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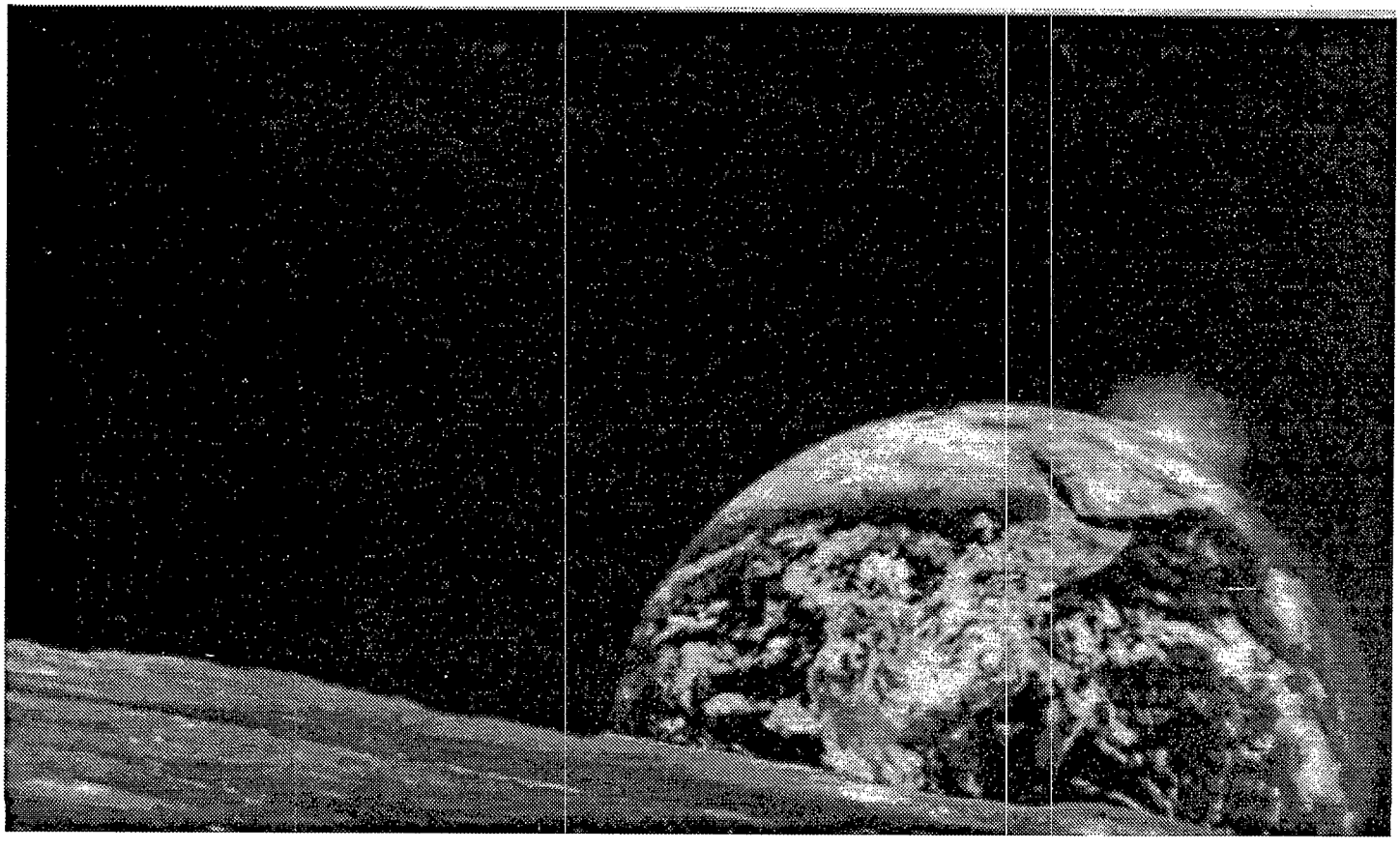
SAB Report: Futures Methods and Issues

A Technical Annex to "Beyond the Horizon: Protecting the Future with Foresight"



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SAB Report: Futures Methods and Issues

A Technical Annex to "Beyond the Horizon: Protecting the Future with Foresight"

Prepared by the

Environmental Futures Committee

Science Advisory Board
Washington, DC 20460

Notice

This technical annex, like the companion report, has been written as part of the activities of the Science Advisory Board (SAB), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

Seven reports were produced from the Environmental Futures Project of the SAB. The titles are listed below:

(1) Environmental Futures Committee EPA-SAB-EC-95-007

[Title: "Beyond the Horizon: Protecting the Future with Foresight," Prepared by the Environmental Futures Committee of the Science Advisory Board's Executive Committee.]

(2) Environmental Futures Committee EPA-SAB-EC-95-007A

Title: Futures Methods and Issues, Technical Annex to the Report entitled "Beyond the Horizon: Protecting the Future with Foresight," Prepared by the Environmental Futures Committee of the Science Advisory Board's Executive Committee.]

(3) Drinking Water Committee EPA-SAB-DWC-95-002

[Title: " Safe Drinking Water: Future Trends and Challenges," Prepared by the Drinking Water Committee, Science Advisory Board.]

(4) Ecological Processes and Effects Committee EPA-SAB-EPEC-95-003

[Title: "Ecosystem Management: Imperative for a Dynamic World," Prepared by the Ecological Processes and Effects Committee, Science Advisory Board.]

(5) Environmental Engineering Committee EPA-SAB-EEC-95-004

[Title: "Review of Environmental Engineering Futures Issues," Prepared by the Environmental Engineering Committee, Science Advisory Board.]

(6) Indoor Air Quality and Total Human Exposure Committee EPA-SAB-IAQC-95-005

[Title: "Human Exposure Assessment: A Guide to Risk Ranking, Risk Reduction and Research Planning," Prepared by the Indoor Air Quality and Total Human Exposure Committee, Science Advisory Board.]

(7) Radiation Advisory Committee EPA-SAB-RAC-95-006

[Title: "Report on Future Issues and Challenges in the Study of Environmental Radiation, with a Focus Toward Future Institutional Readiness by the Environmental Protection Agency," Prepared by the Radiation Environmental Futures Subcommittee of the Radiation Advisory Committee, Science Advisory Board.]

Single copies of any of these reports may be requested and obtained from the SAB.

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[1]The Committee was also assisted by Ms. Linda Greer, Natural Resources Defense Council, Washington, DC, who attended one meeting.

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[2]Mr. Hansen served on the Environmental Futures Committee from December 1993 until September 1994 at which time he resigned to become the Deputy Administrator of EPA.

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Contents

1.0 Introduction

This document is a technical annex to the Science Advisory Board (SAB) report "Beyond the Horizon: Using Foresight to Protect the Environmental Future," EPA-SAB-EC-95-001. It provides details on the activities undertaken by the Environmental Futures Committee (EFC) to address the charge to the SAB. Sections 3-5 include materials developed by EFC work groups on methods and process, driving factors, and specific environmental issues. This information was used by the entire Committee, along with information obtained from documents, presentations from both inside and outside of the Agency, meetings with different types of groups, and personal contacts. Appendices A-G present the lists of issues areas, future issues, potential problems, criteria for selecting issues for further evaluation, and an example of an issue ranking procedure that was developed by the EFC during the Environmental Futures project.

Abraham Lincoln once said, "If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it."[3] To understand "whither we are tending" is to have foresight capability. Foresight capability will help to make one better aware of the consequences of present choices by us and by others.

1.1 Charge to the Committee

On July 16, 1993, Carol Browner, Administrator, United States Environmental Protection Agency (EPA), and David Gardiner, EPA Assistant Administrator for the Office of Policy, Planning and Evaluation, requested that the SAB carry out a study addressing future environmental and human health problems.

The SAB was asked to develop a procedure for conducting a periodic scan of the future horizon and to choose a few of the many possible future developments for in-depth examination of potential environmental impacts.

The Executive Committee of the SAB considered and accepted this request and established an *ad hoc* SAB committee, the EFC, to undertake this effort. Based on the proposed charge, the SAB accepted the following specific goals for this project:

A. Develop procedures for conducting a short (five- to ten-year horizon) and long-term (20-year horizon or longer) scan of future developments that will affect environmental quality and the nation's ability to protect the environment over a medium to long-term time frame.

B. Conduct as comprehensive a scan as practical to identify important future developments and environmental consequences.

C. Choose a limited number of short- and long-term future developments for in-depth evaluation of their environmental consequences.

D. Develop appropriate procedures for conducting in-depth examination of those future developments and consequences.

E. Apply procedures described in D.

F. Draw implications for EPA from the in-depth examination of future developments.

The following points were added by the EFC:

G. Recommend possible actions for addressing the developments and consequences.

H. Propose possible approaches for continuing EPA programs that address evaluation of future developments and environmental consequences.

I. Develop a method for communicating the results of the Futures study so that it will have an impact on appropriate professionals in EPA.

1.2 Procedures of the Committee

The general approach to the EFC efforts is illustrated in Figure 1. The annual SAB meeting in October 1993 was the kickoff event serving as the opportunity to brief all SAB members and other interested individuals about the project and its objectives. Following that meeting several Standing Committees agreed to participate. The EFC met twelve times during this project and conducted six fact-finding sessions with various organizations. The Standing Committee activities are summarized in Section 6.

The project activities drew on knowledge that currently exists and the capabilities of the SAB members. Both the EFC and the SAB Standing Committees used available reports, and the Office of Policy, Planning and Evaluation (OPPE) and SAB staff facilitated project activities. OPPE provided examples of forecasting methods and reports, and sources of data on driving forces. As an example, OPPE funded and made available an earlier study, "Challenges Ahead for the U.S. Environmental Protection Agency in the 21st Century: Final Report of the Megatrends Project," by the World Resources Institute (WRI) which served as a background document. OPPE staff assisted in locating and providing other reports and documents that helped to establish baselines, trends, and procedures.

[3] Grant, L. 1988. Foresight and National Decisions. University of America Press. Lanham, MD.

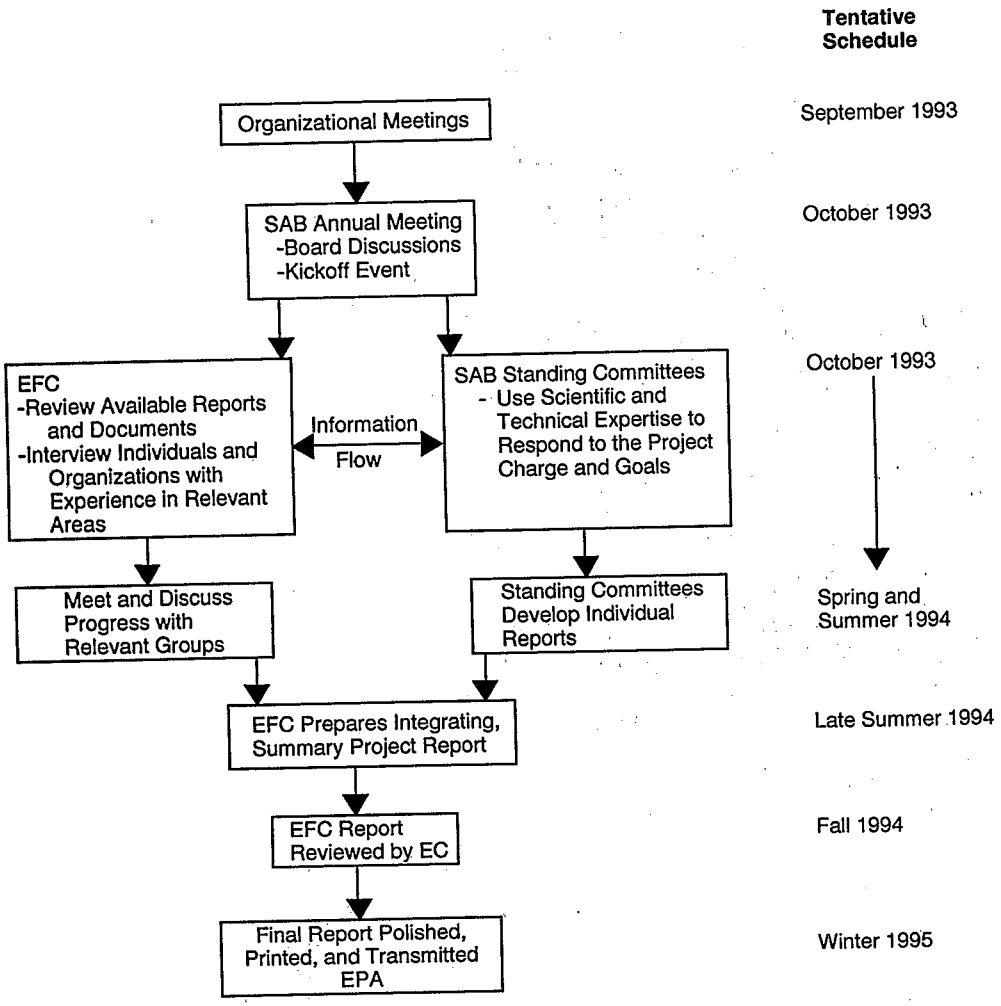

Figure 1. Overview of the Environmental Futures Project.

1.2.1 EFC Activities

The EFC interviewed knowledgeable individuals, including those from relevant organizations, to seek insights and information. Organizations included those that have considered similar issues, such as WRI, Census Bureau, Department of Energy, Department of Commerce, EPA-OPPE staff, industry forecasters and planners, as well as individuals who have focused on issues related to the future and to national and international developments that may affect public health and the environment (Appendix I).

The EFC established four Work Groups on (a) methods, (b) driving forces, (c) specific issues, and (d) scenarios to develop preliminary thoughts in these areas. The Methods Group developed an overview of an early warning system and its possible functions, by drawing from presentations and information from the EFC and from their own expertise. The Scenario Group developed heuristic scenarios for use in the analysis of specific issues and principles for the development and application of scenarios as part of a *top-down* approach for foresight. Actual scenarios were also developed as part of the work of the Ecological Processes and Effects Committee (EPEC), one of the participating Standing Committees of the SAB, and summarized (Section 3.1.2) with the work of the Methods Group. The Driving Forces Group provided valuable insights for interpreting some impacts of drivers and applying foresight methods. They identified policy issues that flow from consideration of future environmental issues that have implications for future society and government policy makers. The Specific Issues Group developed a set of criteria for selecting issues of environmental concern for the future. The Specific Issues Group also facilitated the whole EFC, which served as a pilot "look out" panel.

The results of these four activities are described in detail in this Technical Annex. Section 3 presents the design of a recommended method for detecting and analyzing future environmental problems and sketches of environmental scenarios. Section 4 discusses driving forces --that is those large societal and economic forces that set the stage for future environmental issues and in their evolution result in environmental stresses on a global scale. Section 5 presents specific issues generated by the EFC, criteria for issue evaluation and

a description of the process used by the EFC to identify these issues.

1.2.2 Standing Committee Activities

The Standing Committees were invited to develop their own approaches to the project. Each of the participating Standing Committees became, in effect, a "look out" panel for its own area of interest; each followed its own methods for generating, identifying, and selecting future issues. Each participating Standing Committee also had a representative on the EFC to provide inputs to, and participate in, the work of the EFC and to act as a communication link. From this came a rich variety of responses from the Standing Committees noted below. All committees used their scientific and technical expertise to (a) identify baseline information and trends that may be expected to have future impacts on human health and/or the environment, (b) focus on one or more case studies relevant to their expertise, and (c) describe the procedures they used to recognize future environmental concerns.

Seven Standing Committees participated: the Executive Committee through its Environmental Futures Committee, the Clean Air Scientific Advisory Committee (CASAC), the Drinking Water Committee, the Ecological Processes and Effects Committee, the Environmental Engineering Committee, the Indoor Air Quality and Total Human Exposure Committee, and the Radiation Advisory Committee. CASAC provided issues that are included in the appended lists of issues but did not produce a separate report. The other five technical committees provided issues and also produced separate reports the results of which are reflected in this report. Each Standing Committee report includes a discussion of the premises, methods, and resources that were used in developing findings and recommendations. Highlights of the findings of the Standing Committees are discussed in Section 6; however, the reader should consult the Standing Committee reports for details on the assumptions and implications of those findings. References to the Standing Committee reports are listed below:

Drinking Water Committee	EPA-SAB-DWC-95-002
Ecological Processes and Effects Committee	EPA-SAB-EPEC-95-003
Environmental Engineering Committee	EPA-SAB-EEC-95-004
Indoor Air Quality and Total Human Exposure Committee	EPA-SAB-IAQ-95-005
Radiation Advisory Committee	EPA-SAB-RAC-95-006

These reports are available from the Science Advisory Board (1400), Committee Evaluation and Support Section, 401 M Street, S.W., Washington, DC 20460, (202) 260-8414.

2.0 Background and Agency Futures Experience

2.1 Legacy of Reducing Risk

This project is a logical extension of the SAB reports on "Future Risk" (EPA/630/R-92/001) and "Reducing Risks" (EPA-SAB-EC-90-021). In both reports, the SAB indicated that it was important for EPA to increase its ability to identify the future potential risks to human health and the environment. In both of these earlier reports, the SAB recommended that the Agency use long-range strategic planning and that the Agency focus on setting risk priorities and developing multimedia risk solutions.

2.2 Current Futures Activities in EPA

EPA has several current futures activities that may be useful as the Agency considers the how to implement the recommendations of the EFC. The activities of two organizations are summarized below based on information provided to the EFC by the Office of Research and Development (ORD) and OPPE. In addition, the EFC is aware that EPA has several other projects that could be related to foresight techniques: The Environmental Goals Project; EPA's Strategic Planning activities; and its attempts to develop measurements of environmental results.

2.2.1 EPA Futures Staff

Since the fall of 1989, a small group of EPA professionals have been designing and implementing foresight activities within the OPPE. These activities within EPA were spawned by briefs given to OPPE's Assistant Administrator by a member of the Dutch government engaged in similar activities in preparing their National Environmental Policy Plan and in response to the SAB's *Future Risk Report*.

The present group is composed of three full-time federal employees and is complemented by student interns and staff on loan from other parts of EPA. The group's annual extramural budget within OPPE's Office of Strategic Planning and Environmental Data is just under $300,000.

The Futures staff's self-directed mission is to develop, support, and promote an anticipatory, systematic approach to environmental policy-making. This approach is designed to identify strategic opportunities for sustainable development and pollution prevention, compare potential outcomes of policy options in advance, to sharpen our understanding of forces that shape society and the environment, and to clarify and reduce uncertainties in critical areas. Key activities include:

- Conducting studies to help organizations envision sustainable environmental futures.
- Identifying emerging issues, critical trends, and strategic opportunities relevant to environmental planning and decision-making.
- Collecting and synthesizing information on the environment, economic sectors, and other key drivers to help identify and assess sustainable development policies.
- Identifying, developing, and using tools and methods that support foresight and systematic thinking. These tools and methods are used to develop alternative futures, identify their potential environmental impact, and examine policy options for sustainable development, pollution prevention, and mitigation of problems.
- Coordinating EPA's futures work with complementary work in other agencies, institutions, private corporations, and nonprofit organizations.

Specific projects underway at OPPE include:

- Demographic Change and the Environment (Battelle Northwest via Interagency Agreement with Department of Energy, Richland, WA, Laboratory) - This project is designed to broaden our understanding of population-environment linkages and facilitate the integration of population issues into long-range environmental policy and planning.
- Reinvigorating the National Environmental Policy Act (NEPA) as a Tool for Defining and Measuring Progress Toward A Sustainable United States - Under a cooperative agreement with the Environmental Law Institute, this study will examine how NEPA can be used as a planning and policy tool. NEPA could serve as a government-wide instrument to integrate sustainability into decision-making and to increase foresight and foster interdisciplinary understanding.
- Sustainable Futures for Community Water Resources (Continuing) - Under a cooperative agreement with the Rocky Mountain Institute of Technology Forecasting and Technology Policy, this project supports work on identifying and clarifying emerging issues, trends, and policy alternatives relevant to the development of water infrastructure and water resources. This includes, but it is not limited to, issues, trends, and policies affecting the future of community water services and the environment, with a particular focus on the residential/commercial subsector. A central goal of this project is to help decision-makers develop plans for the sustainable use and management of water resources.

- Identifying Environmentally Important Technologies in the Metal Castings Industry - An in-house exploratory analysis to forecast the potential environmental impacts of advances composite materials technology over the next decade. Based on this analysis, a framework will be developed for near-term government policies that may mitigate long-term environmental impacts.
- Kentucky Futures and Comparative Risks Project (continuing) - This project, an in-house collaboration with the State of Kentucky, is intended to expand the comparative risk process to capitalize on human and social imagination -- creating positive visions of Kentucky and then examining the environmental risks avoided by moving down certain paths of social, economic, technological, and demographic development with a focus on creating a sustainable future. Anticipated products include a long-range sustainable development strategy, over 100 issue papers relating sustainable development to economic sectors and other issues, and partial support of the Long-Range Policy Research Center.
- Industrial Ecology: The Role of the Federal Government (Draft, 1993), and an accompanying annotated bibliography - Industrial ecology is a concept that applies ecological principles to the industrial processes. The concept offers many new approaches to industrial production that could lead to sustainable development in the U.S. and abroad. This paper identifies barriers to implementing the concept and suggests how these barriers can be overcome.
- U.S. EPA Futures Internet Information Server - An Internet-connected, information resource providing the environmental futures community with EPA information. Currently available on all of the major platforms (GOPHER, WAIS, and Mosaic). This server is also being used to enhance networking among state and local governments and to obtain feedback from the field on EPA activities.

For analytical and conceptual support, the Futures staff uses cooperative agreements and contracts to work with such organizations as

- The World Resources Institute, The Rocky Mountain Institute, RAND Corp., Massachusetts Institute of Technology, The National Academy of Sciences/National Research Council, Environmental Law Institute, The Human Affairs Research Center (Battelle), United Nations University (see discussion Section 3.2) and Wide Area Information Servers, Inc.

2.2.2 *Office of Research and Development*

ORD and OPPE initiated an Anticipatory Research Program[4] in January 1994. The major components of that program include new elements: collecting and analyzing a broad range of environmental and human behavioral data; identifying emerging trends in environmental conditions, human activities, and technological choices; improving methods of predicting and evaluating risk; and broadening the type and focus of environmental research. The program was envisioned to include several existing elements: ORD's National Human Exposure Assessment Survey (NHEXAS) and Environmental Monitoring and Assessment Program (EMAP), designed to provide a comprehensive, integrated national data base of human health and environmental conditions, and OPPE's Futures staff's "Critical Trends" work, designed to delineate demographic, economic, behavioral, and other drivers of environmental problems. The program was also considering establishing a technology monitoring/forecasting effort. Final decisions have been delayed until ORD determines how it will implement the recommendations of the EPA laboratory study[5] and its plans for reorganization of ORD.

The Anticipatory Research Program was also described in an ORD Research Issue Plan, draft February 1993.[6] The importance of this research was noted in earlier reports of the SAB and a Peer Review Panel.[7] The term anticipatory was defined in two ways: (1) the anticipation of potential environmental problems before they arise and (2) the identification of currently small scale or poorly defined environmental concerns that have the potential to become more serious. In the Environmental Futures Project, the Look Out panel identified emerging issues that met both of these definitions.

During the Environmental Futures Project, ORD staff presented the results of a survey of ORD Laboratory Directors' opinions regarding the important environmental issues of the future. Each of the laboratories included issues related to social science and concerns over the human values and attitudes toward the environment. In addition, they noted deficiencies in our current ability to deal with land use and environmental resources, growing U.S. and world population pressures on the environment, continuing problems of solid waste, air, and water quality, and the need to develop global strategies to deal with environmental impacts associated with free trade and expanding economies of the world. Coincidently, most of these issues were also identified by the members of the SAB in this project (see Appendix A).

[4] Skumanich, M. and K. Paterson. 1994. Initial Scoping of an ORD Technology Monitoring and Forecasting Effort. Battelle Pacific Northwest Laboratory. Seattle, WA.

[5] Mitre Corp. 1994. Assessment of the Scientific and Technical Laboratories and Facilities of the U.S. Environmental Protection Agency. Performed under Contract No. 68D40003. For information on this report contact Mr. Tom Hadd at 202-260-7500. In addition, SAB. 1994. Review of Mitre Corp. Draft report on the EPA Laboratory Study. Prepared by the Research Strategies Advisory Committee, provided many recommendations that are being addressed under the current ORD reorganization.

[6] ORD. 1993. Strategic Issue Plans. 38. Anticipatory Research and Emerging Environmental Problems. Issue Planner: Hal Zenick.

[7] EPA. 1992. Safeguarding the Future: Credible Science, Credible Decisions. EPA/600/9-91/050. The Report of the Expert Panel on the Role of Science at EPA. January 8, 1992.

3.0 Recommended Methods for Identifying Possible Future Environmental Issues

The Agency should design and implement a comprehensive, continuous, and well integrated system for detecting and analyzing incipient future developments that might threaten the environment or provide new pollution prevention opportunities for the Agency. Of course, many activities are already underway at the Agency that focus on the future including those described in Section 2 by ORD and OPPE. The EFC recommends that the Agency go well beyond such existing and worthwhile current efforts. The Agency should create an in-house information system capable of detecting important "weak signals" of future changes that could impinge adversely on the environment or create new opportunities for the Agency to achieve its goals.

Any early warning system should have the following characteristics; it should:

- draw from a wide range of sources to help assure that a broad net is cast. Specifically, in implementing an early warning system, the Agency should make use of relevant information that exists in data bases, models, and other institutions. It should draw on experts, both in and outside of the Agency, who have firsthand knowledge about changes in process that may presage future issues.
- be global in scope, but without sacrificing attention to national, regional, and local issues.
- operate in a continuous rather than a "one-shot" mode.
- have an institutional memory, so that suggestions that are set aside today for lack of data or interest can be reassessed in the future.
- be quantitative, wherever possible, to facilitate analysis.
- be subject to scrutiny by people outside of the process to help avoid the introduction of biases.
- make goals -- and where possible, values -- explicit.
- recognize that many futures are possible and the conditions that actually emerge are likely to be the product of a huge number of large and small changes and decisions that aggregate in a way that is unknown yet may create vastly different prospects.
- be tolerant of errors and omissions since no analytic method will eliminate the uncertainties of the future.
- encourage rather than repress imaginative views of the future that may seem "far out" today but may nevertheless represent very real threats or opportunities.
- link to and provide information to other activities of the Agency; for example, an effective early warning system should trigger R&D activities and should offer significant background for Agency planning.
- report periodically on principal findings about prospective threats and opportunities to inform the national agenda and stimulate discussion about priorities and policies.

In the remainder of this chapter, a system is described that could meet most of these requirements. Because this is one of many approaches that may prove effective, we offer this system only as an illustration of what might be done. The group within the Agency that is ultimately charged with the responsibility for such a system should design its own approach.

Figure 2 shows the major features of an early warning system.

As this figure illustrates, the approach involves three primary ways to develop information:

Scenarios (Task 1): This method involves constructing a set of internally consistent images of the future based not only on current trends but on perceptions about future developments that could change those trends. In this approach, these images of the future are studied to identify future issues and opportunities; they also serve as backdrop for analyzing the significance of issues identified by other means and for evaluating candidate strategies. This is a "top down" source of ideas about future environmental issues; that is, it builds from big, holistic images about the future circumstances that may exist.

Look Out Panel (Task 2). This approach uses experts in the field and other interested and informed participants who are in a position to observe, firsthand, public health and environmental developments and assess data pertaining to environmental stresses that could serve as early warnings of environmental changes of importance to the nation and the Agency. This is a "bottoms up" source of information about future environmental issues, that is, it is designed to provide judgments from selected participants about specific developments that may be of concern.

Scanning (Task 3): This activity involves a continual and thorough review of published information and contacts with other "futures watching" organizations. With respect to the review of published information, both formal publications in scholarly journals and informal publications in some of the newer media such as science-oriented computer bulletin boards should be included. The scope of this review goes well beyond the bounds of traditional environmental literature to include important peripheral disciplines. Further, it would be useful to include a systematic review of data that are collected

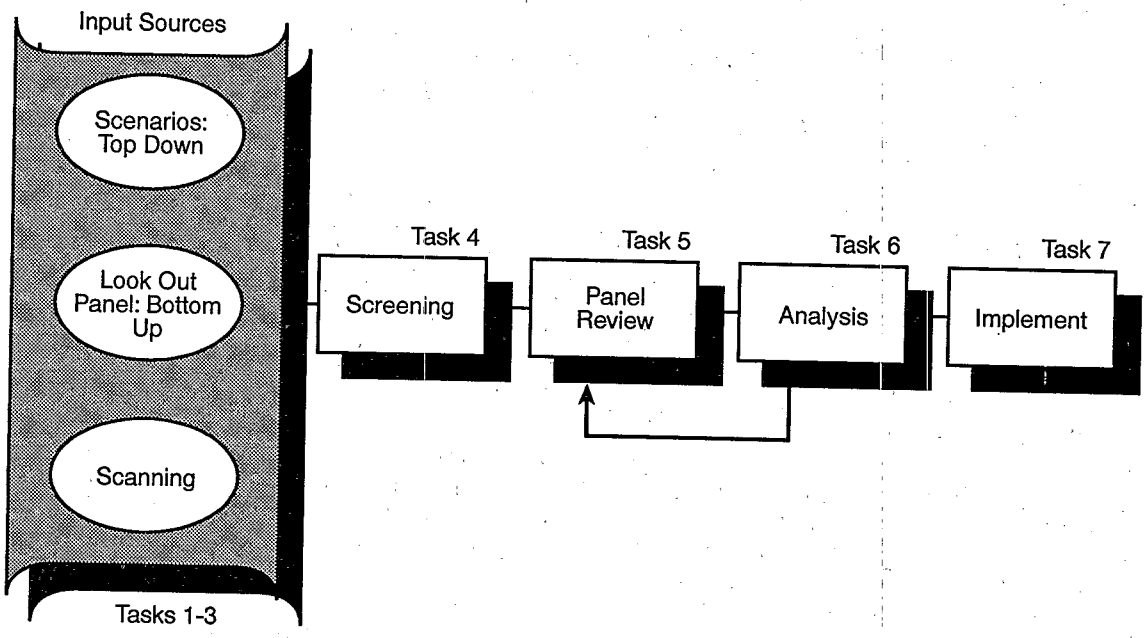

Figure 2. Major Features of the Early Warning System.

by the Agency and other organizations in the United States and abroad. Finally, the Agency should establish formal links to other "futures watching" organizations in the federal government, in foreign governments, and in industry to exchange data and perceptions about future developments that could have environmental consequences.

The information from these three sources is intended to produce an array of possible issues and opportunities for EPA to consider. Many will be uncertain and dependent on other factors; some will be of high probability, others low; some will be significant, others immaterial. The burden of the remaining portions of the system sketched above is to identify the issues likely to be of highest significance, to determine--to the extent possible--their likelihood and impacts, and to devise effective mitigation strategies, given these possibilities.

To accomplish the required assessment, each issue should be screened (Task 4) against a well defined set of criteria that, ideally, will separate those items worth considering from those of lesser significance (see Sections 4.5 and 5.5.1 for an example of such criteria). The items that pass through this filter can be reviewed and assessed by an expert panel (Task 5). This panel might consist of an expansion of the lookout panel of Task 2 or a new panel with in-depth expertise, precisely targeted at the areas related to the issues of interest.

Those items that have priority will be subjected to analysis (Task 6) including modeling, cost benefit analysis, and risk analysis to determine the most promising policy choices. The scenarios constructed in Task 1 will be useful in Task 6 since the assessment of issues suggested by the panel (Task 2) or by the scanning process (Task 3) can be based, at least in part, on the circumstances depicted by the scenarios.

Finally, when appropriate, initial implementation steps will be taken in Task 7.

These tasks are described in more detail in the paragraphs that follow.

3.1 Task 1: Scenarios[8]

A scenario is a rich and detailed portrait of a plausible future world, one sufficiently vivid that a planner can imagine and, to some extent, comprehend the problems, challenges, and opportunities that would be faced in such an environment. A scenario is not a forecast *per se*; rather, it is a synthesizing tool, a plausible description of what *might* occur. Scenarios describe events and trends as they *could* evolve.

Because of the multiplicity of forces that shape the future, their complexity and their interactions, the future that grows from the present can never be accurately or completely known. Most planners and futurists today would reject the idea that planning should be conducted against a single "most likely" scenario or image of the future, since all futures will contain surprises and no particular future that we can describe is in the statistical sense very likely.

Rather than accuracy, the measures of a good scenario are

- plausibility (telling the story about getting from here to there in a rational fashion),
- internal self consistency, and
- usefulness in decision making.

[8]This material is largely drawn from "Scenarios," a methodological report in the series produced by The United Nations University for the UNDP Africa Futures Project, as part of the Millennium Project Feasibility Study. 1994.

Sets of scenarios are used in planning. If the sets encompass a broad span of future possibilities, and plans are generated to cope with the eventualities they portray, then the plans will be robust and the future can be met with some degree of confidence. Most planners who use scenarios recommend that three scenarios -- one optimist, one neutral, and one pessimistic -- should be employed. Generally planners employ richer variations to define a "scenario space."

3.1.1 Describing Future Possible Conditions

In general, the term scenario has been used in two different ways to describe future conditions. First, scenarios are used to describe a future history, that is, the evolution from present conditions to one of several futures. These scenarios are "exploratory" and they lay out the causal chain of decisions and circumstances that lead from the present. The second approach, used primarily for "normative" scenarios, involves "backcasting" in which some desirable future state is postulated and a chain of causality is projected back from that future time to the present to illustrate how the desirable future might be achieved.

EPA planning might benefit from the use of scenarios. Some of the questions that will have to be addressed by the planning team are

- specifically, which scenarios should be included?
- how do these scenarios link to others that exist in the federal government and elsewhere?
- is there a systematic means for choosing the themes of the scenarios to be constructed?
- what should be the geographic and temporal scope of the scenarios?

Ideally, the set of scenarios chosen by EPA should encompass a range broad enough to illustrate important future opportunities and issues that might otherwise have been missed, and yet narrow enough to provide depth to arguments about the severity of future issues, the significance of potential opportunities, and the effectiveness of alternative policies.

Undoubtedly, the Agency will want to choose scenario drivers as the first step in this exercise. The Agency should include consideration of those largely external drivers that will exacerbate or inhibit future environmental issues or affect the capability to deal with these issues. These drivers include:

- population growth in the United States and abroad
- technological developments that can affect the processes through which environmental risks are generated or met
- economic factors (including consideration of personal affluence, industrial evolution and third world development) and the valuation of natural resources in terms of preservation of biodiversity, ecosystem balance, climate, etc.
- public and political awareness of environmental issues and willingness of the public and political institutions to actively pursue goals that affect the environment.

