Note to the Reader:

The attached draft report is a draft report of the EPA Science Advisory Board (SAB). The draft is still undergoing final internal SAB review. Once approved as final, the report will be transmitted to the EPA Administrator and will become available to the interested public as a final report.

This draft has been released for general information to members of the interested public and to EPA staff. The reader should remember that this is an unapproved working draft and that the document should not be used to represent official EPA or SAB views or advice. Draft documents at this stage of the process often undergo significant revisions before the final version is approved and published.

The SAB is not soliciting comments on the advice contained herein. However, as a courtesy to EPA client offices for this review, it is appropriate for them to consider and advise the Board on the questions listed below.

1. Has the Committee adequately responded to the questions posed in the Charge?
2. Are any statements or responses made in the draft unclear?
3. Are there any technical errors?

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March ___, 2005

EPA-SAB-ADV-05-00__

The Honorable Stephen L. Johnson
Acting Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Subject: Science and Research Budgets for the U.S. Environmental Protection Agency (EPA) for Fiscal Year 2006; An Advisory Report by the EPA Science Advisory Board

Dear Administrator Johnson:

This letter transmits the advice of the U.S. EPA Science Advisory Board (SAB) on EPA's science and research budget request for Fiscal Year 2006. The report was developed by the Board as a result of its meeting and discussions with EPA representatives on February 17 and 18, 2005 in Washington, D.C. The Board also held an informational introductory session with Agency representatives on November 30, 2004.

In conducting this advisory interaction, the Board focused on items in its charge that ask for advice on: a) the extent to which the science and research programs described by EPA align with the Agency Strategic program priorities; b) how well EPA's science and research programs reflect coordination among EPA's own offices; c) how well EPA's science and research programs complement and make use of environmental science programs conducted outside EPA; and d) whether EPA's science and research programs are positioned to address the nation's emerging environmental issues in the coming years?

The Board's conclusions about the science and research budget request reflect a fundamental belief that an effective approach to science-based actions at EPA can not be achieved without a continuing, credible investment in developing the needed scientific understanding of issues that are at the core of EPA's mission to protect human health and the environment. Failure to fund a credible science and research program will lead to greater, not reduced, regulatory burdens. Science is the basis for the effective and efficient implementation of EPA's mission components irrespective of whether they are based on partnerships, market-based approaches, or command and control regulations. Thus, the Board again calls on EPA to end the erosion of its science and research budget so that the knowledge necessary to support refinement of the nation's human health and environmental protection actions can be developed.

We appreciate the opportunity to review, and to provide you with advice on, the science and research investments in the FY 2006 budget request. The Board will be pleased to expand on any of the findings described in this report and we look forward to your response.

Sincerely,

Dr. M. Granger Morgan, Chair
EPA Science Advisory Board

Dr. Genevieve Matanoski, Chair
Science and Research Advisory Panel

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory committee 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. Reports of the EPA Science Advisory Board are posted on the EPA website at http://www.epa.gov/sab.

U.S. Environmental Protection Agency
Science Advisory Board
Participants in the February 17-18, 2005
Science and Research Budget Advisory

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SCIENCE AND RESEARCH BUDGETS FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) FOR FISCAL YEAR 2006; AN ADVISORY REPORT BY THE EPA SCIENCE ADVISORY BOARD

1. INTRODUCTION

1.1 Background

This report transmits the advice of the U.S. EPA Science Advisory Board (SAB) on the Fiscal Year 2006 budget request for EPA's science and research activities. This report was prepared by the Board after two meetings (one on November 30, 2004 and the other held from February 17 – 18, 2005) during which discussions were held between the Board and EPA representatives. These meetings were announced in the Federal Register (see 69FR65427 and 70FR4848).

1.2 Charge to the Science Advisory Board

The following four charge questions were given by the Agency to focus the Board's attention during its evaluation:

> a) Based upon the SAB's knowledge of EPA's science programs, do the planned science and research activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional Offices?
>
> b) Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?
>
> c) Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?
>
> d) Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?

