries, etc. The designated uses for the 24 streams evaluated in the Main Report were entirely ignored. Thus, conclusions that a given number of streams would violate certain pollutant standards under various scenarios are incorrect and misleading. Individual state standards should have been used as they apply to the individual state's waters. ORSANCO standards should have been referenced for the Ohio River mainstream.

10. <u>Land Use and Terrestrial Ecosystem Impacts</u>. Land use changes were assessed in the ORBES Main Report by projecting the acreage converted as a result of coal mine, power plant, and transmission line development. Terrestrial ecosystem impacts were assessed by establishing county level indices for four ecological resource variables and projecting the effects according to the various siting configurations. Thus, if a county had an index of ten,

each 650 megawatts of capacity sited in this county would be assessed ten "terrestrial ecosystem assessment units" (TEAU). The four ecological resource variables used were percentage of forest lands, percentage of Class I and II soils, number of natural areas, and number of endangered species.

There are several basic deficiencies in the approaches used by the ORBES researchers, including limited data bases, invalid assumptions, and a disregard with respect to the realities of siting an energy facility. Based on land-use requirements for five new plants, the ORBES researchers deduced that for every 650 mw of installed capacity, 1,100 acres are converted for power plant requirements and 800 acres are converted for the associated transmission lines. Of the five facilities examined by the ORBES researchers, acreage requirements per 650 mw of capacity ranged from 644 to 1,749 acres for power plants and from 262 to 1,677 acres for transmission lines. However, it is very likely that a substantial portion of the land at some of the "data base" plants is reserved for future unit additions beyond those presently planned by the utilities. In short, the ORBES Main Report appears to overstate land requirements for energy facilities.

Terrestrial ecosystem impacts based on county-wide TEAUs should be viewed with extreme caution. The Main Report imples that certain ORBES states would be less severely affected ecologically than other states in a given scenario and certain scenarios would be less damaging ecologically than others. Since each state applies different criteria for classifying a species as endangered and ORBES states vary in the emphasis placed on natural area programs, comparisons between states for any given scenario would be meaningless. Further, ecological impacts are directly related to ORBES' adopted policies inherent in the siting model. Thus, a policy which shifts generating capacity to a state(s) with lower county level ecological indices may imply that the scenario has less of an ecological impact when, in reality, the difference may be explained by inconsistencies in state data bases. Since "scenario addition" plants were only sited to the county level, land use impacts were assessed by assuming that energy facilities displacement would be directly proportional to county level land use data. If half of a county were in forested use, half of the acreage displaced by the new energy facility would be forest lands. This rationale ignores the realities of siting energy facilities to the sub-county and site-specific levels. In essence, the researchers proportioned site-specific impacts according to the county level data base.

Likewise, just because an energy facility is sited in a county with a particular TEAU value does not mean that the facility would have negative impacts on the TEAUs. In practice, a utility would apply ecological siting criteria to the sub-county level and thus either avoid or provide mitigative measures to ensure protection of ecologically sensitive habitats.

11. Conclusion. I appreciate this opportunity to comment on this document. I trust that these observations will be helpful to you and the United States Congress in its further deliberation. While it has not been possible to fully evaluate all support documents developed since the beginning of this undertaking three or more years ago, we have made a concerted effort to point out areas of concern in utilizing the ORBES Main Report as a tool for

evaluating policy alternatives. The comments contained herein have the support of the other members of the Utility Industry Advisors Group and, for purposes of assuring continuity of response in addressing the issue of the ORBES Main Report, should be considered as part of that group's response.

W. S. White, Jr.

February 17, 1981

Appendices

APPENDIX A

ORBES Publications

Phase II

Donald A. Blome, University of Kentucky, Coal Mine Siting for the Ohio River Basin Energy Study, Grant No. EPA R805590

E. Downey Brill, Jr., Shoou-Yuh Chang, Robert W. Fuessle, and Randolph M. Lyon, University of Illinois at Urbana-Champaign, Potential Water Quantity and Water Quality Impacts of Power Development Scenarios on Major Rivers in the Ohio Basin, Subcontract under Prime Contract EPA R805588

Vincent P. Cardi, West Virginia University, editor, West Virginia Baseline, Grant No. EPA R805585