As an example, take the extremes of these four driving dimensions. Permuting these produces sixteen primary global scenario cases; many more are possible if intermediate values for these four driving dimensions are considered. These permutations are too numerous to consider simultaneously. But three of these global scenarios are particularly interesting and recommended for consideration by EPA:

Let the Future Take Care of Itself Case: High population growth everywhere, few capabilities or incentives to improve the processes that result in environmental threats, rapid economic development, and low political awareness and public activism. This combination leads to a polluted and risky future.

A Frustrating Case: High population growth in third world countries and the United States, low technological progress, low affluence, and high political awareness and public activism. Here the public will to protect and improve the environment is also high, but the means -- fiscal and technological -- to pursue desired environmental policies are low.

A Promising Case: Moderate population growth and development in third world countries, high technological progress, relatively high affluence worldwide, and high political awareness and public activism. In this scenario there is public will to improve the environment and the money and the technology to pursue enlightened environmental policies exist simultaneously.

A sketch of the possible world future conditions under these three scenarios is presented on the following page.

EPA should review the principal scenarios that have already been created by other federal agencies and consider the environmental consequences of the conditions described. These existing scenarios could provide a good starting point for the Agency's work. Useful planning scenarios may already exist at the Department of Energy (Energy Information Agency) and elsewhere.[9]

3.1.2 Adding Substance to the Scenario

Once having selected the scenario cases of interest, EPA should consider the following activities:

- define and project drivers of environmental factors in a manner consistent with each scenario case
- analyze and project environmental consequences

[9]For example, among scenarios of particular interest might be those created by
- OECD depicting some potential futures for OECD and developing countries
- California's South Coast Air Management Board
- the energy futures project of the Edison Electric Institute
- the Energy Modeling Forum (see *Energy Policy*, March 1993)
- the Network for European Communications and Transport Study (*Futures*, July/August 1992)

In addition, various country and regional scenarios have been reported in Energy Policy in the last few years, including the Middle East (*Energy Policy*, November 1990), Taiwan (*Energy Policy*, December 1990), USSR (*Energy Policy*, December 1991), Mexico (*Energy Policy*, December 1991), Korea (*Energy Policy*, December 1991), Central America (*Energy Policy*, April 1992, Sub-Sahara Africa (*Energy Policy*, January 1993), and France (*Energy Policy*, March 1993).

Drivers	Scenario 1: Let the Future Take Care of Itself	Scenario 2: A Frustrating Case	Scenario 3 A Promising Case
Environmental Attitudes	Not concerned	Deeply concerned	Deeply concerned
Population Growth	High	High	Moderate
Third World Development	High	Moderate/Low	Moderate
Technological Development	Moderate	Low	High

Domain	Features	Features	Features
Institutional Development	No follow up to Rio Conference	Rio framework results in serious effort to understand and control greenhouse gases	Rio framework results in serious effort to understand and control greenhouse gases
	Global Climate Change Convention is weakly implemented	Global Climate Change Convention is implemented	Global Climate Change Convention is implemented
	Environmental backlash in developing countries	Environmental consciousness grows throughout the world, together with great frustration about lack of accomplishments	Environmental consciousness grows throughout the world, with some satisfaction about progress shown
	NGO efforts frustrated; seem to be part of the problem	NGO efforts frustrated; funding inadequate because of adverse economic conditions	NGO efforts to improve environmental consciousness meet some success
	UN largely ineffective in achieving environmental cooperation	UN efforts in achieving pledges of environmental cooperation succeed, but costly activities are postponed because of lack of funding	UN becomes effective in achieving environmental cooperation
Business Developments	Businesses minimize environmental expenditures	Businesses minimize environmental expenditures	Firms see pollution prevention as a source of competitive advantage
	Business managers have little appreciation for environmental matters	Business managers do what they can to improve the environment but funds are limited	New breed of industrial managers have stronger environmental ethic
Energy	Energy policies unfocused in most countries	Energy policies focus on inexpensive modes but not much gets done	Energy policies geared to conservation and renewables in most countries
	Large-scale electrification	Electricity's share of total energy production remains constant	Electricity's share of total energy production remains constant
	Energy mix stays roughly the same; natural gas increases; solar and renewable slowly increase	Natural gas use grows slowly; inexpensive research is fostered	Natural gas use grows rapidly; it becomes a transitional fuel toward a predominantly solar and renewable economy
	Coal use increases dramatically in China and Russia	Coal use increases dramatically in China and Russia	Coal use increases in China and Russia

Drivers	Scenario 1: Let the Future Take Care of Itself	Scenario 2: A Frustrating Case	Scenario 3 A Promising Case
Environmental Attitudes	Not concerned	Deeply concerned	Deeply concerned
Population Growth	High	High	Moderate
Third World Development	High	Moderate/Low	Moderate
Technological Development	Moderate	Low	High

Domain	Features	Features	Features
Transportation	IC powered vehicles predominant	IC powered vehicles predominant	IC vehicles replaced by mass transit, electric vehicles, natural gas/fuel cell vehicles
Economy	Latin America and Asia have high levels of economic growth	Economic growth everywhere is moderate or low	Economic growth in Latin America and Asia is moderate
	China goes through industrial revolution	China's industrial revolution is slower	China's industrial revolution is slower
Technology	Info technologies improve efficiency	Info technologies lag	Info technologies allow decentralization
	Environmentally friendly technologies not pursued	Some environmentally friendly technologies are approved but use lags	Environmentally friendly technologies developed and are widely applied
	Mega cities in third world	Mega cities in third world	Mega cities averted
	Water treatment technologies are needed but not much is done	Water treatment technologies are needed; research is slow	Water treatment technologies are widely employed
Agriculture	Use of fertilizers and pesticides intensifies	Use of fertilizers and pesticides intensifies	Use of harmful fertilizers and pesticides diminishes; alternatives used
Education	Environmental curricula remain the same or are diminished	Environmental curricula are improved and spread worldwide; global ethics introduced	Environmental curricula are improved and spread worldwide; global ethics introduced
Consequences	Total levels of greenhouse gases and other toxins increase	Total levels of greenhouse gases and other toxins increase	Greenhouse gases and the production of other toxins are stabilized
	Agricultural activities intensify greatly	Agricultural activities intensity greatly	Agricultural activities grow moderately
	Desertification in Africa and parts of Asia	Desertification in Africa and parts of Asia	Desertification generally controlled
	Little trading of greenhouse gas reduction rights	Worldwide trading of greenhouse gas reduction rights save for future era when new facilities can be constructed in earnest	Worldwide trading of greenhouse gas reduction rights helps save many rain forests
	Massive loss of rain forests	Massive loss of rain forests	Some agricultural land returned to rain forests
	Over fishing, depletion	Over fishing, depletion, despite international conventions	International conventions reduce over fishing; aquaculture becomes major industry

Drivers	Scenario 1: Let the Future Take Care of Itself	Scenario 2: A Frustrating Case	Scenario 3 A Promising Case
Environmental Attitudes	Not concerned	Deeply concerned	Deeply concerned
Population Growth	High	High	Moderate
Third World Development	High	Moderate/Low	Moderate
Technological Development	Moderate	Low	High
Domain	**Features**	**Features**	**Features**
	Increased run off, eutrophication, pollution	Increased runoff, eutrophication, pollution	Nonpoint sources brought under control through better land management
	Accelerated depletion of species	Accelerated depletion of species	Biodiversity maintained
	Essentially no endangered species conventions	Essentially no endangered species conventions	Endangered species conventions save many species
	Increased production of solid and hazardous waste	Increased production of solid and hazardous waste but at slower rate because of low economic growth	Less solid and hazardous waste
	Environmental refugees in Africa and parts of Asia	Environmental refugees in Africa and parts of Asia	Few environmental refugees
	Environmental conflicts over war and other resources	Environmental conflicts over water and other resources	Environmental conflicts over water and other resources are averted
	Disparity between haves and have nots increases, increasing the potential for violence	Disparity between haves and have nots increases, increasing the potential for violence	Disparity between haves and have nots improves from today's levels
	Air pollution in major cities intensifies	Air pollution in major cities intensifies	Air pollution in major cities is improved
	Genetic technology advances; applied to agriculture and medicine	Genetic technology advances are slowly realized; applications to agriculture and medicine lag	Genetic technology advances; applied to agriculture and medicine
	Decreased dialogue among decision makers worldwide	Increased dialogue among decision makers worldwide	Increased dialogue among decision makers worldwide

- determine alternative policies for consideration

Among the *drivers*, the Agency may wish to consider, for example, energy supply and usage, demographic factors, economic activity, transportation, industrial production, agriculture, and institutional activities at the international, national, and regional levels.

Within each of these categories, a set of variables should be identified and forecast where possible (e.g. for transportation: the number of miles traveled per year; for social change, consumer purchasing behavior and values and mores relevant to the environment). These variables will not only add substance to the scenarios and facilitate the testing of contemplated policies but will provide the basis for tracking changes as they occur.

Among the *environmental consequences*, the Agency should consider possible impacts on a global, national and regional scale for both current and *emerging issues*, including, for example:

- natural resource depletion
- biodiversity
- human health, particularly the changing nature of risks to health and reproduction
- the sources, nature and quantities of waste products (including heat and hazardous waste production) and the markets for waste products
- land (e.g., acidification, desertification, nutrient quality), water and air quality

- water resources (quantity and quality)
- food availability
- the consequences of environmental changes from the viewpoint of stakeholder communities including state and local governments, industry, labor, and various interest groups

Among *alternative policies*, we suggest that the Agency include examination of "paradigm shift" policies as well as policies that respond to the specific issues that are raised by the scenarios. Among the "paradigm" shift policies are sustainability, industrial ecology, preservation of reproductive vitality, life cycle analysis, intergenerational responsibility, and pollution prevention.

The discussion to this point has focused on *exploratory scenarios*, that is descriptions of plausible self consistent images of what might be expected. A second type of scenario is also important: *normative scenarios*. Normative scenarios are visions of what might be. Scenario 3 described earlier is an example of a normative scenario. Generally, they reflect some single unifying concept of a desirable future that serves as an organizing principle; sometimes normative scenarios result from goal-oriented group process in which individuals or representatives of grass roots organizations interact to articulate desirable goals or end points. Probably the best current example of an organizing principle is *sustainable development*, a concept that was proposed by the World Commission on Environment and Development in 1987.[10]

One of the most promising approaches to forming normative scenarios is "backcasting." In this technique, an image of a desirable future is formed, for example in the form of a description of some future society. The burden of the scenario is then to describe the paths that lead from "there" to "here" in a plausible and self-consistent manner.[11]

The EFC recommends that the Agency form a number of normative scenarios and use them as the basis for collecting and focusing desirable images of the future. These can be the basis for public outreach and can provide cohesive and compelling images of the futures to which the Agency is aspiring.

3.1.3 An Example of the Use of Drivers/ Scenarios

In their environmental future project, EPEC explored and found useful an approach for futures analysis based on the principles developed in "Reducing Risk" (EPA-SAB-EC-90-021) and the Framework for Ecological Risk Assessment (EPA/630/R-92/001). Their approach is repeated here as an example of the kind of scenario-derived problem analysis that might be conducted in Task 1.

A matrix approach is used to evaluate and communicate the intensity of potential ecological effects, the uncertainties of these estimates, the types of ecological responses and the time scales for ecological recoveries following removal of stressors. This approach appears to provide a rational basis for evaluating ecological and other problems at various spatial scales (e.g., local, regional, national, and global) and temporal scales (e.g., 20 years, 100 years). Similarly, this framework provides a process for analyzing stressors and effects, characterizing risks and examining consequences of risk management decisions.

The premise of the ecorisk approach is that adverse effects occur as a result of exposure to one or more stressors. While the foundations of the approach explored by EPEC come from ecological risk assessment, the approach appears to have wider utility in futures analyses in other areas.

The conceptual model for futures analysis provides a methodology for identifying the interactions between drivers (ultimate causes of change), stressors and ecological endpoints, delineating the causes and effects of environmental changes, and exploring ways in which management actions can prevent, influence, and/or mitigate environmental risks. Figure 3 illustrates the elements of the conceptual model.

The use of the conceptual model incorporates a scenario approach with the decision-making framework used for risk assessment. (These may in fact be the same scenarios as developed in Task 1.) Future scenarios are developed using assumptions about driving forces, and the effects of these scenarios on endpoints of concern (ecological health) are determined using the ecological risk assessment framework. The results of the exercise can be used to identify possible consequences and to identify actions that can be taken to avoid or minimize effects (risk management). The process of using the approach appears to foster the development of a strategic vision, and may promote nimble responses to unforeseen events.

The first step in using the conceptual model is to define "drivers"--the major variables that determine trends in resource use. The primary drivers are anthropogenic factors that affect the stressors in some fashion. Table 1 lists some primary drivers, stressors, and ecological endpoints used by EPEC in evaluating alternative energy scenarios.

During the actual scenario development, EPEC found it useful to consider more detailed subcategories of these primary drivers in order to create a more focused story or scenario. For example, assumptions about human population growth and distribution might include increasing proportions of urban, as opposed to rural, populations worldwide. Similarly, assump-

[10] World Commission on Environment and Development. 1987. "Our Common Future," also known as the Bruntland Commission. Published by the United Nations.

[11] The Science Advisory Board received several examples of normative scenarios in the presentations leading to this report. These included the work of the 2050 Project of the World Resources Institute, which is an example of such an approach. This project asks, "Under what conditions will global sustainability be reached in the next century?" Another project based on a future scenario image is the Sustainable Agriculture and Research Program (SARE) of the U.S. Department of Agriculture. In this work, for example, one type of domestic agriculture is practiced on the Twenty-First Century Diversified Farm," which is farmer operated, a partnership of not more than three families, emphasizing use of on-farm resources, in which hired-worker days usually do not exceed farm-family worker days."

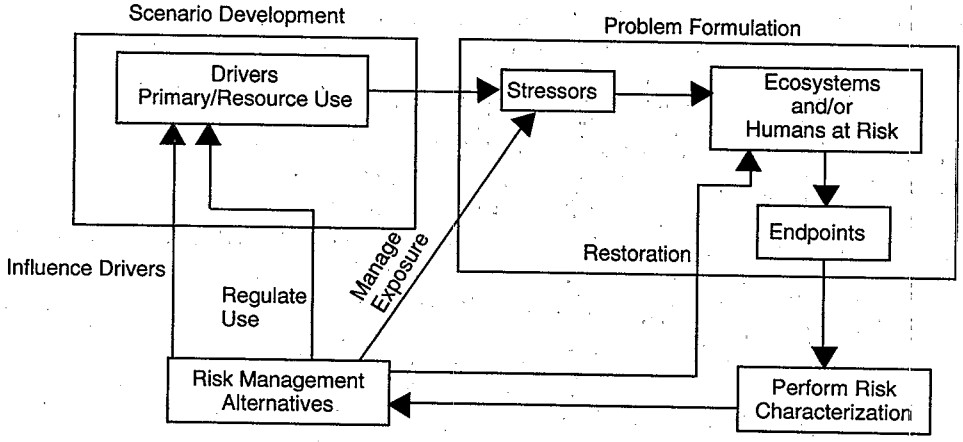

Figure 3. A Conceptual Model for the Use of Futures Analysis in Environmental Risk Assessment.

Table 1. Initial List of Drivers, Stressors and Ecological Endpoints

Drivers	Environmental Stressors	Ecological Endpoints
Government policies	Global climate	Ecological condition
Population growth/ distribution	Habitat alteration	Species
Globalization of economy	Stratospheric ozone	Population
Unequal distribution of wealth	Biological depletion	Community
Consumption per capita	Herbicides/pesticides	Ecosystem
Education	Toxins in surface water	Landscape/region
Energy	Acid deposition	Habitat
Urbanization	Airborne toxins	Biodiversity
Water availability	Nutrients	Productivity
Environmental ethics	BOD	Products and services
Resource ownership	Turbidity	Welfare/vista/aesthetics
Resource depletion	Oil	Community
Agriculture	Ground water contamination	Population
Technology development	Radionuclides	Community
War	Acid inputs to surface water	Ecosystem
	Thermal pollution	Community
	Exotic species introduction	Community

Source: Reducing Risk: Setting Priorities for Environmental Protection (EPA-SAB-EC-90-021).

tions about technology development and use might include broader use of existing industrial technologies in the developing world or development of more environmentally benign technologies distributed globally.

Stressors. After the initial scenario is developed the next step is to determine the implications of the scenario for endpoints of concern. The process can take advantage of already-existing paradigms for predicting ecological effects; the ecorisk framework provides a method for identifying the causes of ecological change or damage, termed "stressors" and evaluating the effects of these stressors on ecosystem components. EPEC concluded that for assessing ecological futures the stressors identified in "Reducing Risk" were the most significant in influencing future environmental problems and continue to pose the greatest risks to the integrity and sustainability of ecosystems (Table 1).

Linkages Between Drivers and Stressors. Each of the drivers may influence ecological stressors. A matrix approach is an effective way to determine and communicate the relationships between the anthropogenic drivers and the ecological stressors and to determine which effects are the most significant. Table 2 illustrates a matrix developed by EPEC for a scenario involving unlimited energy at a global scale with a time horizon of 30 years. For each driver and stressor, the direction of the linkage was characterized as positive (+) , negative (-) or scenario = dependent (+/-), and the strength of the linkage

Table 2. Strength of Linkages Between Divers and Ecological Stressors (Global Scale, 30 years)*

Drivers/ Stressors	Climate Change	Habitat Loss	UVB Levels	Pesticide Use	Pollution	Nutrient Enrichment	Exotic Species
Population	H+	H+	L+	H+	H+	H+	L+
Consumption per capita	H+	H+	L+	L+	H+	H+	M+
Globalization of economy	M+/-	H+/-	L-	H+/-	M+/-	L+/-	H+
Technology	M+/-	M/H +/-	L-	H+/-	M+/-	M+/-	H+
Education	L-	M-	L-	M-	M-	L-	M-
Envir laws policies	M+/-	M+/-	H-	H+/-	H+/-	H+/-	L+/-

*The linkages were designated H-high, M-medium, or L-low and + or - indicates that the stress is increasing or decreasing.

or association was classified as high, medium, or low. For example, an increase in the rate of population growth would be expected to be strongly related to an increase in habitat loss, while stabilization of population growth would be strongly related to a decrease in the rate of habitat loss.

Assessment Endpoints. Assessment endpoints identify those particular characteristics of systems that can be used to characterize the health of the system. In the ecological arena, a suite of ecological endpoints is necessary, explicitly cutting across organizational hierarchy (i.e., organism, population, community, ecosystem, and landscape levels). These endpoints are ecological characteristics, but they are selected to include both things of importance ecologically, (e.g., biodiversity, primary productivity, critical species) and things that are important to humans (e.g., endangered species, and aesthetic, nuisance, or economic disbenefits). A matrix approach similar to that used to link drivers to stressors can be used to link stressors to assessment endpoints.

Mitigation. An important component of the conceptual model for futures analysis outlined in Figure 2 is risk mitigation. Once the risks associated with a particular scenario are identified, formulation of strategies for mitigating or managing the risk can be explored. These may include action on the drivers, stressors, or endpoints. The management options emerge from the generation and analysis of the scenario and characterization of the risks associated with the specific problems defined. Examples of specific risk management strategies might include:

- *Influence the drivers*: The risk is managed by impacting the primary drivers of environmental change. Examples of this approach include changes in regulatory mandates, globalization of the economy (NAFTA or GATT, etc.)
- *Regulate the Use of Resources*: Risks can be reduced at the level of resource utilization through a variety of measures including land use plans, energy utilization controls, water allocation, and timing of resource use.
- *Exposure Management*: This option controls impacts of stressors by limiting or controlling exposure of specific ecosystem components to stress. Innovative technologies that either prevent pollution by process modification or materials substitution preventing the release of materials that can impact the ecosystem are examples that might be considered in this option.
- *Restoration*: Restoration includes a variety of remediation technologies, as well as reintroduction of endangered species, revegetation, etc.

In any case, the analysis can be conducted against a set of "goals and vision statements" that, in the aggregate represent the desired future state of the environment. These visions would, to the extent possible, be in quantitative form and maintained by staff, but informed by a wide variety of inputs from interest groups, experts, policy makers, and others. The techniques for deriving these goals and visions are not suggested here but must include a wide range of outreach techniques that include public meetings.

Policies suggested by the analyses would be tested analytically and could be fed back to the panel for qualitative judgment in Task 5. Those policies that are found to bring the expected future state closer to the desired goals and visions would be recommended for further study or implementing action. In addition, scenario analysis can lead to the identification of options that appear to be useful in all of the scenarios; these clearly are "good bets." Finally, options will be identified that are designed to collect additional information so that the extent of a potential issue can be better assessed.

3.1.4 Final Comments About Scenarios

The EFC recommends that the Agency make a deliberate effort to use material in its scenarios that has been produced by other organizations located in the United States and abroad. It is probably unwise to seek consensus about scenarios among institutions concerned about the future, since much of the benefit of scenarios derives from the act of constructing the scenarios and reasoning through the causal impacts they depict. But, reviewing the scenarios of other institutions will help trigger ideas about change, ease the burden of data collection, and improve communications. EPA might take the lead in establishing a clearinghouse for such information, particularly with respect to environmental scenarios, or it might participate in a consortium that would focus on the findings of future oriented studies.

The scenarios produced by the Agency could be included in a biennial "State of the Environment" report. One of the principal features of this report could be the presentation of the forecasts of range of the variables included in its scenarios, for examples, indicators of sustainability. (See Task 7 for further

discussion about dissemination of the results of the early warning activities of EPA.)

3.2 Task 2: Look Out Panel

The scenarios of Task 1 are "top down" (i.e., the big picture giving rise to images of future environmental issues). By contrast, the look out panel of Task 2 uses "bottom up" (that is, ideas about future issues and opportunities are generated by individuals who, by virtue of their experience, knowledge, and observations, perceive incipient problems and nascent opportunities).

The panelists involved in this enterprise are contacted on-line, through the mail, or by FAX and asked to scan their fields and provide observations about new or intensifying issues or nascent opportunities that might face EPA (Task 2). They are also asked for judgments about developments suggested by other panelists, the possible causes of the reported developments, and policies that might be useful (Task 5). The EFC suggests that a medical metaphor might be appropriate: panelists will be asked for judgments about **symptoms** of newly emerging or future environmental issues, **diagnosis**--that is, the possible causes of the issues , and **therapies,** the options that might be effective in addressing these issues.

Because in any practical design, the number of respondents will be small, a "look out" panel cannot produce statistically significant results. The results provided by the panel will not predict the response of a larger population or even the findings of a different panel. They will represent the synthesis of opinion of that particular group, no more or less.

Since the value of an EPA "look out" panel will depend on the knowledge and cooperation of the panelists, it is essential to include persons who are likely to contribute valuable ideas. In a statistically based study such as a public opinion poll, participants are assumed to be representative of a larger population. In panels of the sort we recommend, nonrepresentative, knowledgeable persons are needed. The panelists not only must be expert in their disciplines, they also must be able to think broadly about environmental problems encompassing many fields. They must be willing to step beyond the usual confines of strict scientific knowledge and "create" a future. EPA laboratory directors, division directors, state environmental personnel, and representatives of environmental action groups might be included in the group invited to participate.

EPA recently funded a study at the United Nations University to investigate the design of such a panel. Among the key findings of this study that are relevant to the design were

- Candidate panelists can be identified through systematic literature searches, nomination by two or more peers in "daisy chain" fashion, and through recommendations of professional organizations.
- Panelists should be compensated for their time and reimbursed for the cost of communications.
- Important qualifications of panelists are his or her discipline, experience, work, and interests. There should be a deliberate attempt to include search mechanisms that seek out creative thinkers and diverse viewpoints. The panel should be global in outlook.
- The composition of the panel should change over time; rotation is to be encouraged to bring fresh minds and views into the process.
- Communications media should include E-Mail, post and FAX. E-Mail, while convenient for the staff, may not expedite two way communications or not be available to all those invited; FAX is most expensive.
- To the extent possible, questions of fact should be directed to those panelists who are expert in that area. Panelists should be able to excuse themselves from answering questions about which they are not expert. (Note: as in EPA's Scientific and Technological Achievement Awards grading system, panelists could state their degree of expertise/experience/knowledge when they answer.)
- Panelist responses should be anonymous when fed back to the group as a whole, although the list of participants should be known to all.[12]

EPA should consider a second, broader, less formal panel as well. This panel would be open to contributions from anyone. In particular, as an experiment, EPA might establish a supervised computer bulletin board on Internet and some of the other computer communications services. The bulletin board could serve as the basis for collecting observations about incipient issues and prospective policies, and provide the medium for debate and discussion about these subjects .

3.3 Task 3: Scanning

This task is designed to generate ideas about potential issues and opportunities through the systematic and continuous review of news about current scientific and technological developments important to the future of the environment. Presently, we believe that there are at least three major elements to be considered: literature review, data base review, and coordination with other agencies.

Literature Review. The literature review should include selected professional journals both within and outside of the environmental disciplines. For example, an engineering journal might provide an early indication of the introduction of a new material; a policy journal might give an indication of public policy that has environmental overtones. Because the literature of possible interest is so immense, a means must be designed to assure high efficiency searches.

The designers of this system should consider subscribing to and reviewing

[12] Gordon, Theodore J. and Jerome Glenn, *Issues in Creating the Millennium Project*, UNU. October 1993. This report also conducted a "test run" using an international panel to identify and evaluate some important future environmental developments as well as to produce a forecast of population size in several countries and regions. This work was funded by OPPE.

- A set of professional journals. Individual staff members should be assigned the responsibility of reviewing and periodically reporting on "early warning" items they find. Some of these journals should deliberately go beyond the immediate environmental disciplines; for example, journals that might be of interest include Technological Forecasting and Social Change and The Social Indicators Network News.
- On-line data bases such as Dialogue or ProQuest (a CD ROM abstracting service). This will provide access to and a means of quickly searching a much wider set of publications. The use of carefully selected search terms will improve the efficiency of this activity. When the review of abstracts indicates a potentially important article, the full text can be obtained for detailed review.
- "Unofficial" media such as selected computer bulletin boards. Several existing bulletin boards or special interest groups might be scanned periodically for information of interest; in addition, as mentioned earlier, it might be worthwhile to experiment with an Internet panel to be created by EPA that invites anyone with access to contribute their observations about incipient changes or threats to the environment.
- Abstracts of presentations and papers delivered at symposia to identify new findings as early as possible. Other potentially important sources include conference and workshop summaries, funded research proposals, and dissertation abstracts.
- Synthesizing publications. For example, *Science News* publishes a weekly "news magazine of science;" *Future Survey* publishes monthly abstracts of articles and books dealing in some way with the future based on a continuing review of the field. A recent issue of *Futures Survey*, for example, uncovered three dozen or so newly published books and papers dealing specifically with environmental issues, many of them containing "early warnings."

Analysis of Quantitative Data Bases. EPA staff could select several sources of data collected by the EPA or other organizations and analyze, track, and forecast these data as a further source of early warning information. In particular:

At EPA, the Environmental Monitoring and Assessment Program (EMAP) is designed "to provide a comprehensive, integrated national database of environmental conditions." EMAP is a geographically oriented database designed to integrate health data and geographic data. Many states use Geographic Information Systems (GIS) for correlating and mapping natural resources and structures. Adding census information and appropriate health or ecological data will provide a framework for ongoing investigations of potential environmental problems. The EMAP system might well be an important source of quantitative information about future environmental risks. For example, by correlating past changes with demographic, societal, and economic factors, forecasts of future conditions could be made. Furthermore, these forecasts could be prepared under the assumptions implicit in the scenarios prepared in Task 1A. This could result in a system capable of tracking future environmental expectations and provide the raw material for issue identification.

A second EPA program may also provide significant early warnings to the proposed system. OPPE is considering whether or not to establish a technology monitoring and forecasting program that will review technologies in the design and development phase to anticipate environmental consequences that might flow from their wider use. This activity could also help establish issues to be monitored.

Two other examples of tracking systems that could be used in a similar manner are

> Worldwatch Institute's Vital Signs report on Trends That are Shaping Our Future (Lester Brown, Christopher Flavin, and Hal Kane, Worldwatch Institute, 1992). This report examines trends in food, agricultural production, energy, the atmosphere, the environment and other domains, and present brief essays and charts depicting key indicators to back up their assertions.
>
> World Resources 1992-93, published by World Resources Institute (Allen Hammond, ed. March, 1992). This is the fifth in a biennial series and focuses on sustainable development.

In addition, the Agency should consider setting up a system in which selected quantitative data bases generated by EPA and other organizations are periodically tapped and analyzed to determine whether past trends are changing. Through regression analysis and other statistical techniques, the correlates of change may be determined and scenario-based forecasts produced.

Coordination With Other Agencies. Formal and informal networks of planners within federal agencies have been formed in the past; wherever the opportunity for participation exists, EPA should continue to be represented or lead in the formation of such groups. The Inter-Agency Consortium on Emerging Issues represents a good example. It was constituted particularly to facilitate the exchange of information about "weak signals" in the operating environment that had been detected by various government planners and forecasters, including USGS, IRS, EPA, NASA, CIA, VA, USBM, and DOD. EPA should investigate the possibility of revitalizing it.

Contact should also be established and maintained with international groups engaged in environmental planning such as the Dutch Committee for Long Term Environmental Policy. Finally, it may be useful to maintain contact with the 2050 Project of the World Resources Institute.

3.4 Task 4: Screening

In the next step, new ideas about future issues generated in Tasks 1-3 are screened for relative importance. Screening is necessary because the volume of issues to investigate will be large. Therefore, the challenge in this task, is that issues of high significance must be distinguished without losing sight of others that may become important later (See Section 5.4 and Appendix B).

The screening step, Task 4, would employ criteria such as

Timing: How soon is this problem likely to emerge, how important is early recognition, and how rapidly can the problem be reversed?

Novelty: To what extent is this a new problem that has not been addressed adequately?

Scope: How extensive—in terms of geography or population affected, for example—is this problem?

Severity: How intensive are the likely health, ecological, economic, and other impacts of this problem, and are they reversible?

Visibility: How much public concern is this problem likely to arouse?

Probability: What is the likelihood of this problem emerging, and necessitating a response, in the future?

A utility matrix (a standard operations research technique) may be constructed to estimate a "score" for each issue. If this approach is used, weights are assigned to each criterion; the weights represent the perceived contribution of each to the relative importance of an issue. A matrix is constructed with the issues on the rows and the criteria in the columns.

Each issue is evaluated with respect to each criterion and the judgments are recorded in the intersecting cells. Finally, "scores" are produced for each issue by taking the weighted sums across the rows. While the use of such an approach can produce "scores" for each issue, these should be considered only in a relative sense to separate the top of the list from the bottom. An example of this approach appears elsewhere in this report (see Section 5.5.2.2 and Appendix E).

3.5 Task 5: Panel Review

The steps discussed so far include a list of potential issues generated for Tasks 1-3. The issues came from the scenario activity (Task 1), the look out panel (Task 2), and the scanning process (Task 3). These issues are screened according to the criteria used in Task 4 to produce a list of top priority issues. Now the key question is "are these prospective issues likely to be real"? To answer this question for a subset of issues, it may be necessary to convene a second panel in Task 5. The members of this panel are different, and perhaps broader, than those constituted in Task 1; they must have in-depth knowledge of the specific issues under study and the ability to look beyond today's world and imagine future circumstances important to the environment. In this Task, the panelists are asked to comment on the issues about which they are expert and on matters such as timing, scope, severity, visibility, novelty and probability; that is, the criteria used to judge the priority of issues, as well as underlying causes for the issue and possible policies that could prove ameliorative.

3.6 Task 6: Analysis

Those issues surviving the scrutiny of Screening (Task 4) and/or Panel Review (Task 5) flow to Task 6, Analysis. The central objective of this task is to perform the required quantitative assessments of key potential issues, to determine their likely scope, severity, and probability as well as to define candidate policies and their costs and benefits. In short, the output of this task will represent an early evaluation of the extent of the problem. This work would be accomplished by staff, appropriate Scientific Advisory Committees, and outside consultants.

The analysis would be conducted against the backdrop of the reference scenarios developed in Task 2. Some issues will gain in intensity as a result of the scenario in which they are placed, others will become less important.

Many different techniques should be employed in this task; to name a few, econometric and cost benefit modeling, public opinion polling, in depth interviewing, structural modeling and other systems analytic techniques, and agent adaptive modeling (of the sort being developed by Brookings Institution as part of the World Resource Institute's 2050 Project).

3.7 Task 7: Implementation

The burden of this task is to start the ball rolling toward implementation of effective policies. If the output of the monitoring system is simply a set of reports, a great opportunity will have been missed. Instead the EFC envisions that the process described here will have multiple dissemination and action paths:

- The look out process will produce information of value to R&D planning: future issues will be identified by this process that should trigger new research programs or create changes in existing programs that are part of the Agency's current or long-range and strategic research plans.
- Long-range planning by the Agency may be affected by Agency responses to these recommendations; hence the process should be tied into Agency planning. The addition of a futures component should help the Agency to take a more strategic approach to developing partnerships and cooperative ventures with other relevant federal agencies, and industrial, academic, and NGO stakeholders.
- Assessment endpoints should be developed for selected issues to monitor changes and report their status so that trends can be evaluated. A future-oriented "State of the Environment" report can be issued in both hard copy and on-line. A report of this sort will be publicly important and a major dissemination medium.
- The process should provide fresh examples of risk assessment issues and insights into emerging patterns of human activities. Analysis of these activities and their potential environmental impacts and the implications for human exposure to stressors should contribute to risk reduction plans within each program office and within each EPA region.

These are just examples. A survey should be conducted of Agency activities that could benefit from look out type information; the process recommended here should become a source of data for these activities.

EPA regions must also be actively involved in this process. Regions are likely to encounter many early warning signs of environmental problems through their own observations and monitoring, and through public inquiries and citizen complaints which they routinely handle. The scanning system, look out panel, and scenario building process must be sensi-

tive to this information. Output from the futures analysis process may assist the regions in communicating with the public, businesses and institutions.

Furthermore, this process should have the ear of the highest level of management at EPA. Quarterly briefings should be prepared for management; this will not only be a vehicle for transferring action recommendations, it will also help legitimize this process within the organization and aid EPA planning and budgeting processes.

Finally, implementation of the early warning process carries an obligation for EPA. If it is implemented, EPA must not only provide a suitable budget for the process, but must be prepared to act on early warnings that the process may evoke. Some of these warnings will inevitably prove incorrect; nevertheless, if expectations are raised without appropriate budget and follow through, the level of disappointment will be high, and the sense of missed opportunity will be disappointing and frustrating both to the public and to those who have participated in the various steps. On the other hand if the Agency can focus on this enterprise, a sense of dynamism, active problem avoidance and forward-looking policy making may provide the Agency unifying cohesion and creative energy.