1.3 Format of this Report

Following this Introduction, the report provides specific responses to the questions contained in the Agency's charge to the Board.

2. RESPONSE TO THE CHARGE

The Board annually conducts an evaluation of EPA's science and research budgets. The report of this activity is used by the EPA Administrator and Congressional Staff in their budget and planning activities. In recent years, this advisory function has been moved to the larger, chartered Board from a smaller SAB standing committee. This enhanced the visibility of the activity and significantly increases the resource and types of expertise available to conduct the activity. The Board has organized itself into six Teams to carry out this advisory. Five of these correlate with specific EPA strategic Goals and one is a Cross Goal Team. The report below was developed by the Teams, and Board staff, as a result of meetings to discuss EPA's science and research activities. The summary in section 2.1 has been prepared from the individual Team contributions that are contained in sections 2.2 through 2.7 of this report.

2.1 Summary Conclusions and Remarks

Comments in this report are the result of the SAB's evaluation of the FY 2006 science and research budget request. The Board recognizes that this budget is now final and that the major opportunity for EPA to adjust its science and research program for the future is to incorporate needed changes as it conducts the planning phase in support of developing its FY 2007 science and research budget request. In addition, EPA might, with the help of Congress, be able to implement some critical adjustments while it implements its FY 2005 program and develops its FY 2006 operating plan.

The SAB evaluated various aspects of the Agency's FY 2006 Science and Research budget request. It considered: 1) how well the science and research aligned with the Agency's strategic priorities; 2) whether there was effective internal coordination of the science and research programs among EPA's offices; 3) the extent of EPA's external coordination in the planning and conduct of its science and research programs; and how well the Agency was positioned to identify and to developed knowledge on emerging human health and environmental issues that are within EPA's mission. The Board's general conclusions about each of these topics are summarized below. Additional issues identified by the Board are also discussed.

a) <u>Alignment of Science and Research with Strategic Priorities</u>: EPA's proposed science and research programs appear to align well with the Agency's strategic priorities in all goals. However; the true issue here is not merely about this type of alignment, rather it is one of resource constraints that preclude EPA from conducting science in all the areas that are necessary for supporting effective environmental policy development. A number of specific examples of research needs that compromise the science-research-program priority alignment are highlighted in the document (e.g., mercury and ammonia monitoring; drinking water distribution systems research; aquatic system assessment, protection and restoration; ecological indicators; human behavioral response to environmental pollution).

b) <u>Internal Coordination of EPA Science and Research</u>: The Board recognizes that EPA's internal coordination of science and research programs has steadily improved in recent years. The ORD research planning process is credited with much of this improvement. This report cites two examples of multi-year plans that exemplify this coordination (contaminated sites

and RCRA research plans). The development of the complex 3MRA model was cited as an example of a work product that demonstrates such coordination. EPA cooperation in this regard was suggested as a model for other agencies, even though the Members acknowledge that there is a need for more transparency in EPA's conduct and documentation of these interactions. There is also a sense among some members that additional attention should be given to satisfying Regional Office needs in this process.

c) External Coordination of EPA Science and Research: The SAB sees evidence of progress in EPA's coordination of its science and research with other federal partners. A complete and quantified representation of EPA's coordination and leveraging is not available for the Board across all programs; however, it is clear that in some programs there is now, and has been for a considerable time, extensive and effective coordination (e.g., the drinking water research program is coordinated nationally and more recently international cooperation has been pursued). Other areas showing good coordination include: contaminated sites and RCRA research, endocrine disruptors, children's health, CAFOs, Advanced Monitoring Initiative, Computational Toxicology Center, and the Pollution Abatement Control Expenditures survey). Other areas show room for additional cooperation and partnering (e.g., risk assessment for air toxics, ecosystem endpoints associated with air pollution, water quality research).