Vincent P. Cardi, Larry Harless, and Thomas Sweet, West Virginia University, Legal and Institutional Issues in the Ohio River Basin Energy Study, Grant No. EPA R805585 and Subcontract under Prime Contract EPA R805588

Duane Chapman, Kathleen Cole, and Michael Slott, Cornell University, Energy Production and Residential Heating: Taxation, Subsidies, and Comparative Costs, Subcontract under Prime Contract EPA R805588

Comments on the Ohio River Basin Energy Study, collected by James J. Stukel, University of Illinois at Urbana-Champaign, and Boyd R. Keenan, University of Illinois at Chicago Circle, Cooperative Agreement No. EPA CR807395

Control Data Corporation, International Research and Technology Corporation, and the MITRE Corporation, Environmental Residual Trends in the Ohio River Basin

Gary L. Fowler, University of Illinois at Chicago Circle; J.C. Randolph, Indiana University; Robert E. Bailey, The Ohio State University; Steven I. Gordon, The Ohio State University; Steven D. Jansen, University of Illinois at Chicago Circle; and W.W. Jones, Indiana University, The Ohio River Basin Energy Facility Siting Model, Grant Nos. EPA R805588, R805589, and R805609 and Subcontract under Prime Contract EPA R805588

Vol. I. Methodology

Vol. II. Sites and On-Line Dates

Steven I. Gordon and Christopher Badger, The Ohio State University, A Model of Migration in the Ohio River Basin Energy Study Region, Subcontract under Prime Contract EPA R805588

Steven I. Gordon and Anna S. Graham, The Ohio State University, Regional Socioeconomic Impacts of Alternative Energy Scenarios for the Ohio River Basin Energy Study Region, Grant No. EPA R805589

Steven I. Gordon and Anna S. Graham, The Ohio State University, Site-Specific Socioeconomic Impacts: Seven Case Studies in the Ohio River Basin Energy Study Region, Grant No. EPA R805589

James P. Hartnett and Jan L. Saper, University of Illinois at Chicago Circle, Energy Consumption Patterns: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia (1975), Grant No. EPA R805588

Steven D. Jansen, University of Illinois at Chicago Circle, Electrical Generating Unit Inventory, 1976-1986: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia, Grant No. EPA R805588

Steven D. Jansen, James P. Hartnett, R. Mastaniah, and Dan Merilatt, University of Illinois at Chicago Circle; Robert E. Bailey, The Ohio State University; J.C. Randolph, Indiana University; Maurice A. Shapiro, University of Pittsburgh; and Hugh T. Spencer, University of Louisville, Nuclear Energy Risks and Benefits, Grant Nos. EPA R804816, R805588, R805608, and R805609 and Subcontracts under Prime Contract EPA R805588

Boyd R. Keenan, University of Illinois at Chicago Circle, Ohio Basin Interstate Energy Options: Constraints of Federalism, Grant No. EPA R805588

Clara Leuthart and Hugh T. Spencer, University of Louisville, Fish Resources and Aquatic Habitat Impact Assessment Methodology for the Ohio River Basin Energy Study Region, Grant No. EPA R804816

Orie Loucks, Thomas V. Armentano, Roland Usher, and Wayne Williams, The Institute of Ecology; Richard W. Miller, The Institute of Ecology and Butler University; and Larry Wong, Indiana University, Crop and Forest Losses Due to Current and Projected Emissions from Coal-Fired Power Plants in the Ohio River Basin, Subcontract under Prime Contract EPA R805588

Patrick C. Mann and Tom S. Witt, West Virginia University, An Economic Analysis of the Electric Utility Sector in the Ohio River Basin Region, Subcontract under Prime Contract EPA R805588

James A. McLaughlin, West Virginia University, Legal and Institutional Aspects of Interstate Power Plant Development in the Ohio River Basin Energy Study Region, Subcontract under Prime Contract EPA R805588

Richard Newcomb and Bruce Bancroft, West Virginia University, Capital Requirements and Busbar Costs for Power in the Ohio River Basin, 1985 and 2000, Subcontract under Prime Contract EPA R805588