4.0 Considerations for the Future

4.1 The Importance of Driving Forces in Shaping Environmental Issues

Future environmental issues and hence, environmental quality, will be affected by the interaction of economic, technological, behavioral and other factors that stimulate change in the condition and thought processes of everyday life. These factors, known as "driving forces," contain possibilities for both improving as well as diminishing environmental quality. The loss of environmental quality and the wasteful consumption of natural resources may influence the choices available to a society for maintaining or changing its standard of living and sustaining its citizens. Any attempt to anticipate or preempt future environmental problems must take such driving forces into account, for ultimately they establish the structure within which policy options will be identified and implemented. The potential environmental effects of several major driving forces are discussed below.

4.1.1 Population Growth

High population growth rates are likely to produce long-term environmental degradation. Urban areas are likely to grow even faster, multiplying the number of urban areas that approach the status of mega-cities, with inhabitants numbering in the range of ten to twenty millions. The requirements for adequate housing, water supply and sewerage infrastructure, transportation, police and other services (which are currently unsatisfactory in many American cities) are greater than at any previous time in human history.

Population growth in cities and elsewhere is likely to increase demand for energy, particularly for fossil fuel based energy sources that are at the heart of the concern over global climate change. Any effort to minimize environmental impacts related to population growth will require a variety of economic, legal, institutional and technological changes--such as eliminating subsidies that promote the use of fossils fuels and water resources, privatizing state owned industries, providing farmers with private property rights on the lands they till, and improving the distribution of information on issues ranging from agricultural to human fertility.

Population growth and its impact upon the environment is very likely to exacerbate national security concerns in the future. The following is an abbreviated scenario describing this potential issue:

> As population levels increase in some developing nations, more ecologically sensitive areas are converted to agricultural uses, large numbers of people move from rural to urban areas, and in many cases fundamental human needs are not met. Under these conditions, population growth increases the number of refugees who move from areas no longer able to sustain them. Instability of governments follows.

4.1.2 Per Capita Income Growth and Energy Use

It is likely that real *per capita* income and the standard of living will increase in many developing countries of the world. Currently, Latin America and the Asian Pacific Rim economics are experiencing rapid economic growth. Over time, economic growth is also likely to occur in other Asian nations and Central and Eastern Europe. This development, coupled to population growth, will result in greater consumption of energy and consumer goods. Although energy growth need not be directly proportional to GNP growth, there is no doubt energy use will rise dramatically in the developing world and will soon dominate energy markets worldwide. According to Department of Energy projections, energy demand in developing nations is likely to reach 240 quadrillion BTUs (quads) by the year 2010, an increase of over 40 percent in 20 years. During the same period, U.S. energy demand is projected to reach 105 quads, a 26 percent increase. By 2010, developing nations could account for more than half of the world's total energy demand. This level of growth is likely even if *per capita* energy consumption in developing countries remains at much lower levels than in the industrialized world.

The strategies employed to provide increased energy services will have a profound impact on the environment. If countries such as China and India choose to generate electricity with conventional coal technologies with minimum controls, the local, regional and global environmental impacts will be substantial. On the other hand, strategies to achieve high levels of efficiency and the use of cleaner fuels could greatly ameliorate what otherwise would occur--significant environmental deterioration.

4.1.3 Technological Change

Ongoing technological change could create a variety of opportunities for environmental improvement, but whether this occurs depends upon the soundness of the economy, creation of regulatory incentives, and a cultural change that values environmental protection. Technological change is accelerating at the highest rate in history and this rate of change probably will increase.

Fundamental technological changes are underway and their impacts can only be guessed. These include new systems of manufacturing, accelerated rates of diffusion of new technologies, miniaturization, new information technologies, virtual

reality, new imaging systems, biotechnology and genetic engineering. We have already witnessed how technological change alters workers' and managers' roles and opportunities (positive and negative), reconfigures the setting where work actually occurs, and confronts business, governmental and social organizations with the need to alter their missions and capabilities to retain their effectiveness.

The driving forces that will shape the future environment are all interrelated. Higher rates of population and *per capita* GNP growth are reasonable expectations for the future; together these forces will create new demands for energy and manufactured products. Over time, higher *per capita* income, combined with improved education and an expanded range of personal choices, should reduce population pressures. Technological choices could exacerbate or ameliorate environmental pressures and affect the rate of *per capita* consumption as well. Cultural values and the manifestation of those values in national policies could influence how effective institutions, both national and international, will be in integrating environmental values into commitments to protect environmental quality.

Such driving forces are not immutable. All are subject to public policy and personal choices. Family planning information and other measures could reduce the rate of population growth. Free trade and investment can affect *per capita* GNP growth. Technology choices can affect the quality of the environment if they introduce inherently less polluting processes and products, or by providing the means for coping with environmental problems (such as insufficient drinking water supplies). Energy policies that encourage the use of cleaner fuels and improved efficiency could reduce the environmental impacts from energy use. These and other examples offer evidence that the environmental future can be chosen.

At present, most environmental policies seek to limit the impacts of technologies and products already in commerce; regulation of this sort may be too cumbersome and inefficient to keep pace with a dynamic marketplace. Perhaps the most fundamental challenge, therefore, is for environmental values to become part of the of the design process of future technologies so that technologies are intrinsically less risky. Creative incentive systems incorporated into a regulatory framework should induce industry to make choices that favor environmental protection.

The central challenge of technologies of the future will be to match the precision necessary to achieve a specific goal with the flexibility required by the user. By recognizing these core technological values, innovators, corporations, governments, and consumers can begin to conceptualize how environmental values might also be served through the process of technological creation, chance and diffusion. Concepts regarding "Design for the Environment" provide an initial glimpse at the possibilities for integrating technological and environmental goals, but such thinking is still in its infancy. More importantly, the structure of the creative process, and the myriad number of decisions by individuals and organizations that influence that process, must incorporate the promotion of environmental values as one of the central reasons for technological change.

4.2 Environmental Issues Can Affect Foreign Affairs

4.2.1 Issues That Cross Political Boundaries

In the next few decades, the world will face a unique problem. Individual countries, now poor, but with every justification, seeking to provide their citizens a better way of life, will through their actions or inactions have the ability to affect the environment of their neighbors and in many instances the world. This potential stems from the drivers of population growth and economic development and from concomitant environmental issues that may include for example allocation and uses of shared water resources, hazardous waste generation and disposal, and emission of greenhouse gasses and particulate matter. All of these imply transborder impacts and hence are potentially subjects of foreign policy. The goals of development and environmental quality may easily come in conflict. The issue is potentially divisive and has already been stated as a developed/developing world dichotomy.

Yet all nations can benefit or suffer in the future from the outcome of this issue. New models of cooperation must be found. These should be based on equity and fairness. Neither in fact nor perception can these models limit any developing nation's ability to choose its own course of development. But the models should include means for facilitating mutual understanding of the goals that may be in conflict, promote understanding of the matters at stake, and arrange for the efficient transfer of technical and financial assistance in the interest of all parties, but with a particular sensitivity to the needs of the developing country.

4.2.2 Environmental Quality as a Foreign Affairs Issue

There is a clear and important link between the need to protect the environment and foreign policy. Opposing forces have used environmental destruction as a major instrument of war. Population growth, terrorism, and nuclear proliferation each has major implications for public health and the environment. The U.S. Congress enacted legislation over two decades ago requiring the executive branch to recognize the "worldwide and long-range character of environmental problems" in the nation's foreign policy.

These examples reinforce the view that environmental issues will comprise a large and growing element of U.S. foreign policy. America will be faced with many more environmental and natural resource-based security challenges in the future. As a result, global environmental quality issues represent one of the single most important strategic issues that will face the U.S. at the dawn of a new century.

While the threat of global nuclear confrontation has diminished, the threat of regional conflicts, terrorism, and pollution has increased. The potential future loss of critical environmental resources, such as forests or the use of water bodies,

may be as critical to the U.S. as the loss of access to imported oil today. The loss of either threatens the stability of economies and governments because it limits their ability to sustain their population.

However, the U.S. government's thinking about the role of environmental issues in foreign policy has emerged on an *ad hoc* basis. What is lacking is an umbrella framework that (1) articulates the nation's foreign policy objectives related to the environment; (2) identifies various risk contingencies and presents the criteria for undertaking economic, diplomatic, or political action to respond to such contingencies; (3) assesses any necessary policy or treaty modifications to enable the U.S. to achieve its environmentally related foreign policy objectives; and (4) encourages all nations--through the UN or bilaterally--to incorporate consideration of environmental matters in their foreign policy initiatives.

5.0 Identification and Selection of Issues for the Future

5.1 Overview of the Approach

Following the development of methodologies for the "top-down" scenario approach and the "bottom-up" approaches of environmental scanning and "lookout" panels, the EFC agreed to act as a pilot Look-Out panel to evaluate the methodology and develop a list of environmental issues of concern for the future. No constraint was place on the fields that the proposed environmental issues could cover, and they were not limited to issues for which EPA has or might have mandates. The EFC invited the Standing Committees of the SAB, their members, and members of the EFC to submit possible environmental issues of the future. The collected issues were collated, refined, and analyzed for significance using a set of criteria developed by the Specific Issues Group and modified by the EFC. Issues selected, based on their significance, were examined in further detail. Individual issues were consolidated into a number of overarching issue areas that were used by the EFC to illustrate the values of foresight methodologies.

5.2 Principal Limitations to the Pilot "Lookout Panel"

There are several important differences between the EFC activities and the functioning of a continuing "lookout panel." The EFC not only collected and examined future issues, it undertook, to a limited degree, the analytical tasks of screening, identifying, or generating issues by different methods, activities that are beyond the defined scope of a typical, continuing "lookout panel." It also developed a set of screening criteria. It did not carry out the full task of analysis or of identifying 'symptoms,' engaging in 'diagnosis,' and prescribing 'therapy,' as described in Section 3.0.

There are several further limitations to the EFC's work. These limitations were inherent in the Environmental Futures Project itself and in its timing. For example, the effort made by the EFC was, as it could only be, a onetime effort. This created limitations that would not be encountered by a continuing "lookout panel;" such a continuing panel could learn by experience and could apply that learning over time. In this case, the SAB did limited analysis of a few methods to define future issues and the issues proposed were discussed only in brief.

While the membership of the EFC was chosen to bring a broad set of backgrounds and experiences to the Environmental Futures Project, it was not selected with the "lookout panel" approach in mind; the approach had not been defined at that time. In contrast, a continuing panel or panels, such as those the EFC recommends for the Agency, should have available a variety of participants with appropriate expertise for evaluating trends in particular drivers, scanning for early warning signals for environmental change or responses to stress. Although the EFC had the advantage of numerous excellent presentations by EPA staff and by outside experts with many different, relevant backgrounds, it could only serve effectively as a limited, pilot "lookout panel" to illustrate and demonstrate some aspects of the concept.

The EFC had adequate staff assistance for its originally conceived purpose and to complete its fundamental task. However, a continuing "lookout panel" would have to have a support staff dedicated to futures work that would bring to bear a degree of continuity and experience that could not be provided on a onetime basis. For example, the Agency may wish to establish "Look Out" Panels for scientific and engineering disciplines and develop networks and procedures to scan routinely for information and trends associated with various driving factors or program components.

5.3 General Outcome of the Pilot Effort

With all of these limitations, the pilot effort of the EFC was therefore only a onetime, truncated simulation of an ongoing "lookout panel" plus some additional activities. But the diversity of talent and information actually available to the EFC was such that the EFC's pilot effort resulted in (a) significant suggestions and recommendations for the design and operation of continuing "lookout panels," properly staffed and supported; (b) suggestions for approaches to be taken in collating, selecting, and identifying significant future environmental issues; and (c) suggestions for major environmental issue areas of potential, future interest.

There is a key point with respect to the results reported in this document and also with respect to the results of any ongoing, continuing "lookout panel." It must be recognized that *any issues identified as potentially important in the future are just that; they should not be considered to be predictions of the future*. They can be of assistance in planning, but the flexibility to alter plans as a regular matter must always be maintained. Also, despite the qualifying statement that identifying a potential issue and predicting the future are not the same thing, the mere act of a "lookout panel" pointing to certain issues or issue areas as being of potential future significance can raise their visibility and, thus, their probability of becoming prominent. EPA must bear this also in mind and be prepared to dedicate the resources needed to deal with identified issues.

5.4 Issue Collection and Refinement

5.4.1 Issue Collection

The Specific Issues Group (SIG) of the EFC asked all members of the EFC and the participating Standing Committees to submit lists of prospective environmental issues. The result was a collection of ninety-four submissions from eleven sources (Appendix A). This was the input data for the pilot, "bottom up" effort. An actual, continuing "lookout panel" would and should make use of a much wider selection of organizations and individuals in seeking input issues and would therefore collect a larger number of issues for the selection process. The SAB constituted a reasonably wide and diverse source for this limited, pilot exercise but, in viewing the results, this limitation should be kept in mind.

As seen in Appendix A, the issues, as submitted, varied greatly in content and specificity. Some were described in one or two lines, others were described at some length, and the topics varied widely. Many issues covered the same subject, or at least different aspects of the same subject, and the next step before any selections could be made had to be a refinement of this submitted list by combining like issues.

5.4.2 Combining Issues

The first combination of related issues was made by the SIG members, in concert. Discussions of that list with the EFC as a whole resulted in further changes and modifications that were incorporated in the final list of refined issues, which were restated as potential future problems given in Appendix B, with captions added to identify each problem briefly. This is the list of problems used in the selection process. The ninety-four issues of Appendix A have been reduced, by combination, to fifty issues which were restated as refined issues in Appendix B. All issue selections were conducted using either the list of collected issues in Appendix A or the first list of refined issues in Appendix B. All further references to refined issues or potential issues in this section refer to the list in Appendix B.

In undertaking the task of combining topics it became clear that issues may be combined in many ways and to many degrees of coverage. Over-combination can lead to "issues" that are so large that they cannot be dealt with without redividing them into smaller, more pointed issues (not necessarily the same as the original issues that were combined to form the too-large "issues"). Similarly, under-combination can lead to "issues" that are merely different aspects of a larger issue and which are better dealt with in that larger form. An issue, to be useful, needs to have a specific point "at issue," something needing resolution. Some of the "overarching" issues identified later in this report are designated as "issue areas" (or problem areas in the overview report) rather than, simply, as "issues;" each is an issue, but to address them practically some subdivision is needed.

5.4.3 Consolidating Issues

In Appendix B the issues are shown classified by general subject matter using, for the most part, conventional classifications: *Human Health Effects and Human Health Risk Assessment, Ecological Effects, Their Assessment and Management, Radiation: Health And Environmental Assessment and Management*, and so forth. For the purpose of issue selection, classification of the issues is not necessary. However, classification is useful in two respects: as a convenience to the user to bring a degree of order to a list of issues and to enable a "lookout panel" to determine if there are important classifications not represented.

That there are many ways to classify issues became apparent in the discussions among the SIG members -- just as there are many ways both to combine and to subdivide issues. One possible alternative classification is shown in Appendix C where the issues of Appendix B have been reclassified by sources of stressors. This classification system-- and others with different logical bases--could have served to organize the refined issues, for the purposes of this report, as well as the one used. Moreover, such reclassifications can serve to further determine if there are any additional areas of classification for which no issues have been developed and so to stimulate thinking in these areas. The two alternative classification methods offered here are but two examples of the many ways in which issues might be classified (for example, by potential mitigating actions). The selection of a preferred method, if such exists, should await further experience on the part of a continuing "lookout panel." Examples of attributes a preferred classification scheme might be based on are mutual exclusivity of the classifications and the ability of the classification scheme to stimulate broad perspective.

Using an issue classification scheme can be especially useful in the collection of issues. Developing a variety of possible classifications and offering them to the prospective contributors to consider can be conducive to wider thought on their part, and these same classification schemes can be of assistance to a "lookout panel" in ensuring completeness of coverage.

5.5 Criteria and Processes for Selecting Potentially Significant Issues from a List of Issues

Many processes are possible for selecting especially interesting or significant issues from a particular set of issues. Briefly, processes can be entirely qualitative, entirely quantitative, or some combination of the two. In any case, a high degree of subjectivity is involved; some kind of agreed-upon mechanism for reaching agreement on the issues selected is needed. Possible mechanisms include reaching a tacit (or explicit) consensus or using some more formal voting process.

5.5.1 Issue-Selection Criteria

Any process for assigning priority to issues will be facilitated by having a set of agreed-upon criteria to bring consistency to the evaluation. The SIG therefore developed a set of issue-selection criteria. These criteria were presented to, discussed with, and modified by the EFC. The resulting six major criteria are *Timing*, *Novelty*, *Scope*, *Severity*, *Visibility*, and *Probability*. These and their use are described in detail in Appendix D and the reader is advised to read this more detailed description of what is meant by each criterion before

attempting to use the criteria to evaluate issues. Brief definitions of each are given in Table 1.

The first five criteria characterize the impact of an issue, supposing that it will in fact develop into a problem, whereas the last one is predictive and describes the likelihood that an issue will, in fact, develop into a problem and need to be dealt with within the future time frame of interest. The last criterion, *Probability*, should be assessed for purposes of issue selection as though the selection of an issue will not affect the probability of its coming into prominence.

In selecting these criteria, the criteria used by a number of the Standing Committees in their work were examined for their applicability to the wide variety of issues collected. In addition, two basic principles were applied: (1) that the major criteria should be as few in number as possible in the interests of ease and certainty of application and (2) that to the extent possible the major criteria should be independent of each other and capable of discrete, clear definition--and, where dependence must occur, it should be explicitly recognized.

Experience with a list of criteria such as this, on the part of a continuing "lookout panel," could and should result in modifications to it that make it more definitive and useful.

5.5.2 Issue-Selection Processes

Both the qualitative and the quantitative approaches to using the issue-selection criteria to select potentially significant future issues were briefly explored by the EFC.

5.5.2.1 Qualitative Selection Processes

The qualitative use of the criteria should, in a continuing issue identification system, involve in-depth discussions of each issue against the criteria and against other issues, the development of lists of possible selections (again, with explicit reference to the criteria) and, finally, the narrowing down of the lists into one list using either the arrival at a tacit or explicit consensus or some form of voting to do so.

A much curtailed process involving some discussion followed voting (but with little discussion of the results aimed at reaching a consensus) was used in this pilot effort, recognizing that the validity of identified issues resulting from this kind of simplified process is highly uncertain. The process was used at two different stages of the development of the pilot study: first, at a stage when the nearly complete list of collected issues (Appendix A) was available and known to all EFC members, before the first refined list of issues was completed (Appendix B), but at a time when the issue-selection criteria were nearly complete and were familiar to all; and second, at a stage when the first refined list and the criteria were in virtually final form and had undergone significant discussion.

The first attempt was an effort to obtain some sense of whether there was any sort of natural consensus on issue selection. In this attempt, the EFC members were asked to submit their individual selections of potentially significant issues from the list of submitted issues. Seven self-selected EFC members responded. Table 2 lists the submitted issues, by number (as in Appendix A), cited by at least four of the seven respondents.

While this simple process is inadequate to give a definitive selection of potentially significant future issues, it does suggest some issue-subjects that need to be analyzed further, along with others, in the preparing a list of issues to be highlighted.

In the second attempt to sound out the preferences of the EFC the nearly complete first list of refined issues (Appendix B) and the nearly final issue-selection criteria were available to all and had undergone significant discussion. The voting took place at the August 2-3, 1994, EFC meeting with each member present (a total of eleven) being asked to list their top issues from the list of refined issues. Only seventeen issues received no votes, nineteen received one vote each, six received two votes apiece, and eight received more than two votes each. This last set of eight issues is shown in Table 3.

Only two issues received relatively large numbers of citations, numbers 29 (nine citations) and 25 (five citations). The subject matters of these two issues were among the subject matters of the most-cited issues in the first selection as well (Table 2), 3-3 and 3-12, each of which received five citations out of a total number of seven respondents. The remainder of the issues in Table 3 have slight to no relation to issues in Table 2.

There are several possible reasons for the differences in outcomes of the two selections, though there is no clear way to decide which reasons truly explain the differences. One is the fact that the second group was not the same as the first one; it did not contain only the same members and it was not self-selected. Two different groups can be expected to arrive at different results in this kind of activity. A second is that the issues, themselves, had been refined (combined, categorized, and reduced in number by almost a factor of two) between the times the two selections took place and thus many had somewhat different content. A third is the fact that a significant amount of discussion and of learning had taken place between the two selections and during the final selection process. And, finally, emphasis had been given in the EFC discussions to two different kinds of issues: issues for which there were evident trends and abundant evidence today and issues which were mere "dots on the horizon," for which there are only indications and weak signals, today, but no generally agreed, current trends visible, and which, on closer approach, may either grow and solidify or disappear. Since one of the functions of a "lookout panel" is to identify the "dots on the horizon" so they can be monitored, it may be that the respondents in the second case were more diligent in including at least some of this kind of issue in their selections.

There is a recognized danger in voting face-to-face, during discussions, rather than anonymously and with opportunity for reflection. The danger is that in a face-to-face situation, particularly persuasive or emphatic panel members can unduly sway a vote that, with the opportunity to reflect and to vote anonymously, might have been different. Voting procedures for a continuing system need to be carefully defined to avoid this type of possible bias. On the other hand, without

Table 1. Definitions of the Six Major Issue-Selection Criteria

Major Issue-Selection Criteria	Definition
1	***Timing*** deals with when an issue will become important in the future period considered and the importance of early recognition of an issue in resolving aspects of the issue, including, especially, its uncertainties.
2	***Novelty*** involves not only the consideration of how new an issue is, *per se*, but also whether there is a newly acquired perception of the amount of attention an issue requires versus the attention it is getting. Assessing Novelty depends to a degree on Timing, which should therefore be assessed first.
3	***Scope*** is an extensive criterion of magnitude dealing with the breadth or extent of the impacts of an issue with respect to factors such as geographic range, population affected, ecosystems affected, temporal scope, socioeconomic factors, legislative and/or regulatory activity, and so forth.
4	***Severity*** is an intrinsic and/or intensive criterion of magnitude dealing with the depth or intensity of impact, or the seriousness of the consequences of an issue with respect to factors such as physical, health, ecological, socioeconomic, legislative and/or regulatory, and welfare factors. In particular, the degree of irreversibility of the effects involved in, or of the consequences of, the issue are important in determining Severity.
5	***Visibility*** refers to the degree to which an issue is or can become visible as a public issue: to influential groups, to the media, to the political establishment, to the public as a whole, considering its scientific, technical and/or economic plausibility, its political appeal, and the recognition it is likely to receive by special groups. Visibility is dependent on components of the first four issues.
6	***Probability*** assesses the likelihood that the issue will need to be addressed. It is highly dependent on the first five criteria. It brings together into a single statement of probability the probability that the issue will arise and need to be dealt with because of scientific, technical, or other similarly definable reasons, whether or not it is publicly visible, and the probability that the issue will arise because, whatever its scientific or technical basis, it has strong public and/or political appeal.

Table 2. First Selection of Issues from the First List of Submitted Issues (Appendix A)

Submitted Issue No.	Brief Description of Submitted Issue Content
1-4	Risk of total, possibly synergistic, air burden growth, requiring integrated management.
1-6	Global importance of persistent toxic emissions increases.
3-1	Importance of sustainable ecosystem management increases.
3-3	Deterioration of the "health" of the oceans progresses.
3-12	Conflicting environmental and land use pressures grow; land use becomes a major, global issue.
7-8	More sustainable agricultural practices needed because of loss of habitat, loss of productive agricultural land, contamination of ground and surface water.

Table 3. Second Selection of Issues from the First List of Refined Issues (*Appendix B*) -- Cited by More Than Two of Eleven Members of the EFC

Refined Issue No.	Brief Description of Refined Issue*
5	Emphasis is placed on multiple endpoints and multiple exposures requiring new risk management criteria (3-7, plus elements of 4-2, 10-1).
8	Technology to control newly recognized pathogens in drinking water is found to be inadequate (6-9 plus elements of 8-3).
16	Animal and human health (e.g., reproductive capacity) and ecosystems are adversely affected by global dispersion of estrogen-mimicking chemicals (3-2, 5-1, 7-4).
21	The need is recognized to evaluate unregulated, untested agents (existing and newly intro duced) and their unforeseen environmental impacts (7-10, 10-1).
25	Increasing environmental pressures require improved land use practices (3-12, 4-4, 6-2, 7-1, 7-2, 7-3, 7-8 plus elements of 9-5, 9-7).
29	"Health" of the oceans deteriorates further (3-3, 10-2).
32	The quality and quantity of surface and ground water diminishes as a result of inefficient use and contamination (5-9, 7-13, 8-3).
36	Inefficient uses of energy for transportation and other uses has growing adverse impacts on environmental quality (3-13, 7-12).

*Numbers in parentheses are those of the submitted issues in Appendix A used in forming each refined issue.

some group discussions, a single member with a particularly good grasp of an issue may not be given an adequate hearing in reaching a group consensus.

In any case, the two lists, if they had been derived by carefully defined voting procedures and by more rigorously held discussions, are the kind of product that would form a suitable basis for the further in-depth panel discussions needed to arrive at a single, final, agreed-upon list. There was not the opportunity for such discussions to take place in this onetime effort, so the selection process was not carried farther along this track to a definitive conclusion.

5.5.2.2 Quantitative Selection Processes

With a set of issue-selection criteria in hand, quantitative weighing of the criteria, and the calculation of some kind of overall weight or score for each issue, is a possibility for selecting the issues most in keeping with the criteria. There are real advantages but also real pitfalls in using such a system. The fact that there are pitfalls should not deter anyone from using quantitative methods; it is necessary to be aware of them and allow for them, however.

Among the advantages are(a) the fact that all criteria are taken into account in some kind of reasonably consistent, systematic fashion as compared to qualitative approaches; (b) the fact that members of a group or panel can be mutually "calibrated" so that the numerical weights selected by different members of the group have consistent, relative meanings so that these weights can be used to reach a group consensus on the relative rankings of the issues; and (c) the fact that a numerically based order of preference is obtained among the issues considered.

Among the pitfalls is the possibility that the system selected may not reflect the decision process or, even, some fundamental--but possibly not known--rules for combining criteria. Also, the weights or scores are, themselves, usually subjective values, subject to great differences from one individual to another or from one time to another for the same individual.

Generally speaking, scoring methods will distinguish between the most important and the least important issues. The possibility of miss-ranking issues arises when their level of importance is close together. It is in this latter situation that sensitivity to changes in individual scores can be most acute.

In the final analysis, the results of any quantitative, scoring method need careful examination, a "reality check," and changes may need to be made in the results accordingly.

Appendix E contains a detailed example of the use of a scoring matrix prepared, as an example of such a method, by one member of the EFC. The same member selected all values used in this example so that the results do not represent, in any sense, any kind of consensus, however preliminary, of the EFC.

In this example, the first five criteria were scored from one to five (lowest to highest importance or weight) while the sixth criterion, *Probability*, was scored from zero to one-hundred. Each criterion was, itself, assigned a weight for reasons given in Appendix E. The product of a criterion score and the weight for the same criterion was the weighted score for that criterion; the sum of the weighted scores of the first five criteria was the Impact Score for the issue considered; and the sum of the Impact Score and the weighted score for probability was the Total Score for that same issue. Table 1 in Appendix E

gives the Impact Scores, the weighted probability scores, and the Total Scores for each of the fifty refined issues listed in Appendix B. Table 2 in Appendix E gives the same information in order of their Total Scores, from the highest to the lowest. Figure 1 in Appendix E shows a plot of the weighted probability score (Probability) against Impact Score (Impact) for the fifty issues. And Table 2 in Appendix E shows a bar chart of the Total Scores for the fifty issues, from the highest to the lowest.

As seen by examining the results in Appendix E, the top issues selected in this example are considerably different from those in either of the two selections already discussed and, since they represent the views of only one individual, they do not approximate in any way what might have been obtained from a carefully arrived-at consensus of the EFC.

The example does illustrate the method, however, and while it uses only one individual's inputs, it is apparent that consensus inputs from the entire EFC could have been used equally well had it been possible to arrive at them. Alternatively, the same scoring method could have been applied to inputs from each of the EFC members and the results compared and discussed so as to reach a consensus set of selected issues.

5.6 Derivation of a Set of Overarching Issues Areas

With the collection of submitted issues in Appendix A in hand, the issue-selection criteria well developed, the first refined issue list in Appendix B partially complete, and the first selection-by-vote (seven respondents) completed, an examination was undertaken to identify major or overarching issue areas evident among the specific issues. A list of seventeen such overarching issue areas (Appendix G) was prepared for discussion with the entire EFC at their July 13, 1994, meeting with the result that the seventeen areas were reduced to a total of eleven. Table 4 summarizes these eleven overarching issue areas; Appendix F gives detailed descriptions of them.

At the EFC's August 2-3, 1994, meeting these eleven issues were further discussed, with all of the collected and refined issues (or potential problems) in hand. From these discussions there then emerged the final five problem areas described in Section II.5 of "Beyond the Horizon," (see EPA-SAB-EC-95-007). These five problem areas are described in Section II.5 as though they already exist to make the point of the problem are as clear. However, it is not predicated that these issue areas will in fact emerge in preference to others (the actual future remains uncertain); they are given as examples of the kinds of problem areas which, given the signs discernible now, might emerge and which are worthy of further consideration along with other possible problem areas. The five issues areas are: (1) Sustainability of Terrestrial Ecosystems, (2) Noncancer Human Health Effects, (3) Total Air Pollutant Loadings, (4) Nontraditional Environmental Stressors, and (5) Health of the Oceans.

5.7 Further Discussions and Recommendations

In the pilot effort, issues were collected from a variety of sources, as described, to whom no instructions had been given other than to ask them to submit issues they thought might have future significance. In the actual operation of a "lookout panel," information intended to stimulate and widen the thoughts of respondents should be supplied. One suggestion is to supply different sets of issue classifications as a stimulus; another is to supply brief descriptions of a variety of drivers and scenario elements. In any case, the intention of supplying such information is not to focus or channel the thinking of respondents but to broaden and stimulate it. Also, a much broader set of respondents should be used than was used in the pilot study.

The EFC's pilot effort shows that, given the high levels of good will, dedication and patience that the members exhibited in this case, an ongoing, continuing system, with the necessary support, is capable of collecting, generating, refining, and assessing potential future issues against a set of issue-selection criteria.

The time the EFC dedicated to this pilot effort was large, as a percentage of the time they had to work together starting at their June 15-16, 1994, meeting, but it was inadequate to complete the task of reaching a true consensus on the selection of issues from the list of refined issues. Separately from this effort, however, but building on its results, they were able to reach a consensus on a small set of overarching issue areas (see Appendix F).

It is apparent that members of ongoing, continuing panels will have to dedicate substantial time to the effort, at least at the start, to bring satisfactory closure to their selections at any point in time. Once established, and with an experienced support staff in place, the time should decrease although it will still represent a substantial commitment for each member and for the staff. With good background preparation and some preliminary meetings, well planned consensus-building meetings to implement combined, qualitative and quantitative approaches (preceded by considerable E-mail or FAX communication) of as much as two days or even more in length may well be necessary to complete issue selection. Part of the time, at least at the start, will turn out to be devoted to a "calibration" of the panel members against each other, either through a deliberate or an incidental process. Doing this "calibration" deliberately will save time and produce a better result.

For issue selection (or potential problem selection) itself, a combination of quantitative and qualitative approaches is best. Neither is satisfactorily certain, by itself, of producing a reasonable selection of issues and each provides a kind of check on the other.

Developing and using a quantitative approach first (one possibility is described in Appendix E) as a means for obtaining an initial preference ranking of a set of refined issues, followed by an in-depth examination and discussion of the ranking so obtained may prove to be the most practical and credible approach. Arriving at quantitative rankings might be accomplished in one of two ways: (1) devote a working session to reaching consensus on the scores to be used to calculate a single ranking to be discussed or (2) have each member generate scores and, thus, individual rankings -- and then devote a working session to discussing these rankings to arrive at a consensus ranking. While the first step of the latter approach can be carried out without meeting face-to-face, the

Table 4. Initial Set of Eleven Overarching Issue Areas Identified by the EFC as Possibly Becoming Important in the Future (Not listed in any preferred order)

What possible contingency plans should EPA design to address these possible future conditions:

a. Energy choices, worldwide, increase the total loadings and adverse impacts of pollutants.

b. Global warming becomes a reality and leads to global and local climate changes and other complex consequences.

c. Increasing environmental pressures require new integrated land use practices that allow for the diversity of needs and interests.

d. The "health" of the oceans deteriorates further and leads to a wide range of serious, adverse consequences.

e. Over-exploitation of natural resources leads to ecosystem and human welfare harm and lack of sustainability.

f. Introduction of exotic species and the favoring of specific species leads to significant threats to endemic species and to overall biodiversity.

g. Failure to maintain a healthy biosphere leads to environmental degradation to the point of preventing the achievement of sustainability and of seriously threatening human well-being.

h. The advent and application of new scientific discoveries about the causes of adverse human health effects, and of extensive data banks, leads to radically new methods of human health risk assessment and management and to new opportunities for, and controversies in, risk management.

i. Increased energy production and use coupled with inefficiencies in its production and use and with inadequately considered energy production alternatives lead to a wide range of adverse environmental impacts.

j. Failure to monitor, assess, and catalog previously unaccounted-for sources of stressors leads to unexpected adverse impacts on human health and ecosystems.

k. Failure to respond to the national and international expansion and growth of the concept of environmental equity leads to disproportionate adverse impacts on significant segments of the world's population.

examination of numerous rankings may prove more difficult than arriving at a consensus on scores. In either case, having a small subgroup of the entire "lookout panel" suggest appropriate scores, with the reasons can, therefore, assist in bringing the remainder of the process to completion more easily. However the process is carried out, it will take a considerable commitment of time.

In reaching a consensus on issue selection, ranking should be viewed as a tool for sorting issues for which there is some consensus; however, it should not be overemphasized so as to replace the worth of single, well-founded voices.

An important point in establishing any ongoing panel is for the members, as they join the panel, to be given a thorough understanding of what it is they will be expected to do and what kind of a commitment they are making; and, if the commitment causes them concern, they can then decide, early, not to make it. In this regard, the operations of ongoing panels for future issue identification and selection are similar to the operations of the committees involved in doing comparative risk ranking and involve similar commitments. Although in each case the members must bring to bear their own expertise in arriving at a result, there are many areas in which scientific or other data, and proof, are minimal or lacking and the members must be committed to using judgment and to arriving at consensus by one means or another. In the case of identifying potential future issues, whose difficulties are at least as well supported by present trends or by a consideration of clearly related and understood driving forces, there are difficulties that arise when all that are available are weak signals that something may be beyond the horizon. It is especially important to focus on such cases since, to fail to pick one up is to fail to identify just the sorts of surprises that a "future issues" effort is supposed to identify. On the other hand, responding to every weak signal can be misleading. This is a difficult area, and members must understand, before they join in a "future issues" effort, that they will be faced with such possibilities and that these are at the very heart of identifying potentially important issues.