Information on the amount of leveraging can be helpful in showing the degree to which environmental research portfolios across the government intersect, the extent of coordination of the various portfolios, and the nuanced differences in the research being conducted in one agency versus another. Therefore, the Board encourages EPA to expand its quantification of the leveraging and cooperative efforts it has going on with other agencies and organizations. In addition, in the face of resource constraints that are likely to continue to be the situation faced by EPA in the near term; the Board strongly encourages EPA to pursue collaborative ventures with organizations beyond those associated with the Federal government. Opportunities for such partnerships exist with governmental agencies other than at the Federal level, nonprofit organizations, and the private sector.

d) Emerging Issues: EPA's very limited, and worsening, ability to conduct research that identifies, as well as builds necessary knowledge and understanding of emerging issues, is a significant concern to the Science Advisory Board. The Board noted that, in each of the Goal areas, EPA science and research is largely focused on legacy issues, i.e., short-term, mission-specific topics. Conducting anticipatory research would allow EPA to take advantage of current windows of opportunity to understand and work in the social and technological systems that are now developing in the United States and in the world. This will not only affect EPA's ability to meet its mission of protecting human health and the environment, it also risks influencing the future U.S. economy by opening our products to safety and other challenges from other nations when they compete for a place in the international market.

The decreased ability to anticipate future environmental issues was linked by the Board to decreases in science and research resources at EPA in general as well as the increased demands of programs for short-term information. Government accountability systems were

thought to contribute to the problem because of their perceived focus on short-term program outcomes.

The Board recommends that EPA develop ways to identify and focus on opportunities for major innovations or new approaches needed to improve our understanding of increasingly complex, emerging, environmental issues. The Board believes that EPA is well positions to serve as a catalyst for collaborative research that anticipates the future.

e) Aspects of STAR: The EPA Science to Achieve Results (STAR) program embodies many aspects that are of significant importance to the science and research that are necessary for EPA's development of policies that will protect human health and the environment, and at the same time contribute to the economy of the US as well as benefit the world. STAR can be viewed from a number of perspectives in this regard, including: 1) its contribution to a total EPA science and research program that makes effective use of a variety of research assets inside and outside the Agency; 2) its contribution to a balanced research program that has a core component that looks to the mid- and long-term needs of EPA as well as the needs of EPA for near-term problem-driven information; and 3) its contribution to specific research needs that have a diffuse constituency with less immediate information needs.

i) Complimentary Science and Research Assets: EPA has a variety of assets that make up its total science and research program. On the **near-term policy development side**, existing science is often assessed and predictions of risk and risk reduction made by organizational components that reside in, or who are contracted to, EPA's program and regional offices. Some major assessments, and much of the assessment methods development activity, also occur in the EPA Office of Research and Development. On the **research side**, much of EPA's activity is conducted by, or in association with the EPA Office of Research and Development (ORD). ORD conducts this work either internally using its own scientists, or through a variety of extramural approaches (e.g, grants, co-operative agreements, contracts) that engage academic or other institutions that conduct research.

Continued cuts to the STAR program degrade an important part of this total science and research program – the extramural component. Historically, extramural research has provided EPA with four essential functions: a) access to expertise outside of the Agency; b) invigoration of EPA science and prevention of stale research from taking hold; c) a flexible mechanism to identify and address emerging issues; and d) leveraging of funds with other agencies or partners. Reducing extramural funds has both direct and indirect effects, and is equivalent to spending one's investment principal. This will have significant long-term costs to the Nation's need for knowledge to inform policy development and help U.S. producers to compete in the international market place.

ii) Balanced Research Program: For many years, consideration of EPA's total research program has grappled with the need for EPA to conduct both "core research" and "problem-driven research." Though fitting specific science and research components into two such categories is difficult, the SAB has routinely in its reports to the

Administrator advised that both types of research are necessary and has recommended that an approximate split of 5o% core and 50% problem-driven research is reasonable. The core component of this program helps EPA develop knowledge that is necessary to understanding current issues and to identifying and to be more prepared to deal with issues that will be on tomorrow's agenda. The problem-driven component allows EPA to develop methods and generate information that is needed by EPA program and regional offices to carry out the day-to-day activities that support the development of sound environmental policies. Cuts to the STAR program thus degrade EPA's ability to conduct the core research needed to maintain EPA scientists at the cutting edge of their disciplines and degrades EPA's overall science capability.