ORBES Core Team, Ohio River Basin Energy Study (ORBES): Main Report, Grant Nos. EPA R804618, R805585, R805588, R805589, R805590, R805603, R805608, R805609, and R806451 and Cooperative Agreement No. EPA CR807395; also published as U.S. Environmental Protection Agency, Interagency Energy/Environment Research and Development Program Report, EPA-600/7-81-008 (January 1981)

Walter P. Page, West Virginia University, An Economic Analysis of Coal Supply in the Ohio River Basin Energy Study Region, Grant No. EPA R805585

Walter P. Page, West Virginia University, Energy Consumption in the Ohio River Basin Energy Study Region, 1974, by End User and Fuel Type, Grant No. EPA R805585

Walter P. Page, James Ciecka, and Gary Arbogast, West Virginia University, and Robert G. Fabian, Estimating Regional Losses to Agricultural Producers from Airborne Residuals in the Ohio River Basin Energy Study Region, 1976-2000, Grant No. EPA R805585 and Subcontract under Prime Contract EPA R805588

Walter P. Page, West Virginia University, and Doug Gilmore and Geoffrey Hewings, University of Illinois at Urbana-Champaign, An Energy and Fuel Demand Model for the Ohio River Basin Energy Study Region, Grant No. EPA R805585 and Subcontract under Prime Contract EPA R805588

Walter P. Page and John Gowdy, West Virginia University, Gross Regional Product in the Ohio River Basin Energy Study Region, 1960-1975, Subcontract under Prime Contract EPA R805588

Walter P. Page and John M. Gowdy, West Virginia University, Economic Losses in the Columbus SMSA Due to Long-Range Transport of Airborne Residuals in the Ohio River Basin Energy Study Region, Grant No. EPA R805585

Harry R. Potter and Heather Norville, Purdue University, Ohio River Basin Energy Study: Social Values and Energy Policy, Grant No. EPA R806451 and Subcontract under Prime Contract EPA R805588

Edward P. Radford, University of Pittsburgh, Impacts on Human Health from the Coal and Nuclear Fuel Cycles and Other Technologies Associated with Electric Power Generation and Transmission, Subcontract under Prime Contract EPA R805588

J.C. Randolph and W.W. Jones, Indiana University, Ohio River Basin Energy Study: Land Use and Terrestrial Ecology, Grant No. EPA R805609

Jan L. Saper and James P. Hartnett, University of Illinois at Chicago Circle, editors; Vincent P. Cardi and Thomas Sweet, West Virginia University; and Gary L. Fowler, Rita Harmata, Steven D. Jansen, and Boyd R. Keenan, University of Illinois at Chicago Circle, The Current Status of the Electric Utility Industry in the Ohio River Basin Energy Study States, Grant Nos. EPA R805585 and R805588

Maurice A. Shapiro, University of Pittsburgh, editor, Pennsylvania Baseline, Grant No. EPA R805608

Maurice A. Shapiro and A.A. Sooky, University of Pittsburgh, Ohio River Basin Energy Study: Health Aspects, Grant No. EPA R805608 and Subcontract under Prime Contract EPA R805588

James J. Stukel, University of Illinois at Urbana-Champaign, editor, Ohio River Basin Energy Study: Air Quality and Related Impacts

Vol. I. James J. Stukel and Brand L. Niemann, University of Illinois at Urbana-Champaign, Documentation in Support of Key ORBES Air Quality Findings, Grant No. EPA R805588

Vol. II. Teknekron Research, Inc., Air Quality and Meteorology in the Ohio River Basin: Baseline and Future Impacts, Subcontract under Prime Contract EPA R805588

Vol. III. Teknekron Research, Inc., Selected Impacts of Electric Utility Operations in the Ohio River Basin (1976-2000): An Application of the Utility Simulation Model, Subcontract under Prime Contract EPA R805588

Symposium on Energy and Human Health: Human Costs of Electric Power Generation, Grant No. EPA R805608 and Subcontract under Prime Contract EPA R805588

David S. Walls, Dwight B. Billings, Mary P. Payne, and Joe F. Childers, Jr., University of Kentucky, A Baseline Assessment of Coal Industry Structure in the Ohio River Basin Energy Study Region, Subcontract under Prime Contract EPA R805588