6.0 Highlights of the Standing Committee Activities

The Environmental Futures Project includes the efforts of seven related panels, working from a common charge, but with varying methods, levels of effort, and approaches. Each panel began with brainstorming sessions to define critical trends, forces, events and/or uncertainties that would have significant impacts on environmental quality or EPA and the nation's ability to deal with environmental quality problems over the next 5-30 years. Each Standing Committee focused on a principal area of their expertise -- drinking water, ecological systems, treatment technologies, exposure assessment, radiation, and air quality. Following that exercise, each group followed its own path to develop issues and recommendations.

In some cases, one or more members of a Standing Committee developed papers to describe the significance of a future event or the implications of the trends on environmental issues of the future.

6.1 Drinking Water Committee Report (EPA-SAB-DWC-95-002)

The Drinking Water Committee (DWC) examined the trends in water resources demands, water treatment technologies, and drinking water quality and their likely impacts on the country's ability to provide safe drinking water in the future. The Committee offered five major recommendations:

1. Improve the management of renewable water resources.

Greater emphasis must be given to improving the management of existing renewable water supplies. A national management program should include (1) prevention of further water supply deterioration and better management of land-use and forestry practices; (2) improvement of our ability to capture a larger proportion of renewable water supplies, including wetland protection and extension; (3) implementation of water recycling and conservation practices to improve efficiencies of water use, including lining of irrigation canals, installation of more efficient plumbing, and consideration of reallocation of water rights.

2. Support the consolidation of small distribution systems.

Consolidation of small water systems should be encouraged to improve the overall quality of water and provide the necessary revenue to implement treatment technologies now available to the larger systems. The drive toward consolidation should take advantage of the replacement of distribution systems that will be necessary in the near future in many communities.

3. Support changes in treatment technologies.

The traditional concepts of water treatment and distribution can be expected to change substantially in the future as a result of the changing profiles of contaminants of concern. A number of promising technologies will need to be improved and implemented, including membrane treatment. In addition, methods will need to be developed for stabilizing water in distribution systems that do not depend on maintenance of a residual oxidant in the distribution system.

4. Accelerate research to spur advances in risk assessment methodologies for both chemical and microbiological contaminants of water.

Modifications of current water disinfection treatments to minimize chemical risks in the drinking water supply must consider the relative risks, i.e., the magnitude of microbial risks that may be introduced as a result of the changes, as well as the creation of other disinfection by-products. Substantial research is needed in risk assessment methodology for both chemical and microbial risks. Without such research, large public investments for changes in drinking water treatment plants may be made on an inadequate and possibly incorrect scientific and technical basis.

5. Establish a surveillance or alert system for emerging waterborne pathogens.

The almost certain changes in water treatment and distribution systems in the next decades and the increased consolidation into larger systems for efficiency of control and delivery of water, pose the very real danger of the generation and transmission to large populations of heretofore unknown microorganisms that may pose serious health risks. A surveillance or alert system to detect these risks early should be put in place.

6.2 Ecological Processes and Effects Committee Report (EPA-SAB-EPEC-95-003)

The Ecological Processes and Effects Committee (EPEC) contributed to the Environmental Futures Project by examining key future developments and then examining the ecological consequences of human activities. The Committee based its procedure on the principles developed In Reducing Risk: Setting Priorities and Strategies for Environmental Protection (EPA-SAB-EC-90-021) and the Framework for Ecological Risk Assessment (EPA/630/R-92/001).

The conceptual model for futures analysis posed by the Committee provides a methodology for developing and then evalu-

ating future scenarios by (1) making assumptions about driving forces (the ultimate causes of change); (2) identifying the interactions between drivers (ultimate causes of change), stressors, and ecological endpoints via development of interaction matrices; (3) delineating the causes and effects of environmental changes; and (4) exploring ways in which management actions can avoid, influence, or mitigate environmental risks. Comparing a series of scenarios can help to define "no regrets" actions which provide benefits under a wide range of scenarios, as well as encourage the development of a strategic vision, and promoting nimble responses to unforeseen events.

The Committee evaluated the approach for futures analysis by applying it to scenarios of energy development and consumption in the United States. These scenarios (Very Low Cost Energy versus Very High Cost Energy) illustrate how the approach can be applied to identify the key components of environmental problems and how risks can be managed. This approach represents an important facet of the scenario analysis method recommended in Section 3 of this Annex.

Based on its study, EPEC presented key conclusions, summarized below, which the Agency should consider as guidance for developing a process for assessing future environmental problems. They also cited examples of potential future problems to illustrate the methodology, including several problems cited in Reducing Risk.

1. The conceptual model for futures analysis, which combines the use of scenarios and the analytical framework for ecological risk assessment (ecorisk framework) provided a formalized approach to assess future environmental risks.

2. This approach when applied to two scenarios making assumptions about the cost of energy, revealed possible ecological consequences that probably would not have been determined through an unstructured brainstorming.

   For example, availability of Very Low Cost Energy (via technological breakthrough in fusion energy and/or plasma energy) may result in increased fragmentation of habitats because very cheap energy could overcome natural constraints such as water availability allowing arid regions to be opened up to development. Light pollution and noise pollution may increase and adversely impact ecological resources. Thus a future with extremely low cost energy may not necessarily mean a green future.

3. Attempting to identify the ecological consequences of the two energy scenarios demonstrated to the Committee the values of examining futures lies in the process rather than the results of the analysis.

   The process makes participants think about risk management options affecting drivers, stressors and ecosystems at risk. The ecosystem management paradigm, while still evolving, embodies elements based on our current understanding of ecosystem structure and function, including the need to comprehensively consider ecosystem products and services and the importance of ecosystem health to human actions and policies. Ecosystem management requires a larger scale and longer-term perspective than typical human planning scales. However, management goals formulated on a broad scale must be implemented on a "local" scale based on ecological management units.

4. The EPEC scenario/futures analysis exercise reaffirmed the conclusions in Reducing Risk that national ecological risks are dominated by larger-scale and longer-time issues, including global climate change and habitat alteration, ozone depletion and introduction of exotic species.

   The adverse impacts from global climate change and stratospheric ozone depletion were described by EPEC as "Stressors Causing Effects in the Longer-Term (30+ years)." Stressors Causing Effects in the Near-term (0-30 years) included habitat alteration and destruction and the introduction of exotic species.

6.3 Environmental Engineering Committee Report (EPA-SAB-EEC-95-004)

The Environmental Engineering Committee (EEC) chose four important issues relating to technology that may emerge in the future. Drivers, scenarios, consequences, and recommendations for Agency actions were developed for each. The EEC also developed an approach by which the EPA could regularly scan the horizon for future issues. An abbreviated version of this approach was used successfully by the EEC to conduct a second search for potential emerging issues.

The four issues developed in detail concerned (1) fostering environmental protection while helping to assure sustained industrial development in an increasingly competitive manufacturing economy;(2) responding to increasing societal pressures for the redevelopment of industrial sites and remediation of land; (3) preparing to address threats posed to human health and natural resources by transient phenomena; and (4) correcting insufficiencies in core technical competencies that are needed to address future environmental challenges.

Based on its experience in identifying these issues, the EEC developed a suggested methodology for continuing work by EPA: (1) establishing lookout panels in the areas of technology, ecology, environmental health, and socioeconomics; (2) continual scanning of their fields by the panels; (3) collecting these observations and referring them back to all panelists for comment; (4) screening of candidate issues using agreed upon criteria; (5) analysis of surviving issues; and (6) recommending near-term actions based on projected futures. This methodology forms an important part of the system recommended in Section 3 of this Annex.

Using a short form of this lookout panel, the EEC identified eight additional issues which EPA should consider evaluating. These issues relate to (1) fossil fuel depletion; (2) industrial accidents and/or terrorist activities; (3) deterioration of urban infrastructure; (4) high-cost benefit of some environmental management strategies; (5) reservoirs of environmental contaminants; (6) pathogens in drinking water; (7) electromagnetic radiation; and (8) industrial ecology.

Based upon its study, the EEC prepared four recommendations for EPA:

1. EPA policy recommendations concerning clean technologies should be carefully constructed and balanced to benefit both the environment and U.S. industrial competitiveness.
2. EPA should ensure the development and use of appropriate technology to enable the redevelopment of urban contaminated industrial sites and remediated land.
3. EPA should strengthen its capabilities and readiness to address potential environmental consequences of natural disasters associated with transient events such as riverine floods and violent regional storms, in the face of trends in population growth and land use.
4. EPA should systematically identify and examine the essential and distinct scientific and engineering capabilities (core competencies) needed to address technical aspects of its present and anticipated future mission and strengthen them where needed.

6.4 The Indoor Air Quality and Total Human Exposure Committee Report (EPA-SAB-IAQC-95-005)

The Indoor Air Quality and Total Human Exposure Committee (IAQTHEC) studied opportunities for advances in the science and art of human exposure assessment, and opportunities that such advances could offer EPA and the nation for improving risk rankings and risk reduction management decisions. Human mortality and morbidity related to causal factors in the environment may not become manifest until decades after the exposures to environmental risk factors. Thus, early recognition of the nature and extent of such exposures can provide opportunities for prevention of adverse effects through regulations and guidance to the public designed to reduce exposures.

The IAQTHEC recognized that technical bases for quantum advances in capabilities for exposure assessment exist in certain critical areas. These are

- *microsensor and microprocessor technologies*. The anticipated advances in these technologies should make it possible to measure and record personal exposures to a wide variety of airborne toxicants at low environmental levels with relatively inexpensive and compact badges for personal monitoring as well as for fixed position monitors in public spaces and around pollution sources.
- *biomarkers of exposure*. Very sensitive biomarkers of exposure to environmental toxicants are being developed at a rapid pace, and will provide a basis for assessing personal exposures via all routes of entry. Complementary research on toxicokinetics and metabolism will provide an improved basis for the interpretation of biomarker indices, and in guiding sampling protocols for biomarkers for the validation of exposure models.
- *database resources*. Federal agencies and large industry groups are creating and improving their capabilities to enter, process, and retain human exposure related data of many kinds. This process has already stimulated efforts to improve the quality and range of the data being collected.

Based upon its study, the IAQTHEC prepared five specific recommendations to EPA:

1. Develop a mechanism to support research, validation and application of (a) more sensitive and specific microsensors, biomarkers, and other monitoring technologies and approaches for measuring exposures and (b) validated data on associated exposure determinants, including demographic characteristics, time-activity patterns, locations of activities, behavioral and life-style factors, etc.
2. Establish a mechanism to develop, validate with field data, and iteratively improve models that integrate (a) measurements of total exposure and their determinants; (b) a better knowledge of exposure distributions across different populations; and (c) the most current understanding available of exposure-dose relationships.
3. Develop, in cooperation with other agencies and stakeholders, a robust database that reflects the status and trends in national exposure to environmental contaminants.
4. Develop sustained mechanisms and incentives to ensure a greater degree of interdisciplinary collaboration in exposure assessment, and, by extension, in risk assessment and risk management activities.
5. Take advantage of exploding capabilities in exposure assessment technology, electronic handling of data, and electronic communications, to establish and disseminate early-warnings of developing environmental stresses.

6.5 Radiation Advisory Committee Report (EPA-SAB-RAC-95-006)

The Radiation Advisory Committee (RAC) formed a subcommittee, the Radiation Environmental Futures Subcommittee (REFS), to address future potential problems in environmental radiation. The REFS carried out a scan of future developments in the field of radiation, particularly as they pertained to environmental radiation. The Subcommittee reached consensus on a list of 21 issues that it considered to be the most relevant ones in environmental radiation over a 5-30-year time frame. From this list, the Subcommittee selected seven major topics that might have a significant impact in the future of our environment. The issue categories were (1) Energy and environmental quality; (2) Exposures, dose-response models, and population susceptibility; (3) Management of radioactive waste material; (4) Nonionizing radiation; (5) Radon and the indoor environment; (6) Loss of control of nuclear materials; (7) How does the EPA become the source of choice for environmental radiation information, and recognition as a leader on these issues?

Based on its study, the RAC Subcommittee recommended that EPA consider the following activities as part of its long-term efforts for the environment:

1) Place greater emphasis on providing scientifically credible information, while relying less on a regulatory role in risk management.

2) Participate in the joint development of national energy policies, focusing on (a) an examination of the overall environmental consequences of different energy production options; (b) the roles of alternative energy sources, including nuclear electricity generation, in curtailing greenhouse gases; (c) potential releases of radioactive materials to the environment; (d) radioactive waste management issues; and (e) possible increases in Ultra Violet (UV) radiation and other harmful stressors.

3) Incorporate into its program activities important research findings related to radiation exposures, dose-response models, and radiation effects, especially in regard to differences in individual susceptibility.

4) Provide an environmental perspective to assure control of nuclear weapons materials through conversion to energy use and/or secure disposal.

5) Stimulate and track research on the potential health effects of exposure to nonionizing radiation and provide non-regulatory federal guidance and advice on the prudent avoidance of unnecessary risks from potential sources of exposure, if such risks are shown to exist.

6) Assume a federal leadership role in activities involving pollution prevention, the management and disposal of radioactive wastes, and in developing criteria and standards for cleanup of sites containing radioactive and mixed wastes.

7) Exercise its federal radiation guidance role, in collaboration with other Federal and state agencies, to promote reduction of population exposure in medical uses of radiation.

8) Continue efforts to focus on characterization of high-risk radon potential regions, improving knowledge about radon risks, and developing more accurate methods of measuring and mitigating radon in buildings. Particular emphasis should be placed on empowerment of stakeholders by dissemination of *all* scientific information available.

9) Become the primary source of information on environmental radiation by providing advice, guidance, and standards, where appropriate, on the scientific basis for risk management decisions and by identifying research needs in radiation-related areas. The continued existence and funding of the Radiation Effects Research Foundation, and its work with the A-bomb survivors will be crucial to these efforts, and

10) Use a process of foresight to develop a capability for scanning the future in order to be proactive, rather than reactive, in shaping environmental radiation policies.

6.6 Clean Air Scientific Advisory Committee

Clean Air Scientific Advisory Committee (CASAC) participated in the environmental futures project by contributing directly to the Environmental Futures Committee (EFC) rather than by producing a separate report of its own. The Committee developed and refined several issues and recommendations related to air quality, which were included in the EFC Overview report and the appendix. Of particular note is the CASAC recommendation regarding the multimedia impacts of total pollutant loadings, which appears in the EFC report as one of the five major issues for consideration in the near term. The recommendation is reiterated here.

> **EPA should begin to address air quality as a total pollutant system producing multimedia insults that transcend national borders.**

Current approaches to air quality management which focus on one pollutant or one impact at a time, do not effectively deal with complex connections among atmospheric processes, synergism of pollutants and resulting impacts, and multimedia affects of air pollutants. These approaches also do not adequately consider the long term, long distance, and often international characteristics of air pollution. They also tend to neglect the associated overriding social and economic factors which can delay or ever deter implementation of strategies which affect the world community in general.

To improve current approaches, EPA will need to develop a broader definition of the total air burden which considers new and emerging air toxics as well as familiar regulated pollutants. EPA will also need to develop a system for addressing diverse sources and multimedia effects of total pollution burden. A shift from single pollutant threshold-based regulations to comparable risk paradigms also may be appropriate given the lower or perhaps more uncertain thresholds associated with the total air burden. New structures for integrated assessments of the multimedia effects of pollutants also may need to be considered to facilitate decision making regarding the total air burden. Finally, in order to take a leadership role internationally in promoting this more holistic approach, EPA will need to take a leadership role internationally in promoting this approach to air quality as an issue that is intimately linked to other environmental, energy, social, and economic concerns.

7.0 Retrospective Analysis

The concept of using foresight to assist long range planning efforts is generally accepted. However, it may be difficult to envision how foresight might change the Agency's response to problems. The EFC recommends that the Agency examine in retrospect the development of a few critical environmental issues that led to environmental policy changes in the past. Environmental issues tend to evolve by passing through a series of stages or steps: the initial "warning signs" of environmental damage; scientific understanding; public awareness; public pressure for action; congressional awareness; and implementation of the statute or policy (Figure 4). A retrospective review should examine the time between several key milestones (e.g., the initial "warning signs" of environmental damage and scientific understanding), the factors that affected the course of the issue, and the shareholders that the Agency contacted for the issue(s). Once the historical relationships have been defined, one possible analytical approach could use normative scenarios to identify desired outcomes. Information on driving factors could be used to develop strategies to reach those outcomes. The EFC has not been able to conduct this type of analysis during this project, and is not suited to doing it. However the Committee has an impression of the process and the likely impact of foresight on the nature and timing of an Agency response. The EPA is nearing the completion of a more extensive review of the benefits of the air pollution controls imposed by the CAA of 1970. This report, and SAB review of it, can provide lessons for the utility of the methodologies used, and the cost benefits from a landmark regulatory statute.

Generally, the period between the initial recognition of an environmental issue and the implementation of a policy or regulation is likely to span several decades. Foresight techniques are most likely to reduce the time between the "early warning signals" and the scientific understanding of the issue and the response of the Agency to it. In a limited study of the 1977 Clean Air Act, OPPE found that net environmental benefits were not realized until more than 13 years after the passage of the CAA due the elaborate process of developing guidance and approving state implementation plans. The retrospective analysis of this case study suggests that the Agency may have many opportunities to accelerate implementation of its regulations and improve its monitoring of weak signals.

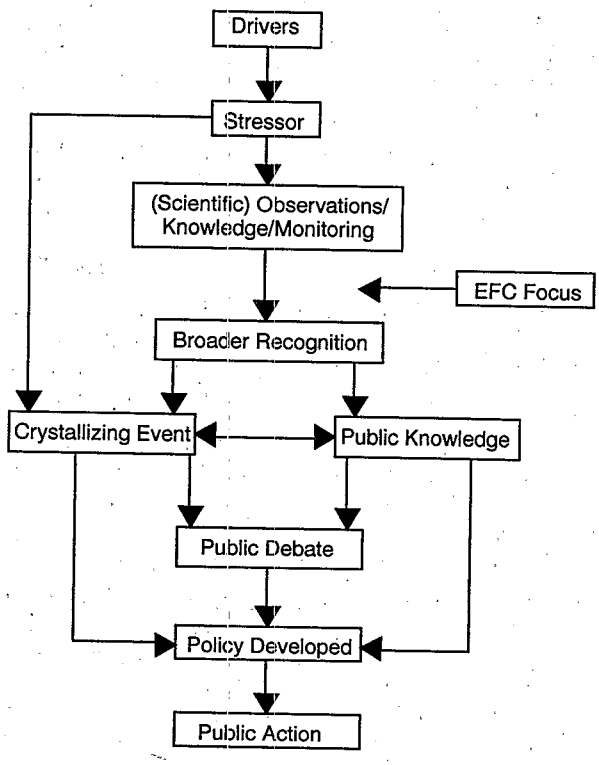

Figure 4. The Evolution of an Environmental Policy.

Appendices

Appendix A
Input Data for Master List of Possible Specific, Future Issues Collected

Note: The eleven sets of issues are given in full, as submitted, with only light editing to eliminate typographical and other minor errors. While these issues cover a broad range of topics, they must not be considered all-inclusive; they are simply the ones submitted by some SAB members in response to the EFC's invitation. Also, while they are possible issues, they are not predictions of problems that will happen.

1-1. Primary particles along with those formed from chemical reactions involving sulfur, nitrogen, and carbon may be reflecting solar radiation back into space, thereby masking the greenhouse effect over some parts of the earth. Without simultaneous management of particles, particle processors and greenhouse gases, global warming could be accelerated or masked. Thus simultaneous management is needed.

1-2. There is increasing evidence that naturally occurring nitrogen deficiencies have been ameliorated in a number of diverse environments possibly due to large urban increases in nitrogen oxide emissions and agricultural ammonia emissions which affect areas far removed from their immediate surroundings. It has been suggested that nitrogen-stimulated carbon uptake in plant tissues of aggrading forests of the northern hemisphere can balance global carbon losses to the atmosphere from agriculture and deforestation. Nitrogen fertilization may therefore serve to postpone the rate of CO_2 accumulation in the atmosphere. Consequently simultaneous: management of CO_2 and N may be needed.

1-3. Formation mechanisms for secondary pollutants such as ozone and fine particles (and visibility-reducing regional haze) in the atmosphere through complex, nonlinear processes are not fully understood. It is further complicated by "uncontrollable factors" such as natural emissions and meteorological influences. As we learn more about such processes, we may have to rethink our present control strategy paradigm.

1-4. Many chemicals are more harmful in general to human health and welfare when acting in the presence of other chemicals. For example, ozone and particles often coexist and high levels of both together results in a suite of adverse impacts. Thus, simultaneous risk-management of the total air burden is needed.

1-5. As we continue to find biological impacts of air pollutants at lower and lower concentrations, the paradigm of setting standards at levels below which effects are seen (and with an adequate margin of safety) will need to be changed to one that is based on comparative risk management.

1-6. Emissions of persistent, or long-lived, toxics as well as other air pollutants are a problem especially in developing countries and especially in local areas where these air contaminants are prevalent in high concentrations. They are also important globally because of long-range transport and transportation. These need proper consideration in the environmental debate.

1-7. The transport of goods from developed to developing countries does not always follow good environmental practices further compounding environmental degradation in developing countries. Until clean technology is available and used worldwide, pollution will continue to rise globally.

1-8. Overarching Air Quality Issue. Current approaches to air quality management which focus on one Issue at a time do not effectively deal with complex connections among atmospheric processes, synergism of pollutants and resulting impacts, and overriding social and economic factors which can delay or even deter implementation of strategies which affect the public in general. Recognition of this situation is leading to a risk-based management treatment of air quality as a total system intimately linked to other factors and to programs encouraging individual participation and commitment to pollution prevention.

1-9. A comprehensive set of early warning signs has yet to be identified. Past elements of the environment that provided early signs provide guidance in developing a set of human health and other environmental signals leading to recognition of potential problems while they are still tractable. Indicators of environmental well being often are difficult to understand except in the case of visual air quality. Often the air looks bad before other senses or body conditions suggest that something is unhealthy with the air. Use of haze as an early warning signal has immediate and long term value.

1-10. Stress, often induced by factors related to or enhanced by environmental degradation, may be growing. This could result in increased physical health problems and for the people most sensitive to equity issues, to increased violence. This leads to an awareness that improvement of environmental quality, particularly in areas of high population, can help reduce antisocial behavior occurring in these areas.

1-11. Individual habits are a major factor determining pollution levels. However, voluntary mandates for personal change do not seem to be effective in many areas, leading to a call for improved environmental education and dialogue among individuals and institutions to promote an awareness of common problems and a common commitment to solutions developed by and for the public in general.

1-12. The lack of acceptance or empowerment felt by a growing number of people worldwide may result in increased violence and apathy especially for those people most sensitive to economic and environmental stress. Because of this, plus the availability of harmful weapons, there may be less respect, and even an indifference, for the environment and other humans. This almost desperate situation leads to an acute awareness that environmental programs must be sensitive to equity issues and address the need for bringing angry voices into the decision process.

2-1. The conservation of biodiversity will become an issue of major importance in the future period under consideration.

3-1. *Sustainable Ecosystem Management.* Mounting population and related pressures will require holistic ecosystem risk assessment and management capable of supporting sustainable development; operational definitions of ecosystems which permit this to be done are not now available.

Discussion: Existing laws, regulations and mechanisms cover only the protection of specific species or of certain features which include one of more ecosystems (e.g., wetlands). Public awareness and interest in this issue is rising. Research is needed to define ecosystems so as to take account of their interrelationships to each other and to the whole; their role in maintaining sufficient biodiversity; their relationships to human health, well being and welfare; their relevance for achieving sustainable development; when ecological change is or is not inimical to human health, well being and welfare; and when remedial action is required. This issue is likely to become prominent early in the period and to have major effect on land use. (See Issue (3-9)).

3-2. *Wildlife Health.* The increasing occurrence of adverse health effects in wildlife populations as a result of exposure to various stressors, especially when more than one species is affected, may indicate or pose risks to human health and the environment.

Discussion: This is an issue not widely known to the public; it is of concern to wildlife biologists, especially in regard to reproductive health. The monitoring of wildlife health, achieving understanding of the relevant etiologies, and determining what effects may be indicated for human health or for ecological damage is needed.

3-3. *Maintenance of the Health of the Oceans.* The overall health of the oceans is deteriorating. Its maintenance needs to be addressed holistically and internationally as population pressures and related drivers bring ever greater stress on the total set of the oceans' regenerative capacities.

Discussion: Numerous instances of adverse impacts on the local (and wider-ranging) conditions of the oceans exist as a result of introducing harmful substances into the oceans as well as because of overstressing the resources of the oceans (e.g., overfishing: world fish catch per person is already level-to-decreasing and further population pressures, even with relatively mild population growth, and the growing demand for protein, could seriously affect this resource and, therefore, the health of oceanic ecologies). This is an international issue, it may have national security aspects, it is not confined to the EPA, and it will probably become prominent toward the end of the period. Research, including policy research, is needed now.

3-4. *Local Climate Change.* Future, more complete definition of the mechanisms of global climate change raises the possibility of identifying factors leading to adverse, local climate changes and the need for methods for their risk assessment and management.

Discussion: The increasing ability to identify local climate change factors and to assess related risks and management options is likely to lead to the development of related policies, legislation and regulation. Public interest is likely in such developments. Research to provide a sound scientific and economic basis will be needed. Effects on land use are likely to be significant. This issue is seen to be longer term, possibly reaching prominence toward the end of the period.

3-5. *Human Health and Ecological Risks of Introduced Bioengineered Species.* Increasing rates of introduction of a growing variety of bioengineered species may cause new human health and ecological risks, both direct (from introduced species) and indirect (from species' alteration); methods for assessing these risks are not available.

Discussion: Risks may not be only those which arise directly from contact with or use of bioengineered species or their products or from their escape into the general environment (as is true with naturally occurring species such as the current case of the zebra mussel invasion of the Great Lakes). Indirect risks might arise from: natural modifications of introduced species, modifications of existing species which interact or exchange genetic material with introduced species either directly or through the mediation of other species (e.g., viruses), or the development of variants of existing species in response to the challenge of introduced species. Research is needed on the existence (or nonexistence) of both direct and indirect risks, and on methods and protocols for hazard identification and risk analysis. As more bioengineered species are produced and used, public interest is likely to be a salient factor in shaping the issue.

3-6. *Environmental Impacts and Benefits of the Information Highway.* Environmental and other benefits of the spread of the information highway throughout out society may bring with them significant personal health and societal risks.

Discussion: Some of the risks are personal isolation and greater separation, in society, between those who can and do enter the information highway and those who cannot or do not do so, as well as the direct health effects involved in exposure to the relevant equipment and the changes in life-style that are likely. Research on the psychological and societal impacts of this development is needed, and on ways to mitigate the impacts since the development, underway already, is not likely to slow down. This issue may assume significant proportions early in the period. EPA could take leadership in addressing and defining this issue.

3-7. *Total Human Health Risk Management.* Growing emphasis on risks of non-cancer, adverse health effects will lead to human health risk assessment and management involving

consideration of all health effects under conditions of both single and multiple exposures with great impact on the regulation and management of health risks.

Discussion: The growing emphasis on risks of non-cancer, adverse health effects seen today is likely to lead to human health risk assessment and management which involves consideration of all health effects under conditions of both single and multiple exposures. The identification of the controlling risk as a means of managing and regulating multiple risks is likely to become possible. EPA should take the lead in pursuing these developments.

3-8. *Biomarkers of Exposure and Biomarkers of Effect.* Rapid strides in understanding human and animal biological and genetic mechanisms at the most basic levels make it likely that significant biomarkers of exposure and of effect will be defined, greatly changing the way human health risks are studied, assessed, regulated and managed.

Discussion: These developments will change the approach to animal testing, epidemiology, and health hazard and risk assessment, and will bring about much more sophisticated methods for regulating health risks. These same techniques, applied to wildlife, will have powerful effects on the issue of wildlife health. EPA should take the lead in pursuing these developments.

3-9. *Susceptibilities to Environmentally Induced Diseases.* Rapid strides being made in understanding human and animal biological and genetic mechanisms at the most basic levels make it likely that individual susceptibilities to diseases will become well understood, greatly changing the way human health risks are studied, assessed, regulated and managed.

Discussion: Such knowledge, applied to health risk regulation, would have direct and powerful effects on such regulation by making it possible to identify, in more instances than is now possible, the most susceptible members of a population. EPA should take the lead in pursuing these developments.

3-10. *Ancillary Information Bearing on Health Risks.* Rapid strides in understanding human and animal biological and genetic mechanisms at the most basic levels make it likely that in vitro and in vivo data and PBPK models will change how human health risk assessment is done, greatly changing the way human health risks are studied, assessed, regulated and managed.

Discussion: Such scientific progress also will likely lead to increased understanding of structure-activity relationships and to their improved application in health risk assessment. EPA should take the lead in pursuing these developments.

3-11. *Environmental Justice -- or Environmental Equity.* Environmental Justice is an existing issue which can expand well beyond its present scope and move in significant, additional directions.

Discussion: Starting as a dot on the horizon in the 1970s, the Environmental Justice issue is rapidly becoming a main stream issue. It is politically attractive and has a growing following. Research is needed to provide the statistical and other evidence to ensure that policy decisions (and any concomitant legislative and/or regulatory decisions) are the best that can be made. Examination of current regulatory structures to determine which may be affected by the Environmental Justice issue (not only those regulatory structures relating to site-related issues but all types of regulations) is needed to determine the scope of the research issue and to set goals.

3-12. *Land Use.* As both direct and indirect land use restrictions grow in number, coverage and complexity, a holistic review of land-use-related laws, regulations and policies will become more urgent as a part of achieving sustainable development.

Discussion: In addition to the many existing, direct, land use laws, regulations and ordinances, there are the indirect land use effects of existing laws which do not have land use as their primary objectives (e.g., the Clean Air Act and its "Bubble" concept) and the potential for further, major land use restrictions arising from the resolution of new issues within the period. Land use restrictions, direct and indirect, with due regard for environmental and human health issues and the laws which regulate them, for agriculture, forestry, industry, housing, recreation, environmental conservation and many other uses will need integrated reexamination and, possibly, reform as a part of achieving sustainable development. Major, technically- and scientifically-backed, integrated, policy research is needed. This issue is likely to become acute in the period.

3-13. *Transportation/Energy/Environmental Policy.* In the light of the growing need for energy efficiency and environmental protection, review of our national transportation systems is needed to determine what developments are desirable and what means and incentives are needed to bring them about in a free society.

Discussion: Transportation in all its forms is a major energy user and has major environmental impacts. New directions (an example might be appropriate combinations of very fast trains with short- and long-haul airplanes and trucks to provide more energy-efficient, environmentally friendly intercity freight and passenger transport) need to be explored and policies developed for the implementation of better systems than are now in place. Current laws, for example, for good but possibly outdated reasons, which now favor certain forms of transportation over others, may need to be rewritten to achieve energy efficiency and lower environmental impact. Incentives to move in the preferred direction need to be devised to effect change in our free society. Life cycle analysis should play a prominent role in this reexamination. While EPA may not be the principal agency involved with this issue, it should have important involvement as the administrator of so many current environmental laws.

4-1. *Managing An Environmental Data Resource.* Risk Assessment and Risk Management decisions would be much more defensible and gain much wider acceptance if they could be based on a firmer data and knowledge base than now exists. Under typical current conditions, relevant data are either nonexistent, not accessible, or of unknown specificity, relevance, or quality, or lack coordinate information that would make them useful.

Discussion: With appropriate specification of the kinds, nature, and amounts of data needed for some of EPA's most common data needs for risk assessment and risk management, much of the potentially useful data being collected by EPA, states, industry, and others could be made much more useful at marginal increases in the cost of acquisition. The existence of a rational and accessible repository of quality-assured data would itself stimulate the acquisition and sharing of additional data that fills the important information needs of the various stakeholders. The mature system would provide for uniform criteria for:

(a) Data collection and entry into universal data resource

(b) Reasonable and open access to universal data resource

(c) Inventory of data and periodic trends analysis

(d) Ongoing system of oversight

(e) Periodic review of analysis based on usage of data resource

4-2. *Defining Acceptable Risk.* There is increasing recognition that there are few environmental exposures resulting from anthropogenic activities that do not create measurable effects on human health and welfare and on ecological balance. There are, however, few established criteria for evaluating and characterizing the nature, distribution, and persistence of these effects, and their acceptability to affected individuals or to society as a whole.

Discussion: There are many dimensions to be considered in defining the acceptability of risk, such as: voluntary vs imposed; familiar vs exotic; transient vs persistent or irreversible; benefits to compensate for risks accepted; personal vs societal; difficulty or cost of risk reduction; willingness to accept or impose remedial costs, etc. When low-cost and/or broadly acceptable risk reduction options are not feasible, risk minimization efforts will depend on broadly acceptable definitions of the circumstances under which specific levels of risk are tolerated by individuals and populations, including those circumstances where anthropogenic program activities increase exposures and risks incrementally above natural background exposures and their associated risks. EPA should consider how to engage appropriate stakeholders in developing and refining criteria for defining acceptable risk for a variety of circumstances where anthropogenic activities can increase and/or redistribute risks to ecological systems and/or human health and welfare.

4-3. Global Atmospheric Composition and Pollutant Dispersion. Trace gases such as ozone (O_3), methane (CH_4), and nitrous oxide (NO) as well as carbon dioxide (CO_2), and fine particles (FP) have been continuously increasing in concentration in the global atmosphere for most or all of the twentieth century, as has the global dispersion of toxic trace elements and compounds that raises the background soil and surface water deposition of these materials. These include lead (Pb), mercury (Hg), arsenic (As), cadmium (Cd), polychlorinated biphenyls (PCBs) dioxins, and pesticides.

Discussion: While some of the effects of this widespread dispersion of pollutants are known to some extent, such as the influence of CO_2, CH_4 and FP on global climate change, and the role of transport in the atmosphere on Hg uptake in fish in distant lakes and its impact on Hg in human diets, others are more speculative. These include the effects of rising background levels of O_3 and FP on the mortality and morbidity associated with daily peak levels of these pollutants. For such issues, trends analysis of rising background pollutant levels may provide early warnings about rising exposures of human and ecosystems that, with improving exposure-response knowledge, could justify controls before waiting for more severe effects to be established.

4-4. *Defining Remediation Criteria.* Contaminated mining, milling, industrial process, and waste disposal sites need to be managed, isolated, and/or decontaminated prior to their use for activities that may lead to exposures to residual waste contaminants in adjacent, downstream and other populations. Decontamination to levels approaching pristine conditions is generally either not possible or far more costly than the value of the benefits from such essentially complete cleanup, removal and disposal of recoverable contaminants.

Discussion: For sites that can be restricted to usage that does not involve full and free access of the general public, such as industrial plants, warehouses, freight terminals, etc. alternative specifications designed to isolate, encapsulate and/or contain contaminants in subsurface soils may serve to protect the workers on the site, and the public outside, from significant exposures from the residual contaminants in the soil and/or water. This can allow restoration of the sites to the local tax roles and the creation of new employment opportunities for local residents. EPA can stimulate local economies and job creation by establishing and enforcing realistic criteria for site remediation for sites which do not warrant restoration to pristine conditions.

5-1. "Feminizing" of animal and human species as a result of exposure to estrogen-mimicking compounds in the environment. Early popular press reports lead to public awareness and concern. EPA's paradigm shifts from exposure to cancer risks, to exposure to risks to the endocrine or reproductive systems of plants and animals, including humans.

5-2. Loss of environmental data archives (including, possibly, stored plant germ plasm) as a result of unauthorized access by data terrorists or destructive hackers.

5-3. Statistically significant increase in atmospheric temperature provides irrefutable evidence of global warming, resulting in acceleration of changes in energy policy in essentially all countries.

5-4. Continued lack of statistical evidence of atmospheric temperature increases, leading to cynicism about global warming and more liberal energy policies.

5-5. Soil depletion, increased addition of dust and particulates to the atmosphere, and accelerating desertification in developing countries–particularly sub-Saharan African countries– resulting from pressures to increase agricultural output to feed large indigenous populations. (African population is expected to rise from 600 million to over 1 billion by 2010; Population Reference Bureau, 1994).

5-6. Loss of an annual crop such as wheat or corn in the United States as a result of an unexpected pathogen–perhaps a mutant virus–that successfully attacks a vulnerable, single species crop. This results in food shortages in countries that would have imported the crop and increased prices as well as

a search for new means of detecting and dealing with plant pathogens and a call for crop diversity.

5-7. Increased presence of lead and more exotic metals in the environment as a result of widespread acceptance of electric or high efficiency automobiles.

5-8. New and unexpected modes of introduction of pollutants and *hazardous* materials into the environment as a result of deterioration of urban infrastructure (decaying of sewer or natural gas pipes, for example).

5-9. Salt intrusion into primary aquifers from run off and leeching into the soil, leading to the need for large scale desalination, with concomitant price increases. This accelerates the search for plant species that can be irrigated with salt or brackish water.

5-10. Practical demonstration that very low frequency non ionizing radiation is causally related to certain forms of cancer. The etiology linking VLF EMR and disease is established; epidemiological inferences are confirmed. Result: the need for new exposure limits, monitoring, and revamping of products and electrical transmission infrastructure.

5-11. Emergence of a possible new endpoint: impacts of environmental pollutants on aging processes of various species (including humans) through, for example, effects on the neuroendocrine system.

5-12. Use of weapons with new properties including sleep inducing, behavior mediation (psychotropics), material digestion, bio-weapons, surface modification (e.g., chemicals for making roads slick), etc.

6-1. The environment and U.S. industrial competitiveness in the global marketplace are at risk if optimal (i.e., not overshoot/undershoot) Agency policy options concerning clean technologies are not adopted.

6-2. A failure to establish an appropriate Agency stance that can enable less costly and more timely redevelopment of urban land and structures could force the development of more pristine land resources, contrary to conservation objectives, and increasingly diminish the ability of urban planners to provide badly needed resources.

6-3. Present Agency capability and readiness are inadequate to address potential environmental consequences of natural disasters in the face of trends in population growth and land use.

6-4. The costs of environmental management strategies will become fully recognized by the public and consequently EPA's programs are challenged.

6-5. Unless appropriately deployed, industrial-ecology concepts will lead to uses of wastes by industrial/commercial sectors that cause more problems than solutions.

6-6. The threat or actuality of terrorist activities related to the environment could reach crisis proportions and become a major focus for the Agency.

6-7. Accelerating deterioration of urban infrastructure (e.g., water, sewerage, fuels) will cause many serious environmental incidents.

6-8. Fossil fuel depletion will lead to use of resources having a greater potential for environmental contamination and habitat loss.

6-9. Technology to control newly recognized pathogens in drinking water will be found to be inadequate.

6-10. Managing environmental reservoirs, such as contaminated sediments, will become recognized to be more critical than increasingly stringent point-discharge management.

6-11. Proliferation of new technologies will increase sources of nonionizing radiation and will become recognized as a major health threat.

6-12. *A Cross-Cutting Issue*: The Agency will not be able to meet future environmental challenges unless it endeavors to identify required core technical and research competencies and, where needed, strives to strengthen them.

6-13. Land use choices made without appropriate environmental considerations can prevent achievement of EPA's biodiversity and human welfare/health goals.

6-14. *International Incident Response*: In order to achieve and maintain environmental goals in the United States EPA, in concert with other countries, will need to develop the capability to respond throughout the world to major releases due to industrial accidents and terrorist acts.

7-1. Species and habitat loss, and loss of productive agricultural land, because of inefficient and inappropriate land use, necessitating more effective, long-range measures to manage land use.

7-2. Broad ranges of environmental problems are exponentially multiplied by increasing human populations, requiring recognition and strategic planning to address population growth.

7-3. Broad ranges of environmental problems are multiplied by high consumption rates for energy and natural resources, requiring increased efficiency in the use of these resources.

7-4. Decreased reproductive ability and health in many animals, including humans, caused by persistent organochlorine wastes (resulting from pesticide use, combustion and industrial processes) being widely distributed through the environment, requiring better control of this class of chemicals and better understanding of their impact on the environment.

7-5. Potentially massive effects on plants and animal life caused by increased UV radiation reaching the earth because of decreasing ozone concentrations in the upper atmosphere, caused by halogens (especially chlorine) reacting with the upper atmosphere, requiring measures to greatly reduce releases of these chemicals to the atmosphere.

7-6. Changes in plant and animal habitats, population centers, agriculture, energy use, etc., as a result of climate changes resulting from IR-absorbing gases released to and remaining in the atmosphere, requiring measures to minimize releases and retention of these gases in the atmosphere.

7-7. Loss of plant and animal species resulting from habitat destruction (through resource extraction, land development... improper/inefficient land use), requiring more efficient use of land and water resources.

7-8. Habitat destruction, chemical and biological contamination of groundwater and surface water, loss of productive agricultural land caused by unsustainable agricultural practices, requires revision of current methods of crop production to more sustainable practices.

7-9. Broad ranges of environmental problems resulting from rapid economic growth in the developing world, requiring strategic technology planning, technology transfer, and negotiations to reduce or slow these impacts.

7-10. Unforeseen but potentially significant environmental impacts resulting from the development, use and disposal of thousands of new chemicals per year, requires better testing and control of these compounds.

7-11. Potential for direct (human health) and indirect (agricultural) effects resulting from "emerging" viruses and opportunistic plants and animals spread by global trade and travel, and treatment-resistant bacteria, require a more careful strategy for understanding, and addressing changing ecosystems.

7-12. Broad ranges of environmental effects resulting from inefficient use of energy for transportation, industrial purposes, and residential use requiring improved conservation and efficiency, and development of energy sources with lower environmental impacts.

7-13. Decreasing availability of the quantity and quality of surface and groundwater resulting from inefficient use and contamination require measures to more efficiently use available resources and protect and restore other resources for sustainable use.

7-14. Declining plant, fish and animal populations resulting from unsustainable harvesting, habitat loss and pollution, require measures to ensure the protection of lands and waters as ecosystems and as a sustainable resources for humans.

- Issues 7-15 through 7-18 are likely to cause significant environmental impact only under specific future scenarios; they are scenario-dependent issues:

7-15. Environmental costs (localized climate change, decreased raptor populations) resulting from increased use of "alternative" (solar, wind) power sources require more comprehensive planning for use of these technologies.

7-16. Unforeseen alterations of ecosystems caused by development and use of genetically-engineered organisms (bacteria, plants, animals), require planning, testing and control of this technology.

7-17. Release of highly radioactive material to the environment caused by accidental or intentional (war, terrorism) events, require more control of these materials.

7-18. Potential human health and environmental effects from exposure to electromagnetic radiation resulting from the rapid growth in the number and power of EM sources (communications, power transmission lines), require a better understanding of effects from these sources.

8-1. Research is needed in developing risk assessment methods for use with infectious agents. Generally, actual levels of exposure are not known; nor is how these factors can vary in their impact with susceptible populations.

8-2. There is a need for the Agency to develop and implement a strategy that focuses future research and development efforts on a regional or geographically oriented basis. Problems of natural resource protection, pollution prevention, toxicant monitoring, water management and conservation, fisheries and wildlife protection, as examples, all have a regional specificity that needs to be addressed if efficiencies are to be realized with the limited available resources. Further, there is a need for interagency planning in this effort due to the severe overlap in many critical areas of environmental concern (e.g., land use, water supplies, fisheries). This regional type of effect could also address differences between laws of adjoining states that create critical rather than supportive public responses.

8-3. There is a current and expanding need to research, develop and implement practices and procedures that will provide adequate future supplies of renewable water in the United States.

- Issues 9-1 through 9-13 were organized into five categories, considering a range of energy scenarios: (1) *Issues from "Reducing Risk"*, (2) *Stressors Causing Effects in the Near Term (0-30 years)*, (3) *Stressors Causing Effects in the Longer Term (30+ years)*, (4) *Other Possible Future Concerns/Stressors*, and (5) *Effects Caused by Cumulative Stresses (Syndromes)*:

(1) **High Risk Problems Identified in "Reducing Risk."**

The importance, significance, and relative ranking of the risks to ecological resources identified in Appendix A of the SAB's "Reducing Risk" report are affirmed. Risks that received high rankings in that report included:

9-1. Global Climate Change

9-2. Habitat Alteration and Destruction

9-3. Loss of Biological Diversity

9-4. Stratospheric Ozone Depletion

These four environmental problems continue to present high risks to ecological systems and human welfare because the geographical scale of all four is very large (regional to global),

and because the time that could be required to mitigate all four is very long and some effects are irreversible.

(2) Stressors Causing Effects in the Near Term (0-30 years)

9-5. *Habitat Alteration and Destruction* - The greatest stressor to the world's biological resources is alteration and loss of habitat. Loss, degradation and fragmentation of habitat due to urbanization, land use changes associated with agricultural and silviculture activities, and transportation stress terrestrial biota. Flow modifications, channel alterations, damming, siltation, and nutrient enrichment eliminate and degrade aquatic habitats impacting aquatic biota.

9-6. *Exotic Species - Accidental or misguided introduction of* exotic species (both plant and animal, terrestrial and aquatic) poise a significant threat to endemic species and overall biodiversity. Introduced species often out compete native species due to lack of predators and disrupt the structure and functioning of ecosystems. Examples include: zebra mussel in Lake Erie, asiatic clam, kudzu, chestnut blight, Dutch Elm disease, water milfoil, hydrilla, mesquite, Japanese beetle, sea lamprey. With internationalization of the economy, a significant risk exists for an increase in the introduction of exotic species. Development of transgenic species may pose a similar threat if not carefully evaluated and managed.

9-7. *Pollution - Persistent bioaccumulative* chemicals, metals, some pesticides and nutrient (phosphorous and nitrogen) continue to have adverse impacts on terrestrial, freshwater and near coastal ecosystems in many parts of the world. Bioaccumulative chemicals such as dioxin and polychlorinated biphenyls (PCBs) concentrate in top predators and can adversely affect growth, development and reproduction of terrestrial and aquatic consumers. Metals in soil, sediments and water can exert acute and chronic toxic effects on plants and animals. Continued use of highly toxic and persistent pesticides particularly in developing countries threatens ecological resources. Excessive use of fertilizers in urban and agricultural applications are causing eutrophication of freshwater and near coastal ecosystems. Eutrophication smothers habitats, encourages growth of nuisance organisms (red tide) and depletes dissolved oxygen.

9-8. *Over Exploitation of Natural Resources* - Adverse impacts on ecological systems are significant from over exploitation of natural resources. Over drafting of groundwater and surface water for irrigation, industrial use and drinking water supply are contributing to an increase in deserts in many parts of the world. Poor agricultural practices contribute to erosion and subsequent loss of soils. Over exploitation of near coastal and marine fisheries have decimated many stocks of fish. Non-sustainable harvesting of timber, particularly in the tropics, causes unprecedented losses of biodiversity. Surface mining of minerals destroys terrestrial habitats and contaminates aquatic ecosystems.

(3) Stressors Causing Effects in the Longer-Term (30+ years)

9-9. Concern continues about the *ecological consequences of global climate change* caused by build up of greenhouse gases and increases in ultra violet light (UVb) caused by depletion of stratospheric ozone. Adverse ecological effects from these stressors such as inundation of coastal wetlands and marshes from thermal expansion of the oceans and UVB impacts on phytoplankton photosynthesis in the oceans may not be realized until many years in the future. However, because of long lag times in realizing the benefits of mitigation activities, efforts should be begun immediately to address these issues.

(4) Other Possible Future Concerns/Stressors

9-10. *Light pollution* - If energy becomes inexpensive and widely available globally due to advances in fusion and/or hydrogen technologies, it is likely that this energy will be used to light up the planet. Many animals and plants use light cues to initiate their reproductive activities. Nocturnal animals have evolved life strategies which partition niches based on night time activities. Excessive light could significantly disrupt plant and animal physiology and behavior and have potentially significant effects.

9-11. *Noise pollution* - A more populated earth with increased dependency on technology (machines) will also be a noisier place. This noise has the potential to disrupt communication critical for reproductive behavior and territorial defense for many species. Many birds use calls to mark and defend their territories. Whales whose population numbers are small communicate over long distances. As noise pollution increases, interference with essential communication activities will increase.

9-12. *Electromagnetic fields* - With inexpensive, widely available energy, it is likely that electromagnetic fields (EMF) will increase. Potential impacts on terrestrial plants and animals will also increase.

(5) Effects Caused By Cumulative Stresses (Syndromes)

9-13. Individual organisms, populations, communities of organisms and ecosystems respond to the *cumulative impacts of stressors*. Examples of significant ecological problems that appear to be caused by cumulative stresses are: marine mammal die-off, forest decline, and coral reef bleaching. These phenomena appear to be increasing in frequency and extent. Protecting ecological resources form cumulative stresses will require an integrated and long term commitment to pollution prevention and resource protection.

10-1. *Environmental Impacts of Unmeasured or Unevaluated Chemicals* -- an overarching futures issue:

Only chemicals cited in permits and regulations are monitored and measured. Previously, these were generic conventional parameters such as BOD, COD, TPH, suspended solids, etc. Now it is likely to be some set of specific chemicals, such as benzene, naphthalene, chlorinated solvents, etc. There are, however, many other chemicals released to the environment that either in combination or alone can have a long term, slow but important effect not appreciated.

It is not prudent to attempt to measure the concentrations of all chemicals that are released. However, there should be attempts to identify the effects that such chemicals may have.

This overarching issue could capture some of the issues noted elsewhere in the list of issues such as: release of bioengineered species, environmental estrogens, loss of specific species (frogs, birds, etc.), or non-cancer effects.

Use of the criteria the EFC has suggested indicate that this issue should be one of the major ones.

10-2. *Health of the Oceans* (suggested as a major issue -- see, too, issue 3-3).

The oceans are an important part of the global environment yet an ecosystem that is poorly understood. In addition, because the oceans border on many countries and are so broad, they are the responsibility of no one country or organization. As a result, environmental changes receive little focus.

There are signs that the environmental health of the oceans may be deteriorating. Fully 45% of the fish stocks whose status is known are now overfished and populations of some species have decreased to 10% of the level that yields the largest sustainable catch (see 1993 *Vital Signs* for other relevant information).

Whether these changes are from overfishing or from other causes is not known. However, the point is that changes in the ocean health are occurring and, whatever the cause, they can have adverse environmental, economic and social impacts. There is need for better science and knowledge to understand the extent and rate of actual changes.

This is an important issue because the oceans: a) are an important sink for CO_2 and other gases, b) are a source of food for much of the world, c) are important in the hydrologic balance and weather patterns that affect all the earth, and d) serve as a reservoir or sink for other chemicals discharged to the atmosphere and to surface waters. The ecosystem health of the oceans is an important national and global issue that also has national security implications. Thus, it is prudent to take steps to increase the evaluation of the health of the oceans and to include observations about ocean health in any lookout and subsequent "future" considerations.

One can recall that concerns with surface water pollution became large with the crystallizing event of fish kills. These were localized, short term events that could be managed by point source pollution controls. As a result, surface water ecosystem health has improved.

Oceans are huge reservoirs whose equilibrium takes a long time to change. However, it also will take a long time to recover once the causes of any adverse effects are identified. In the meantime, large parts of the global human population may be affected by these changes. In estimating the relative risk of adverse impacts, long term, broad impact events should be considered major "future" issues. Ocean health is such an issue.

Another factor that causes this to be a major issue is the fact that there is no organization that has responsibility for the evaluation of ocean ecosystem health. Thus, unless some evaluation of such health is considered in any "futures" effort, this issue will continue to fall through the cracks, be the responsibility of no one, yet have an effect on everyone.

11-1. If the EPA wants to be considered a credible leader among the agencies in the Federal Government with regard to the issues pertaining to energy and the environment it should consider the implementation of unequivocal and forceful policies with regard to energy issues today. The agency actions could have considerable influence on the future of energy supplies and energy production mix of the USA. In order for these actions to be effective they must happen rapidly, and they must give a clear message to the Nation. Ambiguous policy statements will only complicate the issues that will come up in the future. The EPA should clearly enunciate its choice for the future of the environment as to whether greenhouse gas reductions will be a guiding concern in the development of policy alternatives. Furthermore, by the year 2030, the 22% of the energy supply that comes from nuclear power plants will be essentially taken out of the US energy supply unless the issues regarding nuclear energy are resolved to the satisfaction of the people. Barring an unforeseen breakthrough in nuclear fusion technology, fusion energy will not be the panacea to the energy question. Sustainable fusion reactions beyond the "break even" point will require massive amounts of tritium, which will generate a new and different mix of radioactive wastes that is not completely understood at this time. Three scenarios come clearly into view:

1. Greenhouse gases and nuclear waste concerns dominate the future view and no nuclear or fossil energy production facilities come on line. This scenario will require clear and forceful policies for the rapid development of efficient, clean and reliable alternative energy sources that will replace the capacity lost as ageing plants are decommissioned.

2. Greenhouse gases are the dominant concern in the future. In this scenario effective policies for radioactive waste disposal are implemented; concerns of trust in government and politics as they pertain to nuclear safety and risk issues are resolved through information dissemination and education of the general public; and a satisfactory accommodation between opposing political forces is reached. Then new sources of nuclear energy (both fusion and fission) come on line to replace fossil fuel capacity.

3. Nuclear issues are the dominant concerns. The nuclear power capacity goes off-line by the year 2030. Efforts to control greenhouse gases are limited by the energy needs of the Nation. New policies are required for the development of alternative energy sources as in Scenario 1.

All three scenarios require a solution to the waste disposal issues that will incorporate pollution prevention and risk reduction as guiding principles. Furthermore, clear leadership from the EPA will be needed to address the environmental concerns found in all three scenarios. Which way the future develops will be influenced by the energy actions.

11-2. Population exposures and susceptibilities to radiation are an issue. As we learn more about the susceptibility of individuals to radiation from molecular biology it is easy to see that the current regulatory paradigm for radiation may not be able to meet the future issues it will face. As we get more information out of the Human Genome project, and genetic susceptibilities are identified, the EPA will face a crossroad:

to keep adding additional protection factors to the existing limits to protect a few individuals at higher risk than the rest of the population, or to issue guidance that protects the overall population to a certain risk limit while advising those more susceptible individuals to avoid "hot environments." A current example is indoor radon where the data would support an action level of ca. 10 pCi/L for nonsmokers, while smokers may have an action level of ca. 2 pCi/L, yet the agency chose an aggregate risk estimate of 4 pCi/L. The implications of the former set of action levels would require clear policy statements that if you smoke you should ensure that your home's radon level is low. The testing and identification programs for radon would continue as they exist, but remediation programs would be more focused in terms of reducing risks where they exist. This would result in programs that are more efficient and cost-effective. The incorporation of population susceptibility information into the regulatory programs will become an important issue in the future, and EPA will be required to lead the federal government through their authority to issue guidance on radiation exposures. The agency should be prepared to do so in a credible and effective manner.

Appendix B
List of Refined Potential Future Issues Created by Combining Like Future Issues in Appendix A*

(Notes: (1) Numbers in brackets indicate the collected issues in Appendix A used in forming these issues; (2) original authors' words used to the extent possible to preserve meaning in the text of each issue; (3) highlighted captions, summarizing each issue, added. These summary statements of this set of possible, future issues have been written to aid in issue evaluation against a set of criteria by making clear the nature of each issue if it were, in fact, to emerge as a future problem. No inference should be made that these are possible actual predictions, or that this is a comprehensive list of all possible future issues. Rather, these issues are simply one set of possible issues requiring further investigation, analysis and possible aggregation. These possible future issues are listed in no order of priority or importance.

Issue Number — Issue Category, Title And Description

Category
Human Health Effects and Human Health Risk Assessment

1. Health problems and social disorder result from environmental stress.

   Stress, often induced by factors related to or enhanced by environmental degradation, may be growing and could result in increased physical health problems and, for the people most sensitive to equity issues, to increased violence. Improvement of environmental quality, particularly in areas of high population, can help reduce antisocial behavior occurring in these areas. [1-10]

2. The information highway is found to produce psychological and societal impacts.

   Stress from increased personal isolation and separation resulting from increasing use of the "information highway" as the "highway" becomes more developed and encompassing may cause mental health risks and raise serious societal divisions and related problems. Research on the psychological and societal impacts is needed. [3-6]

3. New understanding of secondary air pollutants and their risks requires new risk control strategies.

   Formation mechanisms for secondary pollutants such as ozone and fine particles (and visibility-reducing regional haze) in the atmosphere through complex, nonlinear processes are not fully understood. It is further complicated by "uncontrollable factors" such as natural emissions and meteorological influences. As we learn more about such processes, we may have to rethink our present control strategy paradigm. [1-3]

4. The total toxic air burden, including synergism, requires new, simultaneous risk management.

   Many chemicals are more harmful in general to human health and welfare when acting in the presence of other chemicals. For example, ozone and particles often coexist and high levels of both together results in a suite of adverse impacts. Thus, simultaneous risk management of the total air burden is needed. [1-4]

5. Emphasis is placed on multiple end-points and multiple exposures requiring new risk management criteria.

   A growing emphasis on the risks of non-cancer health effects, including possible new effects (e.g., effects of pollutants on aging), will lead to an encompassing form of human health risk assessment and management to include multiple endpoints (including both cancer and non-cancer effects, together) under conditions of single and multiple exposures (simultaneous or sequential). These developments can have profound effects on health risk regulation, requiring the development and acceptance of criteria for the significance of "acceptability" of various levels of such risks. Despite the growing debate there are only a few established criteria for characterizing risks. [3-7 plus elements of 4-2, 5-11, 10-1]

6. The application of major advances in basic biomedical sciences leads to radically new methods of human health risk assessment and management.

Rapid strides in understanding human and animal biological and genetic mechanisms at the most basic levels make it likely that significant biomarkers of exposure and of effect will be defined, that individual susceptibilities to diseases will become well understood, and that in vitro and *in vivo* data and PBPK models will change how human health risk assessment is done. These increases in understanding will help bring increased understanding, as well, of structure-activity relationships and their improved application in health risk assessment. These developments will greatly change the way human health risks are studied, assessed, regulated and managed. [3-8, 3-9, 3-10]

7. Methods to assess and manage exposures and risks from infectious agents are found to be inadequate.

Research is needed in developing risk assessment methods for use with infectious agents. Generally, actual levels of exposure are not known; nor is how these factors can vary in their impact with susceptible populations. [8-1]

8. Technology to control newly recognized pathogens in drinking water is found to be inadequate.

Technology to control newly recognized pathogens in drinking water will be found to be inadequate. Actual levels of exposure will not be known and will have to be determined. Risk assessment methods for use with such agents are not now available. [6-9 plus elements of 8-1]

Category
Ecological Effects, Their Assessment and Management

9. The development of regional strategies for environmental assessment and protection is found necessary.

There is a need for the Agency to develop and implement a strategy that focuses future research and development efforts on a regional or geographically oriented basis. Problems of natural resource protection, pollution prevention, toxicant monitoring, water management and conservation, fisheries and wildlife protection, as examples, all have a regional specificity that needs to be addressed if efficiencies are to be realized with the limited available resources. Further, there is a need for interagency planning in this effort due to the severe overlap in many critical areas of environmental concern (e.g., land use, water supplies, fisheries). This regional type of effect could also address differences between laws of adjoining states that create critical rather than supportive public responses. [8-2]

10. Increasing light pollution is found to be seriously disruptive to many species' physiology and behavior.

Light pollution: If energy becomes sufficiently inexpensive and widely available globally due to advances in fusion and/or hydrogen technologies, it is likely that this energy will be used to light up the planet. Many animals and plants use light cues to initiate their reproductive activities. Nocturnal animals have evolved life strategies which partition niches based on night time activities. Excessive light could significantly disrupt plant and animal physiology and behavior and have potentially significant effects on population distributions. [9-10]

11. Increasing noise pollution is found to disrupt many species' essential behavior patterns.

Noise pollution: a more populated earth with increased dependency on technology (machines) will also be a noisier place. This noise has the potential to disrupt communication critical for reproductive behavior and territorial defense for many species. Many birds use calls to mark and defend their territories. Whales whose population numbers are small communicate over long distances. As noise pollution increases, interference with essential communication activities will increase. [9-11]

12. Cumulative environmental stresses lead to increasing decline and die-off of sentinel species.

Individual organisms, populations, communities of organisms and ecosystems respond to the cumulative impacts of stressors. Examples of significant ecological problems that appear to be caused by cumulative stresses are: marine mammal die-off, forest decline, and coral reef bleaching. These phenomena appear to be increasing in frequency and extent. Protecting ecological resources from cumulative stresses will require an integrated and long term commitment to pollution prevention and resource protection. [9-13]

13. The use of alternate energy sources leads to adverse impacts on environmental quality.

Energy and environmental quality: by the year 2030, the 22% of the energy supply that comes from nuclear power plants will be essentially taken out of the U.S. energy supply unless the issues regarding nuclear energy are resolved to the satisfaction of the people. Barring an unforeseen breakthrough in nuclear fusion technology, fusion energy will not be the panacea to solve the energy question. Sustainable fusion reactions beyond the "break even" point will require massive amounts of tritium; this will generate a new and different mix of radioactive wastes that is not completely understood at this time. Three scenarios are possible:

1. Greenhouse gases and nuclear waste concerns dominate the future view and no nuclear or fossil energy production facilities come on line.

2 Greenhouse gases are the dominant concern in the future.

3 Nuclear issues are the dominant concerns and the nuclear power capacity goes off-line by the year 2030.

In the first scenario clear and forceful policies for the rapid development of efficient, clean and reliable alternative energy sources to replace the capacity lost as ageing plants are decommissioned are required. In the second scenario effective policies for radioactive waste disposal must implemented; concerns of trust and safety must be resolved. In the third scenario, efforts to control greenhouse gases are limited by the energy needs of the Nation and new policies are required for the development of alternative energy sources as in the first scenario. The EPA needs to take a central role in the decision-making that will shape the future of energy and the environment. [11-1]

14. Global climate changes and stratospheric ozone depletion lead to adverse impacts on ecological systems.

Adverse ecological consequences of global climate change caused by build up of greenhouse gases and increases in ultra violet light (UVb) caused by depletion of stratospheric ozone are a serious issue. Effects caused by these stressors such as inundation of coastal wetlands and marshes from thermal expansion of the oceans and UVB impacts on phytoplankton photosynthesis in the oceans may not be realized until many years in the future and may bring about changes in plant and animal habitats, population centers, agriculture, energy use, etc. However, because of long lag times in realizing the benefits of mitigation activities, efforts should be begun immediately to address these issues. [7-6, 9-9]

15. Losses of monoculture crops occur because of the unexpected pathogens.

Loss of an annual crop such as wheat or corn in the United States as a result of an unexpected pathogen -- perhaps a mutant virus -- that successfully attacks a vulnerable, single species crop can result in food shortages in countries that would have imported the crop and increased prices, as well as a search for new means of detecting and dealing with plant pathogens and a call for crop diversity. [5-6]

Category
Human Health and Ecological Effects, Combined, and Their Assessment and Management

16. Animal and human health (e.g., reproductive capacity) and ecosystems are adversely affected by global dispersion of estrogen-mimicking chemicals.

The increasing occurrence of adverse health effects in wildlife populations as a result of exposure to various stressors, especially when more than one species is affected, may both indicate and pose risks to human health and the environment. An example is the concern about "feminizing" of animal species and humans as a result of exposure to estrogen-mimicking compounds in the environment. The monitoring of wildlife health, achieving understanding of the relevant etiologies, and determining what effects may be indicated for human health or for ecological damage is needed. [3-2, 5-1, 7-4]

17. Long-range transport and global accumulations of pollutants are found to be sources of adverse health and ecological effects.

The atmospheric concentrations of globally dispersed pollutant trace gases such as ozone (O_3), methane (CH_4), and of nitrous oxide (NO), carbon dioxide (CO_2) and fine particles (FP), have been continuously increasing for most or all of the twentieth century, as has the global dispersion of toxic trace elements and compounds that raise the background soil and surface water deposition of these materials. These include lead (Pb), mercury (Hg), arsenic (As), cadmium (Cd), polychlorinated biphenyls (PCBs) dioxins, and pesticides. Trends analysis of rising background pollutant levels may provide early warnings about rising exposures of human and ecosystems that,

with improving exposure-response knowledge, could justify controls before waiting for more severe effects to be established. Two examples are the effects of rising background levels of O_3 and FP on the mortality and morbidity associated with daily peak levels of these pollutants, and the role of transport in the atmosphere on Hg uptake in fish in distant lakes and its impact on Hg in human diet. [4-3]

18. The need is recognized to develop and use early warning signs and signals of potential environmental problems.

Elements of the environment that provide early signs provide guidance in developing a set of human health and other environmental signals leading to recognition of potential problems while they are still tractable. Indicators of environmental well being often are difficult to understand except in the case of visual air quality. Often the air looks bad before other senses or body conditions suggest that something is unhealthy with the air. Use of haze as an early warning signal has immediate and long term value. A comprehensive set of early warning signs has yet to be identified. [1-9]

19. The introduction of exotic species into ecosystems requires the development of new methods for risk assessment and management.

Accidental or misguided introduction of exotic species and the increasing rates of introduction of a growing variety of such species may pose new, unforeseen human health and ecological risks, as well as risks to agriculture, both direct (from introduced species) and indirect (from species' alteration in the environment). The species referred to may be plant or animal species, terrestrial or aquatic, macroscopic or microscopic; they may be existing, exotic species (such as plants and animals spread by global trade and travel), bioengineered species, "emerging" viruses, treatment-resistant bacteria, or others. Ecologically and historically, introduced species have often out competed native species due to lack of predators and have disrupted the structure and functioning of ecosystems (examples include: zebra mussel in the Great Lakes, asiatic clam, kudzu, chestnut blight, Dutch Elm disease, water milfoil, hydrilla, mesquite, Japanese beetle, and the sea lamprey). Health threats, particularly of bioengineered or altered species, are not well assessed. Methods for assessing or managing these risks are not now available. [3-5, 7-11, 7-16, plus elements of 8-1, 9-6]

20. The need is recognized for establishing and maintaining an encompassing environmental data resource for risk management purposes.

Providing an environmental data resource: risk assessment and risk management decisions would be much more defensible and gain much wider acceptance if they could be based on an accessible, firmer, quality-assured, data and knowledge base than now exists. Under typical current conditions, relevant data are either nonexistent, not accessible, or of unknown specificity, relevance, or quality, or lack coordinate information that would make them useful. The mature system would provide for uniform criteria for: a) data collection and entry into universal data resource, b) reasonable and open access to universal data resource, c) inventory of data and periodic trends analysis, d) ongoing system of oversight, and e) periodic review of analysis based on usage of data resource. [4-1]

21. The need is recognized to evaluate unregulated, unevaluated agents (existing and newly introduced) and their unforeseen environmental impacts.

Environmental impacts of unmeasured or unevaluated chemicals and other agents need to be considered. Unforeseen but potentially significant environmental impacts resulting from the development, use and disposal of thousands of new chemicals per year, require attention. At present only chemicals cited in permits and regulations are monitored and measured. Previously, these were included in generic, conventional parameters such as BOD, COD, TPH, suspended solids, etc. Now it is likely to be some set of specific chemicals, such as benzene, naphthalene, chlorinated solvents, etc. There are, however, many other chemicals (and types of agents) released to the environment that either in combination or alone can have a long term, slow but important effect not appreciated. It is not prudent to attempt to measure the concentrations of all chemicals that are released. However, there should be attempts to test the toxicity and identify the effects that such chemicals may have. Other unevaluated agents can include release of bioengineered species, environmental estrogens. Indicators of action or presence can be of many types such as the loss of specific species (frogs, birds, etc.) or the observation of particular non-cancer adverse health effects in humans or animals. [7-10, 10-1]

Category
Radiation: Health and Environmental Assessment and Management

22. Major health hazards of nonionizing radiation are demonstrated.

Exposures to electromagnetic radiation resulting from the rapid proliferation of old and new technologies will increase and nonionizing radiation could be demonstrated to be a major health and environmental threat. The need for new exposure limits, monitoring, and revamping of products and electrical transmission infrastructure will be recognized and better understanding of effects from these sources will be needed. [5-10, 6-11, 7-18, 9-12]

23. Increasing ground-level UV radiation results in massive adverse effects on plant and animal life .

Potentially massive effects on plants and animal life caused by increased ultraviolet (UV) radiation reaching the earth because of decreasing ozone concentrations in the upper atmosphere, caused by halogens (especially chlorine) reacting with the upper atmosphere, requiring measures to greatly reduce releases of these chemicals to the atmosphere. [7-5 plus elements of 9-9]

24. Releases of radioactive materials through accident, war or terrorism lead to the search for better control mechanisms.

Release of highly radioactive material to the environment caused by accidental or intentional (war, terrorism) events, require more control of these materials. [7-17]

Category
Land Use

25. Increasing environmental pressures require improved land use practices.

A new, integrated and holistic approach to land use will become more urgent as a part of achieving sustainable development. Some of the factors that will require this are: the increasing need to prevent species and habitat loss, the need to prevent the loss of productive agricultural land, the need to protect pristine lands, and the need to provide for expanding human populations and their resource-using activities. Land use choices made without appropriate environmental considerations can prevent achievement of biodiversity and human welfare/health goals. Furthermore, the current complexity of laws, regulations and ordinances can raise barriers to achieving improved, overall land use and will only increase under these new pressures unless an integrated approach is taken. Providing for the re-use of already used, contaminated land and structures offers a part of the solution; however, failure to establish a stance that can enable less costly and more timely redevelopment of urban sites could force the development of more pristine land resources. Remediation criteria are needed for sites of all types prior to re-use; decontamination to levels approaching pristine conditions may not be possible and may be too costly compared to the benefits. Restricted use could restore some previously used sites to new industrial or other economic use. [3-12, 4-4, 6-2, 6-13, 7-1, 7-2, 7-3, 7-7, 7-8, Plus elements of 9-5, 9-7]

26. Increasing agricultural intensity in developing countries increases soil depletion, atmospheric particulates, and desertification.