Elbert E. Whitlatch and John A. Aldrich, The Ohio State University, Energy Facility Siting Procedures, Criteria, and Public Participation in the Ohio River Basin Energy Study Region, Grant Nos. EPA R805589 and R805603

Daniel E. Willard, Michael A. Ewert, Mary Ellen Hogan, and Jeffrey D. Martin, Indiana University, A Land Use Analysis of Existing and Potential Coal Surface Mining Areas in the Ohio River Basin Energy Study Region, Subcontract under Prime Contract EPA R805588

NOTE: Copies of the above reports can be obtained from Office of Research and Development Publications, U.S. Environmental Protection Agency, Center for Environmental Research Information, 26 West St. Clair, Cincinnati, Ohio 45268 (513/684-7562).

Phase I

R.E. Bailey, R.G. Barile, D.D. Gray, R.B. Jacko, P. O'Leary, R.A. Rao, and J.E. Reinhardt, Purdue University, Pollutant Transport Models for the ORBES Region, vol. III-H, Grant No. EPA R804849

Donald A. Blome and James E. Jones, Jr., University of Kentucky, Regional Assessment of the Impact of Synthetic Fuel Production, vol. III-J, Grant No. EPA R804817

E. Downey Brill, Jr., Glenn E. Stout, Robert W. Fuessle, Randolph M. Lyon, and Keith E. Wojnarowski, University of Illinois at Urbana-Champaign, Issues Related to Water Allocation in the Lower Ohio River Basin, vol. III-G, Grant No. EPA R804821

Robert C. Dauffenbach and Thomas P. Milke, University of Illinois at Urbana-Champaign, Labor Demand Impact and Labor Market Feasibility of Energy Conversion Facilities in the Ohio River Basin, vol. III-A, Grant No. EPA R804821

Development of Baseline Data for the Ohio River Basin Energy Study, vol. I-B, University of Louisville, University of Kentucky, University of Illinois at Chicago Circle and at Urbana-Champaign, Indiana University, Purdue University, The Ohio State University, and Project Management, Grant Nos. EPA R804816, R804817, R804821, R804849, R804851, and R804848

Independent Comments, vol. IV, Grant No. EPA R804848

Sue Johnson and Esther Weil, University of Kentucky, Social Aspects of Power Plant Siting, vol. III-D, Grant No. EPA R80817

Clara A. Leuthart and Hugh T. Spencer, University of Louisville, Radionuclide and Metal Ion Content of Late Summer Ohio River Sediments: McAlpine Pool 1976, vol. III-I, Grant No. EPA R804816

Sven B. Lundstedt, Henry L. Hunker, and Clark Leavitt, The Ohio State University, Subjective Quality of Life in the Ohio River Basin as Related to Future Energy Development, vol. III-C, Grant No. EPA R804851

Preliminary Technology Assessment Report, Vol. II-A, 3 pts., Indiana University, The Ohio State University, and Purdue University, Grant No. EPA R804849

Preliminary Technology Assessment Report, Vol. II-B, University of Kentucky and University of Louisville, Grant Nos. EPA R804816 and EPA R804817

Preliminary Technology Assessment Report, Vol. II-C, University of Illinois at Chicago Circle and at Urbana-Champaign, Grant No. EPA R804821

Michael Rieber, University of Illinois at Urbana-Champaign, Energy Transportation/Distribution in the Ohio River Basin, vol. III-F, Grant No. EPA R804821

James J. Stukel, University of Illinois at Urbana-Champaign, and Boyd R. Keenan, University of Illinois at Chicago Circle, ORBES Phase I: Interim Findings, vol. I-A, Grant No. EPA R805848; also published as U.S. Environmental Protection Agency, Interagency Energy-Environmental Research and Development Program Report, EPA-600/7-77-120 (November 1977)

Richard A. Tybout, The Ohio State University, A Benefit-Cost Analysis of Power in the ORBES Region, vol. III-B, Grant No. EPA R804851

Nicholas L. White and John F. Fitzgerald, Indiana University, Legal Analysis of Institutional Accountability for the Ohio River Basin, vol. III-E, Grant No. EPA R804849

APPENDIX B

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