Large increases in agricultural intensity in developing countries -- particularly in sub-Saharan Africa and Southeast Asia resulting from pressures to increase agricultural output to feed large indigenous populations -- will increase soil depletion, atmospheric particulates and desertification (African population is expected to rise from 600 million to over 1 billion by 2010; Population Reference Bureau, 1994). [5-5]

27. Inadequate capabilities exist to cope with the environmental consequences of natural disasters.

Present Agency (EPA) capability and readiness are inadequate to address potential environmental consequences of natural disasters in the face of trends in population growth and land use. [6-3, 7-2]

Category
Resource and Depletion

28. Biodiversity is lost as a result of habitat alteration and destruction.

The loss of biodiversity will become an issue of major importance in the future period under consideration. The greatest stressor to the world's biological resources is alteration and loss of habitat. Loss, degradation and fragmentation of habitat due to urbanization, land use changes associated with agricultural and silviculture activities, and transportation stress terrestrial biota. Land use choices made without appropriate environmental considerations can prevent achievement of biodiversity and human welfare/health goals. Flow modifications, channel alterations, damming, siltation, and nutrient enrichment eliminate and degrade aquatic habitats impacting aquatic biota. [2-1, 6-13, 9-5]

29. "Health" of the oceans deteriorates further.

There are signs, today, that the overall health of the oceans, and of the enormously complex ecologies therein, is deteriorating. The maintenance of the health of the oceans needs to be addressed holistically and internationally as population pressures and related drivers bring ever greater stress on the total set of the oceans' slow regenerative capacities. Causes include overuse (such as over-fishing), the impacts of pollutant and solid waste discharges and dumping by nations around the world, dumping and spills at sea, and the absorption of airborne contaminants of all types. There is no one authority responsible for the health of the oceans. At risk is a major source of the world's food supply, a major sink and transporter of CO_2, a major producer of oxygen, and a highly important climatological engine. The issue is likely to become acute within the period if present trends continue. The issue is of global and critical importance. [3-3, 10-2]

30. Fossil fuel depletion leads to use of other, contaminating, habitat-destructive alternatives.

Fossil fuel depletion will lead to use of energy resources having a greater potential for environmental contamination and habitat loss. [6-8]

31. Adverse ecological effects result from over-exploitation of natural terrestrial resources

Adverse impacts on ecological systems are significant from over-exploitation of natural resources. Overdrafting of groundwater and surface water for irrigation, industrial use, and drinking water supply are contributing to an increase in deserts in many parts of the world. Poor agricultural practices contribute to erosion and subsequent loss of soils. Non-sustainable harvesting of timber, particularly in the tropics, causes unprecedented losses of biodiversity. Surface mining of minerals destroys terrestrial habitats and contaminates aquatic ecosystems. The impacts of these problems are exponentially increased by increasing human populations multiplied by high consumption rates for energy and natural resources. Methods are required for holistic ecosystem risk assessment and management capable of supporting sustainable development; operational definitions of ecosystems which permit this to be done are not now available. [3-1, 7-2, 7-3, 7-14, 9-8]

32. The quality and quantity of surface and groundwater diminishes as a result of inefficient use and contamination.

Decreasing availability of the quantity and quality of surface and groundwater, resulting from inefficient use and contamination, leads to a current and expanding need to research, develop and implement practices and procedures that will provide adequate future supplies of renewable water in the United States. This could take the form of measures to more efficiently use available resources, to protect and restore other resources for sustainable use, or to develop altogether new solutions. For example, salt intrusion into primary aquifers from run off and leaching into the soil can lead to the need for large scale desalination with concomitant price increases. This could accelerate the search for plant species that can be irrigated with salt or brackish water. [5-9, 7-13, 8-3]

Category
Climatological Effects and Their Assessment and Management

33. The need for understanding the mechanisms and effects of local climate change becomes apparent.

Local climate change effects: future, more complete definition of the mechanisms of global climate change raises the possibility of identifying factors leading to adverse, local climate changes and effects and the need for methods for their assessment and management. Public interest is likely, and effects on land use are likely to be significant. [3-4]

34. The need for understanding the dynamics of the counteracting effects of atmospheric particles and greenhouse gases on global climate change becomes critical.

Primary particulates together with those formed from reactions involving carbon, nitrogen and sulfur may mask the Greenhouse Effect by reflecting incident sunlight. Increases in urban nitrogen oxide and agricultural ammonia emissions, widely dispersed, may stimulate carbon uptake in plant tissues of aggrading forests of the northern hemisphere to balance global carbon losses to the atmosphere from agriculture and deforestation, thus postponing the rate of CO_2 accumulation in the atmosphere and delaying the Greenhouse Effect. Whether or not statistically significant increases in atmospheric temperature actually occur will have profound effects on the urgency of taking corrective measures. Such measures could involve shifts in energy policy and/or simultaneous management of CO_2, nitrogen compounds, particles and greenhouse gases. [1-1, 1-2, 5-3, 5-4]

Category
Intergovernmental - Governmental - Institutional

35. Local, regional, and global transport and accumulation of pollutants from developing countries becomes a major international environmental problem.

Emissions of persistent, or long-lived, toxics as well as other air pollutants are a problem especially in developing countries and especially in local areas where these air contaminants are prevalent in high concentrations. They are also important globally because of long-range transport and transportation. These need proper consideration in the environmental debate. [1-6]

36. Inefficient uses of energy for transportation and other sectors has growing adverse impacts on environmental quality.

Broad ranges of environmental effects resulting from inefficient use of energy for transportation, industrial purposes, and residential use requiring improved conservation and efficiency, and development of energy sources with lower environmental impacts. For example, a review of our national transportation systems is needed to determine what developments are desirable (what combinations of ground and air, long-haul and short-haul, and new means of transportation such as very fast trains like the French TGVs) and what means and incentives are needed to bring them about in a free society. [3-13, 7-12]

37. Increased use of lead and other metals in "clean" vehicles leads to increased potential for adverse impacts on environmental quality.

Increased presence of lead and more exotic metals in the environment as a result of wide-spread acceptance of electric or high efficiency automobiles. [5-7]

38. Urban infrastructure decay leads to additional and unexpected sources of adverse environmental incidents.

New and unexpected modes of introduction of pollutants and hazardous materials into the environment as a result of the accelerating deterioration of urban infrastructure (decaying of sewer or natural gas pipes, for example) will cause many serious environmental incidents. [5-8, 6-7]

39. The environment and U.S. industrial competitiveness are at risk from non-optimal environmental strategies and their costs.

The environment and U.S. industrial competitiveness in the global marketplace are at risk if optimal (i.e., not overshoot/undershoot) Agency policy options concerning clean technologies are not adopted. As the costs of current environmental management strategies become more fully recognized by the public, EPA's programs may be increasingly challenged. [6-1, 6-4]

40. Industrial uses of wastes cause unexpected problems.

Unless appropriately deployed, industrial-ecology concepts will lead to uses of wastes by industrial/commercial sectors that cause more problems than solutions. [6-5]

41. Scientific/technical core competencies in EPA prove to be inadequate when future challenges arise.

The Agency will not be able to meet future environmental challenges unless it endeavors to identify required core technical and research competencies and, where needed, strives to strengthen them. (A Cross-Cutting Issue). [6-12]

42. Environmental problems result from rapid growth in developing countries.

Broad ranges of environmental problems resulting from rapid economic growth in the developing world, requiring strategic technology planning, technology transfer, and negotiations to reduce or slow these impacts. [7-9]

43. Local climate changes and environmental impacts result from the use of alternative energy sources.

Environmental costs (localized climate change, decreased raptor populations) resulting from increased use of "alternative" (solar, wind) power sources require more comprehensive planning for use of these technologies. [7-15]

44. Environmental emergencies caused by accident, terrorism or c rime require enhanced capabilities for international response.

International Incident Response: In order to achieve and maintain environmental goals in the United States EPA, in concert with other countries' agencies, will need to develop the capability to respond throughout the world to major releases due to industrial accidents and terrorist acts. Loss of environmental data archives, for example (including, possibly, stored plant germ plasm), could occur as a result of unauthorized access by data terrorists or destructive hackers. Weapons with new properties pose special problems. [5-2. 5-12, 6-6, 6-14]

45. Environmental degradation in developing countries is exacerbated by poorly controlled exports from developed countries.

The transport of goods from developed to developing countries does not always follow good environmental practices, further compounding environmental degradation in developing countries. Until clean technology is available and used worldwide, pollution will continue to rise globally. [1-7]

Category
Socioeconomic

46. Voluntary mandates fail to produce changes in behavior needed to sustain and improve environmental quality.

Individual habits are a major factor determining pollution levels. However, voluntary mandates for personal change do not seem to be effective in many areas, leading to a call for improved environmental education and dialogue among individuals and institutions to promote an awareness of common problems and a common commitment to solutions developed by and for the public in general. [1-11]

47. Environmental inequity and environmental and economic stress lead to environmental apathy and violence.

Environmental Justice is an existing issue in the United States which can expand well beyond its present scope and move in significant, additional directions. Worldwide, the lack of acceptance or empowerment felt by a growing number of people may result in both increased violence and apathy especially for those people most sensitive to economic and environmental stress. Because of this, plus the availability of harmful weapons, there may be less respect, and even an indifference, for the world's environment and other humans. This almost desperate situation makes it clear that environmental programs must be sensitive to equity issues and address the need for bringing angry voices into the decision process. In the United States, now, research is needed to provide the statistical and other evidence to ensure that policy decisions (and any concomitant legislative and/or regulatory decisions) are the best that can be made in this politically sensitive and attractive arena. Examination of current regulatory structures to determine which may be affected by the Environmental Justice issue (not only those regulatory structures relating to site-related issues but all types of regulations) is needed to determine the scope of the research issue and to set goals. [1-12, 3-11]

Category
Other Risk Management Issues

48. The continuing lack of societal consensus on criteria for "acceptable" risk requires resolution of the growing debates on the subject.

There is a growing debate about the definition of "acceptable risk." There is increasing recognition that there are few environmental exposures resulting from anthropogenic activities that do not create measurable effects on human health and welfare and on ecological balance. There are, however, few established criteria for evaluating

and characterizing the nature, distribution, and persistence of these effects, and their "acceptability" to affected individuals or to society as a whole. There are many dimensions to be considered in defining the acceptability of risk, such as: voluntary vs imposed; familiar vs exotic; transient vs persistent or irreversible; benefits to compensate for risks accepted; personal vs societal; difficulty or cost of risk reduction; willingness to accept or impose remedial costs, etc. EPA needs to consider how to engage appropriate stakeholders in developing and refining criteria for defining acceptable risk for a variety of circumstances where anthropogenic activities can increase and/or redistribute risks to ecological systems and/or human health and welfare. [4-2]

49. Preventing dispersion of chemicals from environmental reservoirs becomes more critical than point source management.

Managing environmental reservoirs, such as deposits of contaminated sediments, will become recognized to be more critical than increasingly stringent point-discharge management. [6-10]

50. The discovery of adverse effects at ever lower exposures leads to the need to develop new means of managing the net risks of multiple pollutant exposures.

As we continue to find biological impacts of pollutants at lower and lower concentrations, the paradigm of setting standards at levels below which effects are seen (and with an adequate margin of safety) will need to be changed to one that is based on comparative risk management. Furthermore, current approaches to environmental quality management which focus on one issue at a time do not effectively deal with complex connections among atmospheric processes, synergism of pollutants and resulting impacts, and overriding social and economic factors which can delay or even deter implementation of strategies which affect the public in general. Recognition of this situation is leading to a risk-based management treatment of environmental quality as a total system intimately linked to other factors and to programs encouraging individual participation and commitment to pollution prevention. (An "overarching" environmental quality issue). [1-5, 1-8]

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*Following completion and use of this list, a few further suggestions were made of issues that might possibly be combined, as follows:

(1) Issues 8 and 32. Views on whether these could or should be combined were mixed.

(2) Issues 4 and 50. These can easily be combined.

(3) Issues 7 and 8. These can be combined provided the thoughts contained in each are fully and distinctly preserved.

For any future use of this list it is suggested that Issues 4 and 50 should be combined into one issue and Issues 7 and 8 can be combined into one issue, thus reducing the 50 refined issues to as few as 48.

Appendix C
An Alternative Classification of the Refined Issues

Issue Categories by Types of Stressors (Causes)	Issues (Numbers as in Appendix B)
Chemicals from Industrial/Commercial Operations	16, 21, 23, 49
Particles from Industrial/Commercial Operations	34
Agriculture and Natural Resources Harvesting/Extraction Operations	26, 31
Natural Phenomena & Transient Incidents	27, 38, 44
Individual & Institutional Actions	25, 28, 29, 45, 46
Governmental Actions	5, 46, 47 50
Radiation Releases	22, 24
Pathogens, Exotic Species, Engineered Organism Releases	7, 8, 15, 19
Technology Change	2, 39, 40, 42
Population Growth	10, 11
Energy Production/Use	13, 14, 30, 36, 37
Multi-Stressors without Predominance	1, 3, 4, 17, 35
New Information or Understanding	6, 9, 12, 18, 20, 33, 41, 43, 48

Appendix D
Detailed Description of the Issue-Selection Criteria

Six major criteria have been defined and used for the purpose of selecting issues for special consideration and highlighting. These criteria are aimed at deciding whether or not a potential issue will become a significant issue within the future time period considered; whether what may now be only a dot on the horizon will grow and become significant or will disappear. The six criteria are (1) *Timing*, (2) *Novelty*, (3) *Scope*, (4) *Severity*, (5) *Visibility*, and (6) *Probability*.

The first five criteria describe and characterize an issue in various ways, assuming that the issue actually develops as foreseen, whereas the last criterion is predictive and describes the likelihood that an issue will, in fact, develop and need to be dealt with within the future time frame of interest.

In deriving these criteria two principles were adhered to

(1) That the major criteria should be as few in number as possible in the interests of ease of application.

Clearly, if it were possible to have only one criterion the job of selecting the issues best meeting that criterion or of highest weight according to the criterion would be easy. The more criteria there are the more difficult is the job of using them to select issues of special interest, whether the criteria are applied qualitatively or according to some quantitative scoring method (see Appendix E for a description of one quantitative scoring method).

(2) That to the extent possible the major criteria be independent of each other and capable of discrete, clear definition -- and that where dependence occurs it should be clearly indicated.

Independence is not entirely possible in all cases, or even necessarily desirable; where it is not possible, the degree and type of dependence must be clearly defined. For example, *Timing*, *Scope* and *Severity* have a high degree of independence from each other whereas *Visibility* is in part dependent on aspects of these three major criteria as well as on others, yet it is an important criterion in its own right.

The first five criteria and their factors are described as follows:

(1) ***Timing***: This criterion deals with when an issue will become important: sooner (closer to the beginning of the period considered), later (closer to the end of the period) or throughout the period. Greater weight should normally be given to this factor if the timing is sooner rather than later. However, the importance of early recognition of an issue, whatever its timing may be, must enter into the weight given to the timing criterion. While some early-occurring issues might automatically make early recognition important, some late-occurring ones might also if the issue is especially consequential, if the issue or its consequences are hard to define, if a long lead time is needed for understanding the issue, if policy research, planning or laboratory or field research efforts of major magnitude are needed, or if the issue has particularly intractable problems or major uncertainties associated with it. A factor to consider is whether there are already mechanisms in place to address the issue.

(2) ***Novelty***: This criterion involves consideration of what is new about an issue but it also involves consideration of whether sufficient attention is being given to the issue in the near term -- whether the issue itself is new or not. While this latter aspect of the criterion does not deal with the novelty of the issue itself it does deal with an aspect of novelty: a newly acquired perception of the amount of attention an issue requires versus the attention it is getting. The criterion might have been called *Novelty and/or Inattention* but, always keeping the dual definition of novelty in mind, it is called, simply, *Novelty*.

Pursuing the matter of *Inattention* further and its relation to timing, there are few, if any, issues that will loom large on the horizon within the first five years of the time period that can be rated "high" in terms of *Novelty*. However, their imminence, in terms of potential for major impact on society, can be very large and any failure or delay in recognizing the significance of likely impacts and in developing and implementing remedial actions could have serious consequences to environmental quality and/or public health and welfare. For purposes of assessing this dual criterion, some large-looming issues that are already being addressed with significant investigational resources must be excluded, such as stratospheric ozone depletion and global climate change. Rather, focus should be on issues with likely major, near-term impacts that are not receiving strategic evaluation and contingency planning; in other words, on issues that are suffering from a lack of sufficient attention. Hence the designation of this aspect of the dual criterion as "*Inattention*."

In weighing the dual criterion, near term issues might suffer if weighed only on the basis of their own novelty: weighed low on the basis of this aspect, they might nevertheless weigh high on the basis of Inattention -- and both must be considered. Thus, a high degree of Novelty, *per se*, together with a high degree of Inattention gives this dual criterion of Novelty high weight, whatever the Timing might be.

In judging the weight to be given to the dual criterion called *Novelty*, the criterion of *Timing* is important and, therefore, it

is suggested that it be considered and defined before the dual criterion is considered. Following this suggestion *Timing* is here listed first among all the criteria.

When considering the Novelty of an issue, itself, consideration should be given to whether an issue is: a wholly new issue, a significant modification of an existing issue or class of issues, a change of direction of an existing issue or class of issues, a newly recognized aspect of an existing issue, and/or whether new thinking is required or new options must be considered. In addition to considering what is new about an issue, *perceptions* of what are new issues, and what are new ways to deal with existing problems are important.

In weighing this part of the dual criterion (Novelty, *per se*) it is recognized that there will often be an existing base of scientific and technical information around an issue and that there will often be groups of individuals who recognize it as an important issue. The existence of such information or of groups of interested people does not negate the novelty of the issue. Rather, novelty, in addition to capturing wholly new issues, is meant to capture issues which are not generally accepted as matters of concern. One needs to consider whether the issue is generally not accepted as important, or is known or perceived to be an important issue, by one or more groups such as the technical/scientific community, academia in general, governmental personnel, and/or the population as a whole.

(3) ***Scope***: This is an *extensive* criterion of magnitude dealing with the breadth or extent of the issue with respect to the following different kinds of factors: (1) geographic range: local, regional, national or international; (2) population affected: many or few people are affected or a large or small percentage of people are affected; (3) ecosystems affected: many or few ecosystems or ecoregions are affected or a large or small percentage of such systems or regions are affected; (4) environmental coverage: the issue has broad or narrow environmental effects or it affects a large or small percentage of different types of environments; (5) socioeconomic factors: the breadth of impact in this area (how broadly are societal institutions and societal factors affected: education, jobs, etc.); (6) temporal scope: whether the issue is a long term, persistent issue or a shorter term one; (7) impact on regulatory or legislative activity: the degree of pertinence to many or few regulatory or legislative areas or to a large or small percentage of such areas; and (8) agencies affected: the issue is pertinent only to the EPA, it is pertinent to other agencies, or it is pertinent to both. It is important, when considering *Scope*, to define which of the different types of scope are relevant to the assessment being made.

(4) *Severity*: This is an *intrinsic* and/or *intensive* criterion of magnitude dealing with the depth or intensity of impact, or the seriousness of the consequences of an issue: the physical, health, ecological, socioeconomic (how deeply are societal institutions and societal factors affected: education, jobs, etc.), legislative, regulatory, and welfare consequences and, in particular, the irreversibility of the effects involved, or of the consequences of, the issue. The time needed to reverse an adverse effect or the rate of reversibility are further determinants of *Severity*.

(5) ***Visibility***: The "visibility" of an issue refers to the degree to which it is or can become visible as a public issue: to influential groups, to the media, to the political establishment, to the public as a whole. To assess the weight this criterion might have, the following characteristics of the issue need to be considered: its scientific, technical and/or economic plausibility; its political appeal; the recognition it is likely to receive by special groups; and its public comprehension and appeal (including the possibility of the fear of imminent personal harm). *Visibility* is also dependent on components of the first four issues. For example, if a large population were to be affected (under Scope), if *Novelty* were to include a new, important hazard, if *Severity* of an effect, especially on people, were to be large, or if the issue is expected to become a significant factor sooner rather than later (*Timing*) -- all would increase the *Visibility* and all must be considered. Since all these prior criteria must be considered in assessing *Visibility* after assessing the first four criteria are assessed is recommended.

(6) ***Probability***, is the sixth major criterion; it assesses the likelihood that the issue will need to be addressed. It is an integrative and a predictive criterion, highly dependent on the first five criteria.

It expresses the likelihood that an issue will rise to prominence by or within the time period in question and have to be dealt with in the period. It is integrative because all five of the preceding criteria, plus other factors, must be considered in assessing it and it is predictive since it predicts whether an issue is likely to become prominent within the future time frame of interest; it is not a characteristic of the issue, *per se*.

One might view the assessment of *Probability* as involving the estimation of the joint probability of an issue rising to prominence as a result of two other probabilities: (a) the probability that the issue will arise and need to be dealt with because of scientific, technical or other similarly definable reasons whether or not it is publicly visible and (b) the probability that the issue will arise because, whatever its scientific or technical basis, it has strong public and/or political appeal (*Visibility* plays a major role in determining this probability). These two probabilities are not independent of each other, and either one, separately, or both together, can cause a given issue to rank highly with respect to the joint or overall *Probability*. Specifying whether it is one of the two probabilities, or both together, which most determines the assessment of the *Probability* of the issue is important in issue selection.

Estimating the weight of this criterion requires considering the five other criteria already defined and, also, the issue's sensitivity (or lack of same) to scenarios (if these have been defined), and/or to driving forces.

Appendix E
Example of a Scoring Matrix

Introduction

Suppose a decision has to be made that requires the selection of one possible decision from many choices. If a clear winner is apparent, the decision is easy; however, in the real world one alternative may be better than the others in one but worse in other respects. When criteria are in conflict, how can a rational selection be made? One approach is the use of a utility matrix, a technique from the field of operations research. In this method, a list of selection criteria is first made. These criteria define the elements of a good decision such as low cost, low risk and high payoff. The criteria may not have equal weight; for example, low risk may be more important than low cost. Once the criteria and their weights are in hand, each alternative decision is reviewed in terms of each criterion. The review is usually conducted in matrix form, the alternative decisions in the rows and the criteria in the columns. Judgments about how each decision meets each criterion are placed in the cells, and a score is computed based on the weighted sums of the cells in the rows. All other things being equal, the decision that gains the highest score is the one that comes closest to meeting the ideal decision that would best satisfy all criteria.[1]

There are difficulties with this approach. First of all, a simple weighted sum may not reflect the actual decision process. For example, one decision may gain a high overall score despite a low score with respect to a single criterion. Yet this criterion may be absolutely necessary. One approach to meeting this difficulty is to use a formulation other than a simple weighted sum. A necessary criterion may be treated as a multiplicative element: if a decision rates a score of zero with respect to the necessary criterion, the total score will also be zero.

In addition, the method, while systematic, is almost entirely subjective. Thus two different people are apt to fill in the matrix differently and obtain different scores. If several people complete the matrix, the question remains: how should disparate opinions be combined? If an average is used, it will be distorted by extreme opinions. Perhaps the entire matrix should be completed by all participants and the rank order of the decisions compared.

Finally, the scores produced by such matrices may be sensitive to small changes in input.

[1]This type of scoring system is recommended, for example, in EPA's "Guidebook for Comparing Risks and Setting Environmental Priorities, "EPA/230/B93/013 (1993).

Nevertheless, the method is useful when many potentially conflicting decision criteria are involved. It helps sort out what's really important and at very least is capable of separating the subset of best decisions from the worst.

The method can be used to screen issues in EPA's early warning system. The system can generate a plethora of potential future issues. But which of these deserves priority? The criteria for selecting issues from the longer list include (as explained elsewhere in this report) novelty, scope, severity, visibility, timing and probability. The last criterion is of a different sort than the former five which are in fact, elements of an issue's impact. With this scheme, an issue with highest priority would be one that is entirely novel, severely affects essentially everyone, is publicly visible, apt to be felt soon, and is highly probable to emerge.

Test Example

To illustrate the method, a single member of the group prepared a scoring matrix for the set of fifty issues. The judgments were completely subjective and represented only a single person's view about what's important. This illustration is presented in Tables 1 and 2 and in Figures 1 and 2.

The weights assigned to the impact criteria were

Novelty	10
Scope	7
Severity	10
Visibility	5
Timing	5

Judgments were placed in the matrix cells according to the following scale:

Timing	1= +20 years in the future	5= immediate
Novelty	1= old hat	5= never been seen before
Scope	1= affects almost no one	5= affects everyone
Severity	1= slight effect	5= human death
Visibility	1= will be of very little interest	5= will be of great interest

The probability judgments were entered in percentage terms--that is likelihood of occurrence, and the weight used for the probability judgments was .5. Thus, 100% probability had an effect on the total score of an issue that was equal to a novel issue that had "never been seen before."

Table 1 presents the issues and judgments in numerical sequence. Note that for each issue both an "impact score" (composed of timing, novelty, scope, severity, and visibility and) and a total score that adds to the impact score the product of .5 and probability. Figure I presents a graph of impact score vs. probability for each issue. Table 2 presents the issues in rank order according to total score; the total scores are shown in bar graph form in Figure 2.

The top rated issues were

32 Decreasing availability of the quantity and quality of surface groundwater

26 Large increases in land use in developing countries lead to soil depletion, atmospheric particulates and desertification

44 Environmental emergencies caused by accident, terrorism, or crime

29 Health of the oceans deteriorates further

8 Technology to control newly recognized pathogens in drinking water is found inadequate

49 Contamination from dispersion of chemicals from storage reservoirs, more critical than management of point sources

7 Exposure to infectious agents becomes EPA concern

13 Adverse impacts of alternate energy sources on environmental quality

22 Demonstration of a major health hazard from non ionizing radiation

35 Emissions of persistent toxics and pollutants in developing countries, transported globally by long range atmospheric mechanisms

Analysis

Analyses of this sort should be used only to separate top rated issues from lower rated issues. It is inappropriate to argue on the basis of such an analysis that, say, issue 22 (ranked 9th) is more important than issue 35 (ranked 10th). The score difference between the two is insignificant and a small change in one judgment can swamp the small score differences that were computed.

To illustrate the sensitivity of such an analysis to variations in judgments, consider how changes to the entries for issue 32, the top rated issue would change the outcome. Suppose that instead of judgment of "5" for severity, a "4" was substituted. This change drops the rank of this issue from the top of the list to 3rd, and dropping it to "3" would place the issue as 6th. In other words, it would have remained in the top 10, despite such changes.

A very interesting use of the results of such an analysis is depicted in Figure 1. By plotting impact score against probability it is possible to identify regions of relative risk and return. For example:

High Impact, High Probability: These issues should clearly be given priority

High Impact, Low Probability: These are the surprise issues and preparation for them, despite their low probability may be appropriate

Low Impact, High Probability: These issues may be on us soon so preparation may be in order

Low Impact, Low Probability: These issues should not be on the urgent list

A prudent R&D program may cut diagonally across Figure 1, indicating a portfolio of issues for attention that includes essentially all high impact, high probability issues as well as moderate to high impact, lower probability issues.

One variation on this theme may be of interest. Suppose a group begins the exercise by assigning a total score to each of the issues, based purely on judgment. If the issues are then judged in the matrix form described above, it is possible to perform a regression analysis and deduce the criterion weights that come closest to "explaining" the assigned initial scores.

Table 1. Issue Scoring Example

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score
1	Environmental stresses cause of health problems and social disorder	2	3	2	2	3	86	35	103.5
2	Information highway causes psychological and societal impacts	1	3	2	4	3	86	35	103.5
3	Secondary pollutants found toxic	4	4	3	1	3	118	75	155.5
4	Synergistic chemicals found toxic, requiring management of the total, toxic air burden	3	4	3	2	2	108	85	150.5
5	Non cancer health effects emphasized leading to multiple end point human health risk assessment	4	4	3	2	4	128	90	173
6	Application of biological and genetic mechanisms to biomarkers, leading to changes in the way human health risks are studied	4	4	3	2	3	123	95	170.5
7	Exposure to infectious agents becomes EPA concern	3	5	4	4	3	140	90	185
8	Technology to control newly recognized pathogens in drinking water is found inadequate	2	5	5	5	4	150	98	199
9	Regional specificity becomes necessary in developing strategies for environmental protection	2	4	2	2	3	93	45	115.5
10	Ecological effects of light pollution found disruptive	3	3	2	1	1	81	25	93.5
11	Ecological effects of noise pollution found to disrupt communications and territorial response in many species	2	3	2	1	2	76	25	88.5
12	Cumulative stresses on sentinal species result in increasing frequency of die-off	2	3	2	2	2	81	95	128.5
13	Adverse impacts of alternate energy sources on environmental quality	2	5	5	4	3	140	85	182.5
14	Adverse ecological consequences of global climate changes	2	3	3	3	3	101	90	146
15	Loss of an annual crop in US as a result of unexpected pathogen	3	4	4	2	3	123	25	135.5
16	"Feminizing" of animal species and humans resulting from exposure to estrogen-mimicking chemicals	4	4	4	2	4	138	75	175.5
17	Long-range transport of pollutants found to be an important mechanism in accumulation of pollutants with severe effects	4	4	3	2	3	123	65	155.5
18	Recognition of the need to develop early warning signs and signals of potential environmental problems	4	4	3	2	3	123	50	148
19	Introduction of exotic species into new ecosystems	3	3	3	2	4	111	85	153.5
20	Recognition that data needed for environmental policy making are lacking	3	3	2	2	3	96	75	133.5
21	Unforeseen environmental impacts from the introduction of new chemicals	3	4	3	2	3	113	95	160.5
22	Demonstration of a major health hazard from non ionizing radiation	3	5	4	5	4	150	65	182.5
23	Great impacts on plants and animals of increasing ground level UV radiation	2	3	3	4	3	106	50	131
24	Release of radioactive material to the environment caused by accident, war or terrorism	3	5	5	2	3	140	60	170

(continued)

*Denotes weight.

Table 1. Continued

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score
25	Need for improved land use planning, including prevention of habitat loss, remediation, and urban land use	2	2	2	3	4	89	95	136.5
26	Large increases in land use in developing countries lead to soil depletion, atmospheric particulates and desertification	3	5	5	4	4	155	95	202.5
27	inadequate response to the environmental consequences of natural disasters	4	3	4	2	4	131	70	166
28	Loss of biodiversity as a result of loss and alteration of habitat	3	3	4	4	3	126	85	168.5
29	Health of the oceans deteriorates further	2	5	5	5	5	155	90	200
30	Fossil fuel depletion leading to greater use of resources that cause contamination and habitat loss	2	3	3	3	2	96	95	143.5
31	Over exploitation of natural resources leading to adverse ecological impacts	2	3	3	3	2	96	90	141
32	Decreasing availability of the quantity and quality of surface groundwater	4	4	5	5	5	168	85	210.5
33	Need for understanding the mechanisms and effects of local climate changes	4	2	2	2	2	94	25	106.5
34	Masking of greenhouse effects by counter-balancing effects of particulates that reflect incident sunlight	4	5	5	5	2	160	25	172.5
35	Emissions of persistent toxics and pollutants in developing countries, transported globally by long-range atmospheric mechanisms	4	5	4	3	4	150	65	182.5
36	Inefficient use of energy for transportation resulting in a broad range of environmental effects	4	3	3	3	2	116	45	138.5
37	Increased presence of lead and exotic metal resulting from use in electric or high efficiency vehicle	5	3	3	2	3	126	40	146
38	New and unexpected modes of introduction of pollutants and hazardous materials as a result of decay of urban infrastructure	5	4	3	2	3	133	80	173
39	Adverse effects on US industrial competitiveness as a result of non optimal environmental policies	5	3	2	2	3	116	35	133.5
40	Uses of wastes (encouraged by industrial ecology) leads to more problems than solutions	5	3	3	2	3	126	30	141
41	Lack of core competencies at EPA	2	3	3	2	5	106	185	148.5
42	Environmental problems resulting from rapid economic growth in developing countries	3	5	4	3	3	135	95	182.5
43	Localized climate change and other environmental effects resulting from use of alternate power sources	4	3	3	2	2	111	25	123.5
44	Environmental emergencies caused by accident, terrorism, or crime	4	5	5	4	4	165	75	202.5
45	Environmental degradation resulting from the export of goods from developing countries	4	3	3	3	3	121	35	138.5
46	Voluntary mandates fail to produce desirable changes in behavior affecting pollution levels	3	2	3	2	3	99	85	141.5
47	Lack of acceptance or empowerment results violence and apathy, especially among people who are sensitive to economic and environmental issues	5	3	3	3	3	131	75	168.5

(continued)

Table 1. Continued

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score
48	Growing debate about the definition of "acceptable risk"	4	3	3	3	2	116	65	148.5
49	Contamination from dispersion of chemicals from storage reservoirs, more critical than management of point sources	4	4	5	3	4	153	80	193
50	Continual discovery of biological impacts of pollutants at lower and lower concentrations requiring development of a new means of managing net risks	4	3	4	3	3	131	95	178.5

Table 2. Issue Scoring Example: Rank Order

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score	RANK
32	Decreasing availability of the quantity and quality of surface ground water	4	4	5	5	5	168	85	210.5 210.5	1 1
26	Large increases in land use in developing countries lead to soil depletion, particulates and desertification	3	5	5	4	4	155	95	202.5 202.5 202.5	2 2 2
44	Environmental emergencies caused by accident, terrorism, or crime	4	5	5	4	4	165	75	202.5 202.5	3 3
29	Health of the oceans deteriorates further	2	5	5	5	5	155	90	200	4
8	Technology to control newly recognized pathogens in drinking water is found inadequate	2	5	5	5	4	150	98	199 199 199	5 5 5
49	Contamination from dispersion of chemicals from storage reservoirs, more critical than management of point sources	4	4	5	3	4	153	80	193 193 193	6 6 6
7	Exposure to infectious agents becomes EPA concern	3	5	4	4	3	140	90	185 185	7 7
13	Adverse impacts of alternate energy sources on environmental quality	2	5	5	4	3	140	85	182.5 182.5	8 8
22	Demonstration of a major health hazard from non ionizing radiation	3	5	4	5	4	150	65	182.5 182.5	9 9
35	Emissions of persistent toxics and in developing countries, transported globally by long-range atmospheric mechanisms	4	5	4	3	4	150	65	182.5 182.5 182.5	10 10 10
42	Environmental problems resulting from rapid economic growth in developing countries	3	5	4	3	3	135	95	182.5 182.5	11 11
50	Continual discovery of biological impacts of pollutants at lower and lower concentrations, requiring development of a new means of managing net risks	4	3	4	3	3	131	95	178.5 178.5 178.5 178.5	12 12 12 12

(continued)

*Denotes weight.

Table 2. Continued.

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score	RANK
16	"Feminizing" of animal species and humans resulting from exposure to estrogen-mimicking chemicals	4	4	4	2	4	138	75	175.5 175.5 175.5	13 13 13
5	Noncancer health effects emphasized leading to multiple end point human health risk assessment	4	4	3	2	4	128	90	173 173 173	14 13 13
38	New and unexpected modes of introduction of pollutants and hazardous materials as a result of decay of urban infrastructure	5	4	3	2	3	133	80	173 173 173	13 13 13
34	Masking greenhouse effects by counter-balancing effects of particulates that reflect incident sunlight	4	5	5	5	2	160	25	172.5 172.5 172.5	14 14 14
6	Application of biological and genetic mechanisms to biomarkers, leading to changes in the way human health risks are studied	4	4	3	2	3	123	95	170.5 170.5 170.5 170.5	15 15 17 17
24	Release of radioactive material to the environment caused by accident, war, or terrorism	3	5	5	2	3	140	60	170 170 170	18 18 18
28	Loss of biodiversity as a result of loss and alteration of habitat	3	3	4	4	3	126	85	168.5 168.5	19 19
47	Lack of acceptance or empowerment results in violence and apathy, especially among people who are sensitive to economic and environmental stress	5	3	3	3	3	131	75	168.5 168.5 168.5 168.5	19 19 19 21
27	Inadequate response to the environmental consequences of natural disasters	4	3	4	2	4	131	70	166 166	22 22
21	Unforeseen environmental impacts from the introduction of new chemicals	3	4	3	2	3	113	95	160.5 160.5	23 23
3	Secondary pollutants found toxic	4	4	3	1	3	118	75	155.5	24
17	Long-range transport of pollutants found to be an important mechanism in accumulation of pollutants with severe effects	4	4	3	2	3	123	65	155.5 155.5 155.5	24 24 24
19	Introduction of exotic species into new ecosystems	3	3	3	2	4	111	85	153.5 153.5	25 25
4	Synergistic chemicals found toxic, requiring management of the total, toxic air burden	3	4	3	2	2	108	85	150.5 150.5	26 26
41	Lack of core competencies at EPA	2	3	3	2	5	106	85	148.5	27
48	Growing debate about the definition of "acceptable risk"	4	3	3	3	2	116	65	148.5 148.5	27 27
18	Recognition of the need to develop early warning signs and signals of potential environmental problems	4	4	3	2	3	123	50	148 148 148	28 28 28
14	Adverse ecological consequences of global climate changes	2	3	3	3	3	101	90	146 146	29 29
37	Increase presence of lead and exotic metals resulting from use in electric or high efficiency vehicles	5	3	3	2	3	126	40	146 146 146	29 29 29

(continued)

Table 2. Continued.

No.	Development	Novelty 10*	Scope 7*	Severity 10*	Visibility 5*	Timing 5*	Impact Score	Probability 0.5*	Total Score	RANK
30	Fossil fuel depletion leading to greater use of resources that cause contamination and habitat loss	2	3	3	3	2	96	95	143.5 143.5 143.5	30 30 33
46	Voluntary mandates fail to produce desirable changes in behavior affecting pollution levels	3	2	3	2	3	99	85	141.5 141.5	34 34
31	Over exploitation of natural resources leading to adverse ecological impacts	2	3	3	3	2	96	90	141 141	35 35
40	Uses of wastes (encouraged by industrial ecology) leads to more problems than solutions	5	3	3	2	3	126	30	141 141	35 35
36	Inefficient use of energy for transportation resulting in a broad range of environmental effects	4	3	3	3	2	116	45	138.5 138.5	36 36
45	Environmental degradation resulting from the export of goods from developing countries	4	3	3	3	3	121	35	138.5 138.5	36 38
25	Need for improved land use planning, including prevention of habitat loss, remediation, and urban land use	2	2	2	3	4	89	95	136.5 136.5 136.5	39 39 39
15	Loss of an annual crop in US as a result unexpected pathogen	3	4	4	2	3	123	25	135.5 135.5	40 40
20	Recognition that data needed for environmental policy making are lacking	3	3	2	2	3	96	75	133.5 133.5	41 40
39	Adverse effects on US industrial competitiveness as a result of non-optimal environmental policies	5	3	2	2	3	116	35	133.5 133.5 133.5	40 40 40
23	Great impacts on plants and animals of increasing ground level UV radiation	2	3	3	4	3	106	50	131 131	41 41
12	Cumulative stresses on sentinal species result in increasing frequency of die-off	2	3	2	2	2	81	95	128.5 128.5	42 42
43	Localized climate change and other environmental effects resulting from use alternate power sources	4	3	3	2	2	111	25	123.5 123.5 123.5	43 43 43
9	Regional specificity becomes necessary developing strategies for environmental protection	2	4	2	2	3	93	45	115.5 115.5 115.5	44 44 44
33	Need for understanding the mechanisms and effects of local climate changes	4	2	2	2	2	94	25	106.5 106.5	45 45
1	Environmental stresses cause of health problems and social disorder	2	3	2	2	3	86	35	103.5 103.5	46 46
2	Information highway causes psychological and societal impacts	1	3	2	4	3	86	35	103.5 103.5	46 46
10	Ecological effects of light pollution found disruptive	3	3	2	1	1	81	25	93.5 93.5	47 47
11	Ecological effects of noise pollution found to disrupt communications and territorial response in many species	2	3	2	1	2	76	25	88.5 88.5 88.5	50 50 50

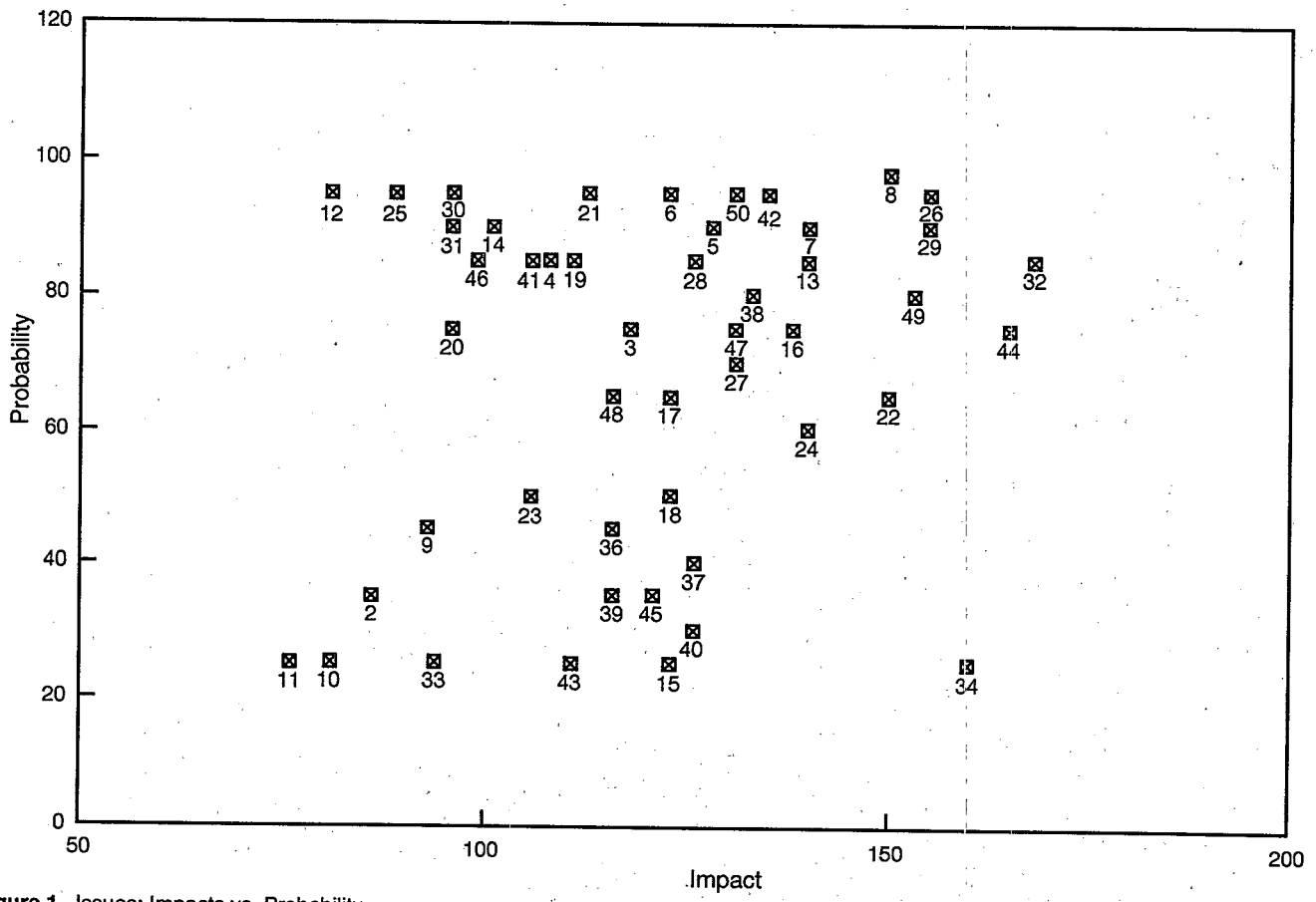

Figure 1. Issues: Impacts vs. Probability.
(The numbers identify the specific issue evaluated.)

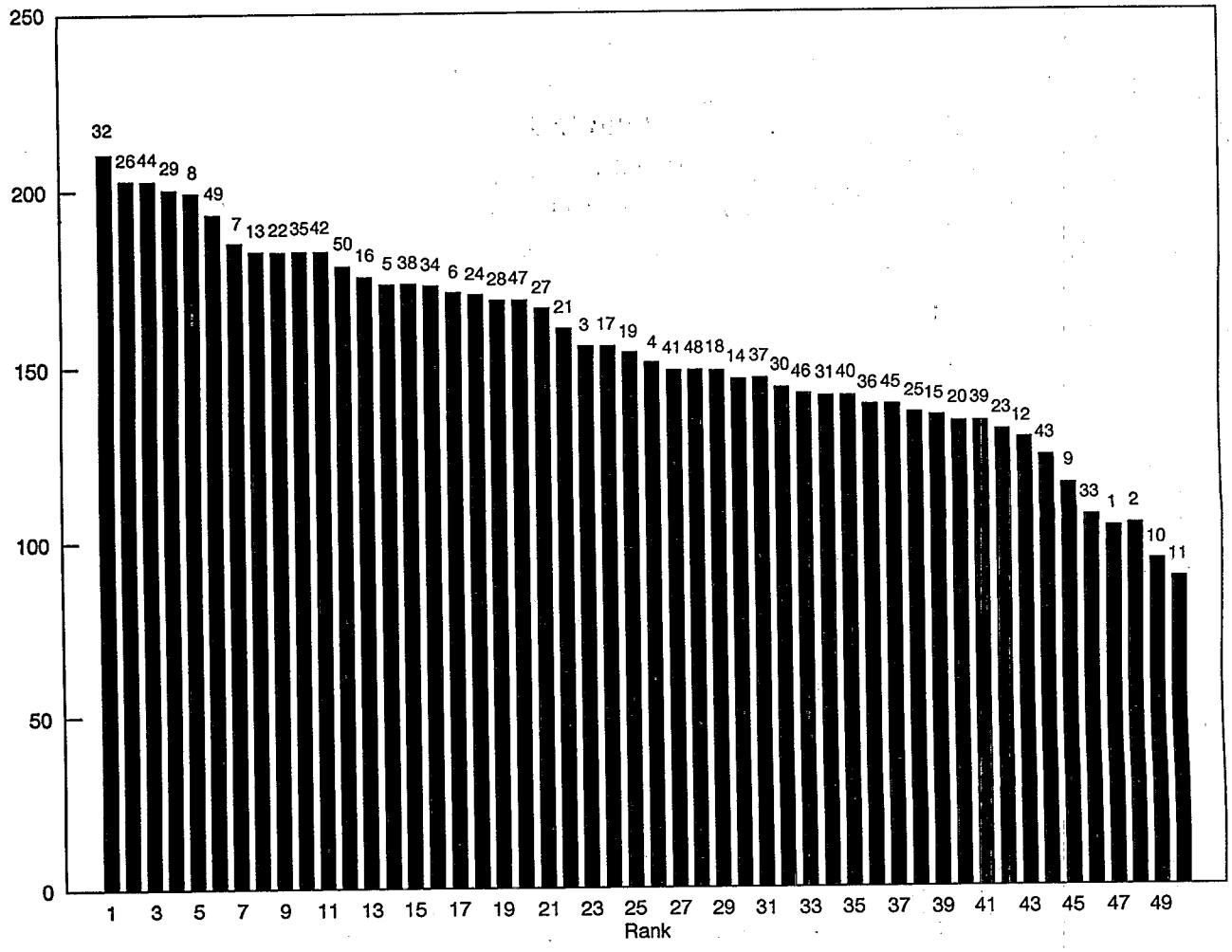

Figure 2. Total Scores for the Issues.
(This rank order plot is derived from the data in Table 2.)

Appendix F
A Set of Eleven Overarching Issue Areas
(Not listed in any order of preference)

NOTE: With the descriptive title of each overarching issue area two sets of numbers are given: in Arabic numerals, the collected issues listed Appendix A relevant to these issues; and in Roman numerals, the preliminary overarching issue areas listed in Appendix G. Not all of the underlying potential problems have been used explicitly in formulating the descriptions of the overarching issue areas although all have been considered. To the extent possible, the wording of the originators of the issues has been used so as to preserve meaning; where necessary additional or modified wording has been provided. The descriptive titles are written as though, in a future time, the problems associated with the issue areas are in existence.

No inference should be made that these are possible actual predictions, or that this is a comprehensive list of all possible future issues. Rather, these issues are simply one set of possible issues requiring further investigation, analysis and possible aggregation. These possible future issues are listed in no order of priority or importance.

A. Energy Choices, Worldwide, Increase the Total Loadings and Adverse Impacts of Pollutants -- 1-3, 1-4, 1-5, 1-6, 1-8, 4-3; I.

Continued and, in significant areas of the world, increasing use of fossil fuels as a main source of energy, without fully adequate, increasingly stringent, pollution controls, will lead to increasing pollution burdens and impacts on human and ecosystem health, worldwide. In many areas of the world, where fossil fuels remain the primary energy choice, development will remain closely linked to fossil fuel use.

Pollution of the air, water and land result from current fossil fuel burning: from contaminants directly emitted into the air; from contaminants formed in the air as a result of chemical reactions involving emitted contaminants; from deposition of some atmospheric contaminants into water and land; and from those solid and liquid wastes which are also pollution by-products of fossil fuel use and which contaminate both water and land directly.

The effects of pollution range from immediate local insults to longer range, regional impacts to global climate change. Many contaminants deposit onto the land and into the waterways at locations far removed from the original emission sites. Also, the increase in air pollutants is already resulting in an increase in global background levels of harmful agents. Pollutants that react chemically to form ozone, haze and acids cause problems on a regional scale and carbon dioxide, which does not enter into these types of reactions, is a major by-product of fossil fuel burning; it diffuses into all levels of the atmosphere, including the stratosphere, and can affect temperature and rainfall balances worldwide.

Current approaches to air quality management which focus on one issue at a time do not effectively deal with complex reaction sequences among atmospheric constituents, synergism between pollutants (including trace contaminants and particulates), emissions of persistent, or long-lived, toxics as well as other air pollutants, the accumulation of contaminants over time, and their dispersion and transport, inter-regionally and internationally. Developing countries, through their rapid expansion in the use of local wood and coal as fuel sources, pose particular problems to themselves and others as well as to specific, local areas where air contaminants are prevalent in high concentrations.

Recognition of this situation by national and international authorities must lead to risk-based management of air quality as a total system intimately linked to other factors and to programs encouraging individual participation and commitment to pollution prevention.

Trends analysis of rising background pollutant levels should provide early warnings about rising exposures of humans and ecosystems that, with improving exposure-response knowledge, could justify risk management actions before waiting for more severe effects to be established.

As we learn more about persistent pollutants, their interactions and transport, the United States' present control strategy paradigm will have to be rethought (simultaneous risk-management of the total air burden may be needed) and international cooperation will be required.

B. Global Warming Becomes a Reality and Leads to Global and Local Climate Changes and Other Complex Consequences -- 1-1, 1-2, 1-3, 3-4, 5-3, 5-4, 7-5, 7-6, 11-1, plus elements of 6-3; II.

Global warming is a well recognized issue, the subject, today, of much research, speculation and uncertainty. Major uncertainties exist as to if, when, and to what degree global warming will occur, possible mitigating mechanisms, and whether or not its effects will be more adverse than beneficial, overall. In the meantime numerous specific questions surrounding the interrelated issues need attention and a concerted effort to seek out and investigate such questions is needed. Some examples are

- Primary particles along with those formed from chemical reactions involving sulfur, nitrogen and carbon may be reflecting solar radiation back into space, thereby mask-

ing the greenhouse effect over some parts of the earth. Formation mechanisms for secondary pollutants such as ozone and fine particles (and visibility-reducing regional haze) in the atmosphere through complex, nonlinear processes are not fully understood. It is further complicated by uncontrollable factors such as natural emissions and meteorological influences. Better understanding of the simultaneous effects of particles, particle precursors and greenhouse gases is needed to devise appropriate risk management plans.

- Increased nitrogen-containing emissions (urban nitrogen oxide and agricultural ammonia emissions) may stimulate carbon uptake in plant tissues and thus may tend to balance global carbon losses to the atmosphere from agriculture and deforestation. Nitrogen fertilization may therefore serve to postpone the rate of CO_2 accumulation in the atmosphere.

- Future, more complete definition of the mechanisms of global climate change raises the possibility of identifying factors leading to adverse, local climate changes and the need for methods for their risk assessment and management. An example is the possibility of increased storm-system intensity, frequency and geographic coverage caused by the transformation of some of the additional thermal atmospheric energy of global warming into the mechanical energy of moving air masses.

- If the belief prevails and/or evidence shows that significant global warming will occur and that its effects are, overall, adverse, the selection and implementation of energy policies will be affected by factors such as whether concerns over greenhouse gas emissions or nuclear waste disposal -- or a combination of the two concerns -- dominate. Several scenarios based on these concerns could affect energy policy choices between the utilization of: (a) nuclear fission (or possibly, in the future, fusion); (b) fossil fuels; (c) alternative energy sources; or (d) combinations of these sources, as major sources of energy supply (see Issue XI).

C. Increasing Environmental Pressures Require New, Integrated Land Use Practices Which Allow for the Diversity of Needs and Interests -- 3-12, 4-4, 5-5, 6-2, 6-13, 7-1, 7-2, 7-3, 7-7, 7-8 plus elements of 6-3, 9-5, 9-7; III, XIII.

A new, integrated and holistic approach to land use will become more urgent nationally and internationally as a part of achieving sustainable development as population pressures and related environmental stressors increase. Land use choices made without appropriate environmental considerations can cause irretrievable losses of biodiversity and habitat, and can prevent the long term achievement of human welfare and health goals and sustainability. Some of the countervailing needs involved in the issue of land use are

- The increasing need to prevent species and habitat loss.

- The need to prevent the loss of productive agricultural land.

- The need to protect pristine lands.

- The need to prevent soil depletion and "dust bowl" creation (and, on a larger scale, desertification as in sub-Saharan Africa).

- The need to provide for expanding human populations, their needs, and their resource-using activities (e.g., increases in agricultural intensity in developing countries in order to feed large and growing local populations as in sub-Saharan Africa and Southeast Asia).

- The need to consider the increased individual and total population risks due to flooding as a result of increasing total population and/or increased population density in flood-prone areas, and related development activities. Greater storm intensities, a possible consequence of global warming, will exacerbate flooding problems.

- The need to give full consideration to the rights of property owners and their legal guarantees in future land use planning in the United States and in other countries.

- The need to cope with the current complexity and diversity of laws, regulations and ordinances within nations; this complexity and diversity is very great and can raise barriers to achieving improved, overall land use.

Providing for the reuse of already used, contaminated land and structures offers a solution to one aspect of the overall land use problem; however, failure to establish a stance that can enable less costly and more timely redevelopment of urban sites could force the development of more pristine land resources. Remediation criteria are needed for sites of all types prior to reuse; decontamination to levels approaching pristine conditions may not be possible and may be too costly compared to the benefits. Restricted use could restore some previously used sites to new industrial or other economic use.

This issue is likely to become acute in the period. In addition to its national and international scope, in some regions of the world it has national security implications.

D. The "Health" of the Oceans Deteriorates Further and Leads to a Wide Range of Serious, Adverse Consequences. -- 3-3, 7-14 (in part), 10-2; V.

The oceans are a major part of the global environment, covering over seventy percent of the surface of the Earth. They are a major source of food for many species, including the global human population; interacting with the atmosphere, they are a major part of the mechanism which generates the world's climatic conditions; they absorb and fix CO2 in various organic and inorganic forms; they absorb atmospheric contaminants (gases and particulates), purifying the atmosphere; and their worldwide blanket of chlorophyll-containing plant species, in the upper, photic layer of the oceanic waters, produces as much or more oxygen as terrestrial plants do.

There are early signs that the environmental health of the oceans is deteriorating. Most of these signs are seen in the coastal and near-coastal waters of the oceans, but some are showing up in the deep, open seas as well. Given the interconnections of all the parts of the oceans, it is not surprising that this should happen at some time.

Damage to the condition of the oceans comes about in two principal ways: (1) over-exploitation of their resources and (2) the introduction of pollutants and wastes into their waters.

The harvesting of marine life for food is the primary, current concern insofar as over-exploitation of resources is concerned. Much of the overharvesting has occurred in the relatively shallow (less than 1,000 feet deep) waters over the continental shelves where national Exclusive Economic Zones have been established and within which some nations, such as the U.S., are taking measures to restore depleted stocks. Commercial deep sea fishing and hunting is not so easily regulated, worldwide, however. At the present time, fully 45% of the fish stocks whose status is known are now overfished and populations of some species have decreased to 10% of the level that yields the largest sustainable catch (see 1993 *Vital Signs* for other relevant information).

Overharvesting is not solely a concern from the standpoint of human food supplies. The reduction of food availability affects other species and is not limited to coastal species since the food chains of the oceans are highly interconnected (the "food web"), longer, on average, than terrestrial food chains, and include species living at all depths.

Insofar as pollutants and wastes are concerned, the oceans are a major, frequently final, sink for pollutants and wastes of all kinds: pollutants in runoff from the land masses and from most rivers enter the oceans at every shoreline; airborne gaseous and particulate pollutants enter the oceans across their entire surfaces (see issue area A); liquid and solid wastes, including untreated sewage and radioactive wastes, from shore-based facilities and ships throughout the world are deliberately dumped into the oceans despite local laws and international conventions; accidental dumping from spills or other accidents introduce many types of contaminants and wastes into the oceans; and naval and military activities provide further sources of contamination.

The greatest burdens and impacts of pollution are found in the coastal regions and they have increased measurably in frequency and extent over the last two decades; some examples of impacts are: tumor-bearing fish, shell fish and marine mammals; red algae blooms (which have increased in number and in geographic distribution in the last decade) and which are due, in part, to nutrient pollutants; and contaminated fish, shell fish, and marine mammals. Red (and other) algal blooms cut off sunlight and deplete dissolved oxygen, causing great harm to other marine life; and their toxins, bioaccumulated in fish and shell fish, have sickened people and killed both whales and fish. Currents have transported such blooms hundreds of miles.

Although most of the effects of pollution and its impacts are seen in the coastal waters of the continental shelf around the world, ocean currents and the food web have carried individual contaminants to non-coastal waters. Many fish, including those normally harvested in coastal waters, migrate across great expanses of the oceans. Contaminants such as pesticides and PCBs have been found, widespread, in the open seas not only in the tissues of fish and marine mammals but in the seawater, itself. And solid waste such as polystyrene foam particles, bottles, and the like, have been found floating in the Sargasso Sea far from the beaches of the world where they so often appear. So far, in the open seas, the presence of contaminants and solid wastes is detectable, but their effects have not been detectable in many planktonic or nektonic life forms. Their presence stands as another, possible, early warning sign of larger, future problems.

The oceans are a vast (but not endless) complex of ecosystems that is as yet poorly understood compared to terrestrial systems and whose biodiversity may be greater than that of the land. Marine scientists have recently, at a National Research Council Conference, expressed concerns that oceanic biodiversity is at risk and must be much better understood in the near future. Because the oceans border on many countries and are so broad, they are the responsibility of no one country or organization. As a result, it is difficult to bring a single focus to bear on environmental events and changes in the oceans so that the integrated significance of such changes to the environment of the Earth can be evaluated. Oceans are huge reservoirs whose equilibrium takes a long time to change. However, it also will take a long time to recover once the causes of any adverse effects are identified. In the meantime, large parts of the ever-growing, global, human population may be affected by these changes. Assuming that "dilution is the solution to pollution" is no more valid for the oceans than for other segments of the Earth's environment.

Bringing an integrated focus to monitoring and assessing the important environmental consequences of the oceans, globally, will require firm, farseeing leadership.

E. Over-Exploitation of Natural Resources Leads to Ecosystem and Human Welfare Harm and Lack of Sustainability -- 6-5, 7-2, 7-3, 7-7, 7-13, 7-14, 8-3, 9-8, 11-1 (relates to 3-3, 10-2); IV, VI.

The problems connected with resource use and, in particular, resource depletion, worldwide, can be exacerbated by the lack of adequate alternatives for achieving short-term economic growth in many areas where the resource depletion is viewed as necessary for economic survival. Adverse impacts on ecological and other natural systems can be significant from the over exploitation of natural resources, however, and can threaten the long-term well- being of the ecologies of the planet as a whole, including human populations.

Some of the particular concerns are: over drafting of groundwater and surface water for irrigation, industrial use and drinking water supply are contributing to ground-level subsidence and concerns about our ability to supply ourselves with adequate quantities of drinking water of good quality. Poor agricultural practices contribute to erosion and subsequent loss of soils and reliance on monoculture crops poses risks to the food supply. Over exploitation of near coastal and marine fisheries has decimated many stocks of fish (see issue area D). Non-sustainable harvesting of timber and other causes of deforestation, not only in the tropical rainforests but elsewhere as well, cause unprecedented losses of biodiversity. Surface mining of minerals destroys terrestrial habitats and contaminates aquatic ecosystems. And poorly thought through land use practices in all areas contribute to many types of resource depletion (see issue area C).

Waste management, national and worldwide, goes hand-in-hand with resource use. The ultimate resting grounds of wastes are, in themselves, natural resources. Even with the maximum utilization of less polluting technologies, pollution prevention in general, waste utilization, and recycling, there will be waste to be disposed of, and increases in population and in energy use and material consumption per capita will exacerbate this issue. Increasing amounts of radioactive wastes will continue to pose their own particular problems. Efforts to prevent pollution and promote utilization and recycling will not proceed or succeed at the same rate in all regions of the world: they will take time to take hold. Thus the period of concern is one of many years' duration. The urgent need for economic improvement in some regions of the world will delay the full implementation of these more sophisticated approaches to pollution prevention and abatement.

Novel approaches to all of these problems will be needed. Economic offsets will not solve the underlying physical problems but they can make some of the interim adjustments more feasible and acceptable.

F. Introduction of Exotic Species and the Favoring of Specific Species Leads to Significant Threats to Endemic Species and to Overall Biodiversity -- 3-5, 7-11, 7-16, 9-6; VII.

The intentional introduction of exotic species (plant or animal, terrestrial or aquatic, microscopic or macroscopic, and natural or bioengineered), is usually done to obtain specific, clear benefits, as is the deliberate favoring of one species over another. Accidental introductions occur as well.

Practices that favor one species over another (as in fish hatcheries and silviculture) can change the ecological balance by helping the favored species to become dominant. Introductions can pose significant threats to endemic species and to overall biodiversity. Introduced species often out-compete native species, due to lack of predators, and disrupt the structure and functioning of ecosystems. Examples of natural species' introduction include: the zebra mussel in the Great Lakes, the Asiatic clam, kudzu, chestnut blight, Dutch elm disease, water milfoil, hydrilla, mesquite, the Japanese beetle and the sea lamprey.

The introduction of bioengineered species raises human health risk fears, too, not only from direct impact of the species in question but from unforeseen variations which may occur in nature to such species or the changes that unpredicted exchanges of genetic material may give rise to. The development of bioengineered species needs to be carefully evaluated and managed. Research is needed on both direct and indirect risks from bioengineered species, and on methods and protocols for hazard identification and risk analysis. As more bioengineered species are produced and used, public interest may become a salient factor in shaping the issue.

With the internationalization of the economy and the rapid development of bioengineering, a significant likelihood exists for an increase in the introduction of exotic species of all types; how to cope with these introductions will become an increasingly more severe problem.

G. Failure to Maintain a Healthy Biosphere Leads to Environmental Degradation to the Point of Preventing the Achievement of Sustainability an of Seriously Threatening Human Well-Being -- 2-1, 3-1, 5-6, 6-13, 7-8, 9-5, 9-10, 9-11, 9-12; VIII.

Achieving and supporting sustainable development in the face of mounting population and the pressures related to it (for example: increasing use of resources, including land; and increasing pollution, including that of light and noise) require holistic ecosystem risk assessment and management capable of maintaining a healthy, viable biosphere. Failure to maintain such a viable biosphere will result in ecological damage such as loss of habitat and of biodiversity and, ultimately, risks to human well being.

To maintain a healthy biosphere and achieve sustainable development, operational definitions of ecosystems which facilitate risk assessment and management will be needed, as well as research to define ecosystems, including their interrelationships to each other, to the whole, and to human health, well being and welfare; to define their role in maintaining sufficient biodiversity (and define such concepts as "sufficient biodiversity" and "sufficient habitat"); to define their relevance for achieving sustainable development; to define when ecological change is or is not inimical to the ecologies and to human health, well being and welfare; and to define when remedial action is required -- and what it is. This issue is likely to become prominent early in the period and to have major effect on land use policies (see Issue C).

H. The Advent And Application Of New Scientific Discoveries About the Causes of Adverse Human Health Effects, and of Extensive Data Banks, Leads to Radically New Methods of Human Health Risk Assessment and Management and to New Opportunities for, and Controversies in, Risk Management -- 1-4, 1-5, 3-7,3-8, 3-9, 4-1, 4-2, 5-10, 6-10, 6-11, 7-10, 7-18, 8-1, 11-2; X.

The challenges to human health risk assessment and management will remain high throughout the future period considered whether the agents in question are specific chemicals, mixtures of substances in solution or as suspended particulate or other finely divided matter, biological organisms, or any of many types of radiation. The questions of how to define and use, in risk assessments: (1) information as it is obtained in areas such as individual susceptibility to agents (especially for susceptible subpopulations); (2) the accounting for multiple or cumulative exposures including synergism between agents of all types; (3) biomarkers of exposure and/or of effect: and (4) information on mechanisms of action will continue to be of prime importance.

The increasing use, as knowledge is obtained from risk assessment-oriented studies or from other studies such as those involved in the Human Genome Project, of new information will lead to new methods of risk assessment, including developing techniques for the prediction of predisposition to disease. These, in turn, will have major effects on traditional methods of risk management and regulation and may require totally new strategies.

Risk assessment is further complicated by the diversity of backgrounds and ages in susceptible groups and the differences in population responses to risk due to economic, cultural or educational differences. With sufficient impetus, the harmonization of the assessment of risks of cancer and non-cancer endpoints is likely to come about, and the development of extensive and proven managed databases of exposures will become available.

As methods for accounting for multiple exposures and endpoints are developed (for cancer and non-cancer endpoints, together) and as previously unevaluated agents and effects are monitored and exposure data banks become more and more encompassing (see issue area J) there will be a tendency for regulations to become more stringent. Consequently, there will need to be better, more accepted methods for taking account of the benefits of risk reduction and for assessing risk versus risk. These developments, as they occur, will make the development of harmonized criteria of the "acceptabilities" of risks a more urgent problem.

I. Increased Energy Production and Use Coupled With Inefficiencies in Its Production and Use and With Inadequately Considered Energy Production Alternatives Lead to a Wide Range of Adverse Environmental Impacts -- 3-13, 6-8, 7-12, 7-15, 11-1; XI.

The production and use of energy in all its forms is among the greatest technological benefits enjoyed in the world today. The availability of just one form of energy, alone, electrical energy, for lighting, refrigeration of foods and medicines, communications, and education is a great and powerful positive force for human health and welfare. Thus, increased use of electrical energy from clean and efficient sources in developing societies has been viewed as a major step toward sustainable societies.

The environmental impacts of energy production and use will remain a major United States and worldwide issue throughout the period considered. As an overall issue it is not novel. For the United States, as the largest producer and user of energy in the world, the issue has a special criticality.

Some examples of areas requiring focused and integrated attention, in the U.S. and worldwide, are

- The recognition of the broad ranges of adverse environmental effects resulting from inefficient use of energy for transportation, industrial purposes, and residential use will lead to requirements for improved conservation and efficiency, and development of economic energy sources with lower environmental impacts.
- Transportation, in all its forms, is a major energy user and has major environmental impacts. In the light of the growing need for energy efficiency and environmental protection, a comprehensive review of our national transportation systems (ground, water and air) is needed to determine what developments are desirable (what combinations of types of transportation best fit differing needs and distances covered) and what means and incentives are needed to bring them about in a free society.
- The anticipation of an accelerated use of highly-polluting coal, with its release of particulates and hazardous substances (including radionuclides) and its potential impact on the global climate, in developing countries poses a worldwide issue. The United States' position as the largest user of energy makes this a particularly difficult issue to deal with from this country's standpoint.
- The need to avoid the possibility that fossil fuel depletion will lead to the use of resources having a greater potential for environmental contamination and habitat loss.
- The possibility that environmental costs (localized climate change, decreased raptor populations) resulting from increased use of alternative (e.g., solar, wind) power sources require more comprehensive planning prior to widespread use of these technologies.
- The particular issue of energy policy choices between the utilization of (a) nuclear fission (or possibly, in the future, fusion); (b) fossil fuels; (c) alternative energy sources; or (d) combinations of these sources, as major sources of energy supply need to be considered in the light of factors such as greenhouse emissions and nuclear waste disposal (see Issue B).

J. Failure to Monitor, Assess and Catalog Previously Unaccounted for Sources of Stressors Leads to Unexpected Adverse Impacts on Human Health and Ecosystems -- 1-6, 1-7, 1-9, 3-2, 4-1, 5-1, 7-4, 9-7, 9-13, 10-1; IX, XIV, XV.

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J. Failure to Monitor, Assess and Catalog Previously Unaccounted for Sources of Stressors Leads to Unexpected Adverse Impacts on Human Health and Ecosystems -- 1-6, 1-7, 1-9, 3-2, 4-1, 5-1, 7-4, 9-7, 9-13, 10-1; IX, XIV, XV.

Current requirements to report, monitor or measure contaminants (including biological contaminants) in, or released to, the environment may appear to be highly inclusive. However, such is not the case because contaminants can enter into, migrate and disperse in, change in, interact within, and accumulate in the environment, including the biosphere, in many now unaccounted ways both within and across media. Transport, dispersion, migration and dissemination can include not only the above means but also the transport of contaminants in goods from developed to developing countries and vice versa. The issue is of interregional and international scope, involving both developed and third world countries and their diverse practices. The effects of such contaminants on human health and ecosystems is not now sufficiently known, but as time goes on and accumulation continues, previously imperceptible risks may be perceived.

Currently, in the United States, only chemicals cited in permits and regulations are regularly monitored and measured. Historically, generic conventional parameters such as BOD, COD, TPH, or suspended solids, were monitored. Now it is likely as well to be some set of specific chemicals, such as benzene, naphthalene, chlorinated solvents, and the like. And while the *Toxic Substances Control Act*, along with other acts, causes the reporting of many new substances not otherwise reported to the EPA prior to their introduction as commercial products -- so that these substances are known to the EPA -- many other chemicals exist and migrate in the environment from a variety of direct and indirect sources that either in combination or alone can have long-term, slow but important health or ecological effects not now appreciated. Examples of bioaccumulative chemicals are:

(1) dioxin and polychlorinated biphenyls (PCBs) which concentrate in top predators and can adversely affect growth, development and reproduction of both terrestrial and aquatic consumers; while

(2) metals in soil, sediments and water can exert acute and chronic toxic effects on plants and animals, including humans.

It is not prudent to attempt to measure the concentrations or amounts of all contaminants that are released from various sources. However, there should be attempts to identify, record, monitor and analyze effects that may be caused by contaminants, both currently monitored or regulated contaminants and others, as a means of initiating studies aimed at identifying the actual stressors causing observed effects. One approach is the monitoring of early warning signs that adverse effects may exist. A comprehensive set of early warning signs has yet to be identified. Indicators of environmental harm, and therefore of underlying stressors, often are difficult to understand except in the case of visual air quality. Use of haze as an early warning signal has immediate and long term value, for example, and the monitoring of wildlife health for effects such as the current ones of environmental estrogens or the sudden reductions in populations, (e.g., the current collapse of frog populations) are examples of possible early warning signs. But more such signs need to be identified, catalogued, and entered into a readily accessible information system for use in identifying previously undetected exposures with effects. Public judgement that there is an environmental health problem based on perceptions of visual air quality and odor and human perceptions of environmental quality are indicators that should be followed up.

A second, companion approach is to develop an environmental data resource of high quality and reliability. With appropriate specification of the kinds, nature and amounts of data needed for some of EPA's most common data needs for risk assessment and risk management, much of the potentially useful data being collected by EPA, states, industry, and others could be made much more useful at marginal increases in cost of acquisition. The existence of a rational and potentially accessible repository of quality-assured data would itself stimulate the acquisition and sharing of additional data suitable for the needs of the various stakeholders. The mature system would provide for uniform criteria for (a) data collection and entry into the universal data resource, (b) reasonable and open access to the universal data resource, (c) inventorying of data and periodic trends analysis, (d) ongoing system of oversight and (e) periodic review of analyses based on usage of the data resource.

K. Failure to Respond to the National and International Expansion and Growth of the Concept of Environmental Equity Leads to Disproportionate Adverse Impacts on Significant Segments of the World's Population. -- 1-10, 1-12, 3-11; XVI.

Environmental justice or equity is an evolving issue in the United States which can expand well beyond its present scope and move in significant, additional directions. It is also an emerging international issue, particularly evident when developed nations ignore or are insensitive to environmental problems and environmental health in less developed nations. The problems of economic survival and improvement in those nations are too seldom recognized, and differences in living habits, nutritional levels, cultural practices and susceptibilities to diseases must be borne in mind; and it must be remembered that environmental "solutions" satisfactory for more developed nations may be infeasible or unacceptable in less developed nations. Assistance in forms that less developed nations can use and accept is needed. This issue may become one of the most important ones in the coming period with major international aspects and consequences and possibly national security aspects.

In the United States the issue is based on the fact that people of lower economic means, among whom the proportion of minorities is often higher than in the general population, are generally more highly exposed to environmental contaminants, either through living in proximity to manufacturing areas, waste disposal sites or other facilities or in higher contaminated areas, or because of the nature and basis of regulations written for "average" individuals, or otherwise. This segment of the population may have different food intake patterns and habits of living because of differences in economic conditions and cultural backgrounds from the "average" member of the population and may have consequent different overall levels of health and individual susceptibilities to diseases. In addition to the possibility that such portions of the population might experience an excess of adverse health effects, compared with the rest of the population, from such exposures, stress induced by factors related to or enhanced by environmental degradation might result in increased physical health problems or, even, increased violence.

In the United States the issue has a growing following, and environmental programs must be sensitive to equity and address the need for bringing diverse, even angry voices into the decision process. Research is needed to provide the statistical and other evidence to ensure that policy decisions (and any concomitant legislative and/or regulatory decisions) are the best that can be made; but it must be remembered that equity is a matter of human values and is not an issue to be resolved by science but, at most, illuminated by it. Examination of current regulatory structures to determine which may be affected by the environmental equity issue (not only those regulatory structures relating to site-related issues but all types of regulations) is needed to determine the true scope of the issue and to set goals.

Appendix G
Overarching Issue Areas Prepared for Discussion With the EFC
(Not listed in any order of preference)

NOTE: With the title of each overarching issue area the numbers of the relevant issues in Appendix A are given. Not all of the underlying issues were used explicitly in formulating the descriptions of the overarching issues although all were considered. The wording of the issues in Appendix A was used to the extent possible to preserve original meaning. Titles were added to indicate the general subjects of the issues areas, not to summarize the issues.

No inference should be made that these are possible actual predictions, or that this is a comprehensive list of all possible future issues. Rather, these issues are simply one set of possible issues requiring further investigation, analysis and possible aggregation. These possible future issues are listed in no order of priority or importance.

I. Integrated Atmospheric Contaminant Management -- 1-3, 1-4, 1-5, 1-6, 1-8, 4-3.

Current approaches to air quality management which focus on one issue at a time do not effectively deal with complex connections among atmospheric processes, synergism between pollutants (including trace contaminants and particulates), emissions of persistent, or long-lived, toxics as well as other air pollutants, the accumulation of contaminants over time, and their dispersion and transport, inter-regionally and internationally. Developing countries in particular pose problems as do local areas where air contaminants are prevalent in high concentrations.

Recognition of this situation is leading to risk-based management of air quality as a total system intimately linked to other factors and to programs encouraging individual participation and commitment to pollution prevention. Trends analysis of rising background pollutant levels may provide early warnings about rising exposures of humans and ecosystems that, with improving exposure-response knowledge, could justify risk management actions before waiting for more severe effects to be established. As we learn more about persistent pollutants, their interactions and transport, we will have to rethink our present control strategy paradigm. Simultaneous risk-management of the total air burden may be needed.

II. Climate Change: Global Warming -- 1-1, 1-2, 1-3, 3-4, 5-3, 5-4, 7-5, 7-6, 11-1.

Global warming is a well recognized issue, the subject, today, of much research, speculation and uncertainty. Major uncertainties exist as to if, when, and to what degree global warming will occur, considering possible mitigating mechanisms, and whether or not its effects will be more adverse than beneficial, overall. In the meantime numerous specific questions surrounding the interrelated issues need attention and a concerted effort to seek out and investigate such questions is needed. Some examples are

- Formation mechanisms for secondary pollutants such as ozone and fine particles (and visibility-reducing regional haze) in the atmosphere through complex, nonlinear processes are not fully understood. It is further complicated by "uncontrollable factors" such as natural emissions and meteorological influences.
- Primary particles along with those formed from chemical reactions involving sulfur, nitrogen and carbon may be reflecting solar radiation back into space, thereby masking the greenhouse effect over some parts of the earth. Better understanding of the simultaneous effects of particles, particle processors and greenhouse gases is needed to devise appropriate risk management plans.
- Increased nitrogen-containing emissions (urban nitrogen oxide and agricultural ammonia emissions) may stimulate carbon uptake in plant tissues and thus may tend to balance global carbon losses to the atmosphere from agriculture and deforestation. Nitrogen fertilization may therefore serve to postpone the rate of CO_2 accumulation in the atmosphere.
- Future, more complete definition of the mechanisms of global climate change raises the possibility of identifying factors leading to adverse, local climate changes and the need for methods for their risk assessment and management.
- If the belief prevails that global warming will occur and that its effects are, overall, adverse, the selection and implementation of energy policies will be affected by factors such as whether concerns over greenhouse gas emissions or nuclear waste disposal -- or a combination of the two concerns -- dominate. Several scenarios based on these concerns could affect energy policy choices between the utilization of (a) nuclear fission (or possibly, in the future, fusion), (b) fossil fuels, (c) alternative energy sources, or (d) combinations of these sources, as major sources of energy supply (see Issue XI).

III. Land Use and Management -- 3-12, 4-4, 5-5, 6-13, 7-1, 7-7.

As both direct and indirect land use restrictions grow in number, coverage and complexity, a holistic review of land use-related laws, regulations and policies will become more urgent as a part of achieving sustainable development. Policies dealing with land use choices will have to include health

considerations as well as ecological considerations such as loss of biodiversity, habitat destruction, soil depletion, "dust bowl" creation (and, on a larger scale, desertification). The reuse of land must be considered: remediation criteria for the decontamination of land previously subjected to many types of uses to make it suitable for reuse will be needed, including consideration of health, ecological and cost and benefit factors. This issue is likely to become acute in the period. It has national and international implications; in some regions of the world it has national security implications.

IV. Global Waste Management Issues -- 6-5, 7-2, 7-3, 11-2.

Only a few of the issues collected address waste, per se, and it is not the main topic of any of the issues. However the interregional, international and global implications of this issue are likely to become large within the period despite efforts to prevent pollution and promote recycling and novel approaches will be needed. Increases in population, in energy use per capita, in consumption per capita, and in the sophistication of the very methods for dealing with wastes, will exacerbate this issue.

V. The Health of the Oceans -- 3-3, 7-14 (in part), 10-2

There are signs, today, that the overall health of the oceans, and of the enormously complex ecologies therein, is deteriorating. The maintenance of the health of the oceans needs to be addressed holistically and internationally as population pressures and related drivers bring ever greater stress on the total set of the oceans' slow regenerative capacities. Causes include overuse (such as overfishing), the impacts of pollutant and solid waste discharges and dumping by nations around the world, dumping and spills at sea, and the absorption of airborne contaminants of all types. There is no one authority responsible for the health of the oceans. At risk is a major source of the world's food supply, a major sink and transporter of CO_2, a major producer of oxygen, and a highly important climatological engine. The issue is likely to become acute within the period if present trends continue. The issue is of global and critical importance.

VI. Over Exploitation of Natural Resources -- 7-7, 7-13, 7-14, 8-3, 9-8, (relates to 3-3, 10-2).

Adverse impacts on ecological and other natural systems are significant from over exploitation of natural resources. Over drafting of groundwater and surface water for irrigation, industrial use and drinking water supply are contributing to in increase in deserts in many parts of the world as well as to concerns about our ability to supply ourselves with adequate quantities of drinking water of good quality. Poor agricultural practices contribute to erosion and subsequent loss of soils. Over exploitation of near coastal and marine fisheries have decimated many stocks of fish (see Issue V). Non-sustainable harvesting of timber particularly in the tropics cause unprecedented losses of biodiversity. Surface mining of minerals destroys terrestrial habitats and contaminates aquatic ecosystems. And poorly thought through land use practices in all areas, contribute to many types of resource depletion (see Issue III).

VII. Accidental or Misguided Introduction of Exotic Species -- 3-5, 7-11, 7-16, 9-6.

Accidental or misguided introduction of exotic species (both plant and animal, terrestrial and aquatic species, and both and natural and bioengineered species) pose a significant threat to endemic species and overall biodiversity. Introduced species often out-compete native species, due to lack of predators, and disrupt the structure and functioning of ecosystems. Examples of natural species introduction include: zebra mussel in the Great Lakes, Asiatic clam, kudzu, chestnut blight, Dutch elm disease, water milfoil, hydrilla, mesquite, Japanese beetle, sea lamprey. The introduction of bioengineered species raises human health risk questions, too, not only from direct impact of the species in question but from variations which may occur in nature to such species or the changes that exchanges of genetic material may give rise to. With the internationalization of the economy and the rapid development of bioengineering, a significant risk exists for an increase in the introduction of exotic species. Development of bioengineered species needs to be carefully evaluated and managed. Research is needed on the existence (or nonexistence) of both direct and indirect risks from bioengineered species, and on methods and protocols for hazard identification and risk analysis. As more bioengineered species are produced and used, public interest is likely to be a salient factor in shaping the issue.

VIII. Sustainable Development and the Maintenance of a Healthy Biosphere -- 2-1, 3-1, 5-6, 6-13, 7-8, 9-5, 9-10, 9-11, 9-12.

While human health and welfare considerations are the governing reasons for seeking to achieve sustainable development, and are, therefore, important in defining and achieving it, ecological factors, especially loss of habitat and of biodiversity, represent great threats to our ability to achieve sustainable development. Mounting population and the pressures related to it (land use, pollution including that of light and noise, for example) will require holistic ecosystem risk assessment and management capable of supporting sustainable development; operational definitions of ecosystems which permit this to be done are not now available and research is needed to define ecosystems so as to take account of their interrelationships: to each other, and to the whole; their role in maintaining sufficient biodiversity; their relationships to human health, well being and welfare; their relevance for achieving sustainable development; when ecological change is or is not inimical to human health, well being and welfare; and when remedial action is required. This issue is likely to become prominent early in the period and to have major effect on land use policies (see Issue III).

IX. Migration and Accumulation of Pollutants -- 1-6, 1-7, 9-7, 9-13.

The dissemination, dispersion, migration and long-range transport of contaminants (including biological contaminants), especially persistent ones, by many pathways, and their accumulation in the environment, including the biosphere, over time, poses a large and difficult issue in risk assessment and management. Major risks can arise if this issue is not

addressed and the phenomena not monitored in a concerted way. For example, bioaccumulative chemicals such as dioxin and poly chlorinated biphenyls (PCBs) concentrate in top predators and can adversely affect growth, development and reproduction of both terrestrial and aquatic consumers while metals in soil, sediments and water can exert acute and chronic toxic effects on plants and animals, including humans. Transport, dispersion, migration and dissemination can include not only traditional means but the transport of contaminants in goods from developed to developing countries (which does not always follow good environmental practices) -- and vice versa. The issue is of inter-regional and international scope, involving both developed and third world countries and their diverse practices.

X. Human Health Risk Assessment and Management -- 1-4, 1-5, 3-7, 3-8, 3-9, 4-1, 4-2, 5-10, 6-10, 6-11, 7-10, 7-18, 8-1, 11-2.

The challenges to human health risk assessment and management will remain high throughout the future period considered whether the agents in question are chemical substances, particulate matter, biological organisms, or any of many types of radiation. The questions of how to define and use, in risk assessments, such information as it is obtained in areas such as individual susceptibility to agents (and especially susceptible subpopulations), the accounting for multiple or cumulative exposures including synergism between agents of all types, biomarkers of exposure and/or of effect, and ancillary information on mechanisms of action will continue to be of prime importance; the increasing use, as knowledge is obtained, of information in these areas will lead to new methods of risk assessment which, in turn, will have major effects on risk management and regulation. With sufficient impetus, the harmonization of the assessment of risks of cancer and non-cancer endpoints is likely to come about, and the development of extensive and proven managed databases of exposures will become available. In all likelihood, regulations in many cases will become more stringent, especially as methods for accounting for multiple exposures are developed, including multiple effects: cancer and non-cancer endpoints, together. These developments, as they occur, will make the development of harmonized criteria of the acceptabilities of risks a more urgent problem; whether it will or can be resolved explicitly is not clear.

XI. Energy Production and Use -- 3-13, 6-8, 7-12, 7-15, 11-1.

Energy production and use, and its environmental impacts, is and will remain a major issue throughout the period considered. As an overall issue it is not novel.

As the largest producer and user of energy in the world, the issue is especially critical in the United States. Some examples of areas requiring focused and integrated attention are:

- The fact that the broad ranges of environmental effects resulting from inefficient use of energy for transportation, industrial purposes, and residential use require improved conservation and efficiency, and development of economic energy sources with lower environmental impacts;
- The need to avoid the possibility that fossil fuel depletion will lead to use of resources having a greater potential for environmental contamination and habitat loss; and
- The possibility that environmental costs (localized climate change, decreased raptor populations) resulting from increased use of alternative (e.g., solar, wind) power sources require more comprehensive planning for use of these technologies.
- The particular issue of transportation. Transportation in all its forms is a major energy user and has major environmental impacts. In the light of the growing need for energy efficiency and environmental protection, review of our national transportation systems (ground, water and air) is needed to determine what developments are desirable (what combinations of types of transportation best fit differing needs and distances covered) and what means and incentives are needed to bring them about in a free society.
- The particular issue of energy policy choices between the utilization of (a) nuclear fission (or possibly, in the future, fusion), (b) fossil fuels, (c) alternative energy sources, or (d) combinations of these sources, as major sources of energy supply need to be considered in the light of factors such as greenhouse emissions and nuclear waste disposal (see Issue II).

XII. Technological Innovation, Development or Decay -- 3-6, 5-7, 5-8, 6-1, 6-7, 6-11, 7-9.

It will be important to look for and monitor risks related to technological causes -- new, developing or in a state of decay -- on a continuing basis as time goes on. This should be an ongoing task of an established "lookout" panel. Some examples of these types of risks are:

- Environmental and other benefits of the spread of the information highway throughout society may bring with them significant personal (mental) health and societal risks.
- Increased presence of lead and more exotic metals in the environment as a result of widespread acceptance of electric or high efficiency automobiles.
- Proliferation of new technologies will increase sources of non-ionizing radiation, a possible important health threat.
- Broad ranges of environmental problems result from rapid economic growth in the developing world, require strategic technology planning, technology transfer, and negotiations to reduce or slow these impacts.
- Accelerating deterioration of urban infrastructure (e.g., water, sewerage, fuels) will cause many serious environmental incidents and the introduction of unexpected pollutants into the environment.

XIII. Management of Natural Environmental Disasters -- 6-3.

Continued growth of the U.S. population, especially since it tends to result in larger, densely populated city-plexes, and the increasing utilization of land for agricultural and other pur-

poses (including widely separated residences and other inhabited facilities) as population grows, make the occurrence of any natural disaster, whether the disaster be caused by floods, storms, earthquakes, or fires, more severe and extensive in its impact on human life, safety, and welfare and on regional and national economics. The same can be said internationally. In the case of floods and storms, phenomena associated with atmospheric action, the onset of global warming, if it should occur without significant mitigation, will increase the danger still further because of the partitioning of energy in the atmosphere between thermal and mechanical modes, coupled with the inherently chaotic nature of atmospheric phenomena. Recent experience, alone, demonstrates the seriousness of these types of environmental hazards and after-the-fact rescue plans alone (Federal Emergency Management Agency), however well conceived and carried out, will not suffice as we enter and move through the time period under consideration. An effort is needed, starting now, to lay plans for preventative measures as well as rescue and repair measures. This issue will have important impact on such other issues as Issue III.

XIV. Information on Measures and Indicators of Human Health and Ecological Risks -- 1-9, 3-2, 4-1, 5-1, 7-4, 10-1.

Two factors are critical to the identification, assessment and ultimately, risk management of hitherto undetected adverse effects on human health and ecosystems: (1) the monitoring of early warning signs that such effects may exist and (2) an environmental data resource of high quality and reliability. Needed now, the need for these two items will only grow in the future.

With regard to the first item, a comprehensive set of early warning signs has yet to be identified. Indicators of environmental harm often are difficult to understand except in the case of visual air quality. Use of haze as an early warning signal has immediate and long term value, for example, and the monitoring of wildlife health, with its possible meaning for human health, is another, but more such signs need to be identified, catalogued, and entered into a readily accessible information system for use in identifying previously undetected effects.

With regard to the second item, with appropriate specification of the kinds, nature, specified and amounts of data needed for some of EPA's most common data needs for risk assessment and risk management, much of the potentially useful data being collected by EPA, states, industry, and others could be made much more useful at marginal increases in cost of acquisition. The existence of a rational and potentially accessible repository of quality assured data would itself stimulate the acquisition and sharing of additional data that filled important information needs of the various stakeholders. The mature system would provide for uniform criteria for: a) data collection and entry into the universal data resource, b) reasonable and open access to the universal data resource c) inventorying of data and periodic trends analysis d) ongoing system of oversight and e) periodic review of analyses based on usage of the data resource.

XV. Novel and Unaccounted Sources of Stressors -- 10-1.

Only chemicals cited in permits and regulations are now regularly monitored and measured. Previously, generic conventional parameters such as BOD, COD, TPH, suspended solids, were monitored. Now it is likely as well to be some set of specific chemicals, such as benzene, naphthalene, chlorinated solvents, and the like. There are, however, many other chemicals released to the environment that either in combination or alone can have a long term, slow but important health or ecological effects not now appreciated. It is not prudent to attempt to measure the concentrations of all chemicals that are released. However, there should be attempts to identify, record, monitor and analyze effects that may be caused by chemicals, both currently monitored or regulated chemicals and others, as a means of initiating studies aimed at identifying the actual causes of observed effects. Current examples of the kinds of effects that might be picked up are release of bioengineered species, the effects of environmental estrogens or other specific disease endpoints, or the disappearances of specific species (e.g., the current losses of frogs). (See, too, Issues VII, IX, X and XIV).

XVI. Environmental Equity -- 1-10, 1-12, 3-11.

Environmental justice or equity is an existing issue which can expand well beyond its present scope and move in significant. additional directions. It is an issue affecting mainly the lower economic strata of society among which, in the United States, there is a disproportionately large number of minorities. It is based on the fact that people in this stratum of society are generally more greatly exposed to environmental pollutants and wastes, either through proximity to living areas, the work place, the nature and basis of regulations written for "average" individuals, or otherwise. In addition to the possibility that such portions of the population might experience an excess of adverse health effects, compared with the rest of the population, from such exposures, stress induced by factors related to or enhanced by environmental degradation, may be growing and might result in increased physical health problems or, even, increased violence.

The issue is politically attractive, it has a growing following, and environmental programs must be sensitive to equity and address the need for bringing angry voices into the decision process. Research is needed to provide the statistical and other evidence to ensure that policy decisions (and any concomitant legislative and/or regulatory decisions) are the best that can be made. Examination of current regulatory structures to determine which may be affected by the Environmental Justice issue (not only those regulatory structures relating to site-related issues but all types of regulations) is needed to determine the true scope of the issue and to set goals.

XVII. Education, Culture and Environmental Awareness -- 1-11, 6-4.

The costs of environmental management strategies are growing and are increasingly of concern to various sectors of the population, including the public at large. In many areas, already, the traditional "command and control" environmental strategies are being challenged, and these challenges are likely to grow. Also, voluntary "mandates" for personal change do not seem to be effective. Effective alternatives to traditional approaches are needed now and will be increasingly needed in the future.

Cultural characteristics which determine individual habits can be major factors in determining pollution levels and the degree to which wastes of many types are properly handled and disposed of. Improved, more widespread, environmental education and dialogue among individuals and institutions is needed to promote an awareness of common environmental problems, a common commitment to solutions developed by and for the public in general, and, ultimately, to bring about environmentally favorable cultural changes. The processes for bringing about cultural changes are slow-acting ones at best and require the dedication of large resources, skillfully, creatively, consistently and persistently over time.

Appendix H
Selected Published Information on Foresight and Driving Factors

A. Foresight Techniques and Forecasts

Brown, L.R., H. Kane, and E. Ayres. 1993. *Vital Signs: The Trends That are Shaping our Future*. W.W. Norton and Company, New York, 150 pp.

ICF. 1990. Environmental Forecasting: Problems, Study Profiles, and a Selected Bibliography. (Prepared for the Environmental Results and Forecasting Branch, OPPE, EPA)

Girl Scouts of America. 1993. Environmental Scanning Report 1994-1996. (Available from Research Group, GSUSA, 420 Fifth Avenue, New York, N.Y. 10018-2702

Gordon, T.J. and J.C. Glenn. 1993. Issues in Creating the Millennium Project. (This was an initial report from the Milennium Project Feasibility Study, United Nations University, 4421 Garrison Street, N.W., Washington, D.C. 20016-4055. It was prepared for EPA and sections are used in this document with permission of the authors. A copy of the detailed report is available on the Internet "Worldewide Web. Futures@EPA.GOV. Select Pointers and Guides and the Millinenium Project is under that heading.)

Grant, L. 1988. Foresight and National Decisions: The Horseman and the Bureaucrat. 273p. University Press of America. Lanham, MD.

Schwartz, P. 1991. *The Art of the Long View*. Doubleday Publishers, New York, 258 pp.

Schwarz, B., U. Svedin, and B. Wittrock. 1982. *Methods in Futures Studies: Problems and Applications*. Westview Press. Boulder, Colorado (Consulted only chapter 3 pp. 11-45).

Shoemaker, P.J.H. and C.A.J.M. van der Heijden. 1992. Case Study: Integrating Scenarios into Strategic Planning at Royal Dutch/Shell. *Planning Review* (May/June): 41-48.

B. Population and Demographics

Population Reference Bureau. 1993. World Population Data Sheet (Demographic data and estimates for the countries and regions of the world). (Available from Circulation Department, PRB, P.O. Box 96452, Washington, D.C. 20090-6452 or 800-877-9881).

Day, J.C. 1994. Projection of the United States, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050. P25-1104. U.S. Government Printing Office, Washington, D.C. (Current Population Reports by the U.S. Bureau of the Census)

United Nations. 1992. Long-Range World Population Projections. ST/ESA/SER.A/125. New York. (These are biennial projections prepared by the UN).

C. Driving Factors

Dutch Committee for Long Term Environmental Policy. 1991. Highlights from "The Environment: Ideas for the 21st Century". (This article and the 640 page book it describes are available from CLTM, P.O. Box 90740, 2509 LS The Hague, Netherlands.)

McCabe, G., C. Orians, C. Cluett, K. Branch, and N. Johnson. 1991. Driving Variables that Impact Environmental Quality. (Prepared by Battelle Human Affairs Research Centers, Seattle and Department of Economics, University of Washington for the Environmental Forecasting Project, EPA)

D. Energy

Office of Technology Assessment. 1993. Assessment Activities.

World Resources Institute. 1991. A Comparative of U.S. Energy Sector Forecasts and Their Usefulness to EPA. (Prepared in support of the EPA.)

E. Technology

Carnegie Commission. 1992. Enabling the Future: Linking Science and Technology to Societal Goals. (Available from the Carnegie Commission, 10 Waverly Place, New York, N.Y. 10003)

National Science Technology Council. 1994. Technology for a Sustainable Future: A Framework for Action. (Available from Environmental Technology Strategy Staff, OSTP, Room 443, Old Executive Office Building, Washington, D.C. 20500)

Olson, R.L. and M. Superka. 1994. Technology for a Sustainable Future. Institute for Alternative Futures. Alexandria, VA. (Available from IAF, 108 N. Alfred Street, Alexandria, VA)

F. Trends

Gas Research Institute. 1992. Environmental Trends and Issues at the Research Horizon. GRI-92/0156. (Available from the Gas Research Institute, 8600 Bryn Mawr Avenue, Chicago, IL 60631.)

U.S. Army Environmental Policy Institute. 1994. 1994 Environmental Trends Update. (Available from Mr. Robert Jarrett, U.S. Army Environmental Policy Institute, 430 Tenth St., NW, Suite S-206, Atlanta, GA 30318. Note the SAB was given a working draft of this paper which may not be available, however, a 1993 Environmental Trends Update has been published.)

G. Ocean Health

Anderson, D.M. 1994. Red Tides. *Scientific American* (August):62.

Culotta, E. February 1994. Is Marine Biodiversity at Risk? *Science 263*:918.

Holloway, M. 1994. Diversity Blues. *Scientific American.* (August) p. 16.

Hughes, T. P. 1994. Catastrophes, Phase Shifts and Large-Scale Degradation of a Caribbean Coral Reef. *Science 265*:1547-1551.

Kerr, R.A. 1988. Linking Earth, Ocean, and Air at AGU. *Science 239*:259.

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Robinson, M. 1986. Update: Sellafield Sea-Dumping. in *Letters Harpers 272* (1633):4.

"Sources if Marine Pollution" 1989. In: *The Time Atlas and Encyclopedia of the Sea.* Alastair Couper, Ed. Harper and Row. New York. pp.172-177.

The Encyclopedia of the Environment. Ruth A. Eblen and William R. Eblen, Editors. Houghton Mifflin Company. New York (1994). See articles p. 168 "Marine Ecology" by James Nybakken, Moss Landing Marine Laboratory, California State University; p. 252 "Fishing Industry" by William G. Gordon, Marine Fisheries Consultant, Fairplay, Colorado; p. 294 "Marine Geology" by James Craig, Virginia Polytechnic Institute and State University, Blacksburg, Virginia; p. 641 "Sea and Lake Zones" by Patrick L. Brezonik, University of Minnesota; p. 121 "Coral Reefs" by Thomas L. Goreau, Global Coral Reef Alliance; p. 495 "Ocean Dumping" by Julia Ruttenberg, Dubos Center for Human Environments, Inc., New York, New York; p. 595 "Oceanography" by William A. Nieremberg, Scripps Institution of Oceanography, La Jolla, California; p. 512 "Oxygen Cycle" by Aharon Gibor, University of California at Santa Barbara; p. 645 "Seawater" by William R. Eblen, Dubos Center for Human Environments, Inc., New York, New York.

"The Ocean Crisis" 1993. In: *An Atlas of Planet Management.* Norman Myers, Editor. Doubleday. New York .pp.76-93

Appendix I
List of Organizations and Individuals Contacted

Futures Methods (How to do it)

Bob Olson
Jonathan Peck
Institute for Alternative Futures*

William Leffler, Shell Oil Company*

Lester Brown, Worldwatch Institute*

Rob Axtel and
John Epstein
Brookings Institution*

Institutional process (How to make it count)

Mr. Dewitt John
National Association of Public Administration*

Dr. Mary Lowe Good**
Under Secretary for Technology Administration
Department of Commerce

Ms. Sherri Goodman**
Deputy Under Secretary of Defense
for Environmental Security
Department of Defense

Ms. Christine Ervin**
Assistant Secretary for Energy
Efficiency and Renewable Energy
Department of Energy

Dr. Chia Shih**
Associate Administrator for Research,
Technology, and Analysis
Department of Transportation

Dr. Karen Hulebak**
Office of Policy
Food and Drug Administration

Dr. David Berry**
Materials Branch
Bureau of Mines

Megatrends and Drivers (Activities that shape the future)

1. *Demographics-Census, UN*

Carl Haub, Population Institute*

Mr. Jack Sullivan, American Water Works Association*

2. *Science and Technology*

Dr. Peter Blair, Office of Technology Assessment*

Stephen Wolff, National Science Foundation*

Ms. Meg Maguire, Maguire Associates*

Mr. Peter Hawley, National Endowment for the Arts*

American Institute of Chemical Engineers

American Industrial Health Council**

3. *Energy-EPRI, Gas Research Institute, DOE*

Dr. Michael Totten, Director of Solar Energy Research and Education Foundation*

Dr. Irwin Billick
Gas Research Institute

4. *Agriculture-USDA*

Dr. George Byrd, Michigan State University*

Dr. Daniel Kugler*, Deputy Administrator, Cooperative Extension Service, USDA, Washington, DC

5. *Environmental Groups*

Mr. Jonathan Lash, President,
World Resources Institute

Dr. Robert Coppock, Director Project 2050**
Washington, DC

Dr. Allen Hammond*
World Resources Institute,
New York, NY.

Mr. Ralph DeGennaro**
Ms. Velma Smith
Friends of the Earth

Nature Conservancy
Arlington, VA

Sharon Newsome**
National Wildlife Federation

Dr. Theo Colborn**
World Wildlife Fund

Ms. Debora James**
National Audubon Society
New York, NY

*Made a presentation at a public meeting.
**Participated in a fact-finding session.
All others have attended meetings, offered coments and ideas, and provided documents.

Ms. Debbie Sease
Sierra Club
Washington, DC

Mr. Bill Roberts
Environmental Defense Fund
Washington, DC

Dr. William Futrell**
Environmental Law Institute

Dr. Raymond Hayes*
Dr. S. Taseer Hussain*
Howard University (Public Health Risks of Climate Change)

6. *Business Forecasting (Oil, Pharmaceuticals, etc.)*

Mr. Eugene Wheeler**
Vice President, Health, Safety and Environment
The Clorox Company
Pleasanton, CA

Ms. Helen Shapiro**
Technical Affairs
American Automobile Manufacturers Association

Ms. Pat Kenworthy**
Monsanto Company
800 N. Lindbergh Boulevard
St.. Louis, MO

Mr. John Festa**
Mr. Con Schlage**
American Forest Products and Paper Association
Washington, DC

Mr. Carl Costello
Environmental Issues Specialist
American Institute of Architects
Washington, DC

Mr. William Frick, Vice President
Health, Environment and Safety
Mr. Paul Bailey, Director**
Health and Environmental Affairs
American Petroleum Institute
Washington, DC

Mr. Joseph Mayhew**
Assistant Vice President for Health and Safety
Chemical Manufacturers Association
Washington, DC

7. *Ocean "Health" Contacts*

The following individuals provided comments and observations which are reflected in the development of the EFC discussions on the Health of the Oceans in the Overview report, and in Appendix A under items 3-3 and 10-2, in Appendix B under issue 29, and in Appendix G Overarching Issue Area V. This issue is an example of how additional information from experts outside the SAB was gathered.

Dr. Dean Stackwell
Dr. Tony Amos
University of Texas Marine Laboratory
Port Aransas, TX

Dr. Jimmy Ray, Director
Texas A&M Marine Station
Galveston, TX

Dr. James Brooks, Director
GERG
Texas A&M University
College Station, TX

Dr. John Farrington, Dean
Woods Hole Oceanographic Institution
Woods Hole, MA

Dr. Jane Lubchenko, Professor
Oregon State University
Corvallis, OR

Dr. Fred Grassle
Rutgers University
Newark, NJ