The need for EPA's conduct of different types of research has been considered many times in the past. The National Academy of Sciences, the EPA Science Advisory Board, and others have noted the importance of EPA's core and problem-driven research to the attainment of the nation's environmental goals. Effective science and research planning requires the full cooperation across EPA offices to attain an appropriate balance among the various research types. This coordinated planning must be a multi-directional activity in which EPA's Office of Research and Development openly discusses its core and applied research plans with program offices and program offices openly discuss their own science and any existing research activities with ORD. Without this interaction, the development of an overall cohesive and complimentary EPA science and research program is not possible. Thus, the SAB considers the issue of cooperative research planning each year during its science and research budget review.

iii) Research Areas Having Diffuse Constituencies and Uncertain Time Horizons: Two aspects of this component are best exemplified by emerging issues and ecosystem research. Both share the common problems of focusing on complex and uncertain issues and their long-term time horizons.

EPA often must look at legacy issues that are on its active agenda. Though desiring to look at longer term, emerging issues, it is often forced by resource and time constraints to keep its focus short. The Agency has thus not been able to give significant attention to **exploratory research** that would allow it to take advantage of current windows of opportunity to understand and work in the social and technological systems that are now developing in the United States and in the world. In fact, EPA has further diverted funds from exploratory research in the FY 2006 budget thus exacerbating the problem. This will not only affect EPA's ability to meet its mission of protecting human health and the environment, it also risks influencing the future U.S. economy by opening our products to safety and other challenges from other nations when they compete for a place in the international market.

Ecosystem health is an important aspect of the nation's environmental quality. Among the major elements of the Agency's strategic plan is a commitment to "protect, sustain, and restore the health of natural habitats and ecosystems."

Fundamental to this objective is creation of scientific tools to assess the current condition of the nation's ecosystems, and then apply these tools to assemble a coherent picture of the state of our ecological systems. The importance of this objective is underscored by the conclusions of the Agency's Report on the Environment (EPA SAB, 2004b), as well as the independent "State of the Nation's Ecosystems" report of the Heinz Center (The Heinz Center, 2003), that most of the information required to characterize and track changes in ecosystem health is not currently available nationwide.

This research not only informs Goal 4 objectives, but also supports efforts under EPA's other strategic Goals. For example, the ecological indicators that were being developed under ecosystems research were to be the next generation of integrated indictors for use by the States to meet their assessment requirements under the Clean Water Act (303 listings). The FY 2005 budget made deep cuts in the programs related to ecosystem assessment (e.g. ecological indicators) and the FY 2006 budget request makes even deeper cuts, including nearly $5M from Western EMAP, National Coastal Assessment, and Regional Vulnerability Assessment programs.

These cuts appear emblematic of a broader trend to cut ecosystem research, despite its fundamental importance to the Agency's mission. Ecosystem research has long received too little attention at EPA, and the situation is getting worse. Important parts of EPA's mission of environmental protection can not be efficiently and adequately addressed if the Agency does not have a strong base in ecosystem research. Part of the problem seems to be that ecosystem health does not have the same immediate constituency within EPA that human health does even though American's have clearly demonstrated their concern for the quality of their wild and managed lands and waters and expect government to provide adequate protection. If the Agency does not improve its research capabilities in this area, it will not be able to meet public expectations nor its regulatory responsibilities for protection of the environment.

The Board strongly urges the Agency to reverse the erosion in ecological research, determine the most effective ways to proceed with ecological assessment, and reinstate funds to pursue them. In addition, EPA, while continuing to look at legacy issues, needs to work on developing strategies for identifying and focusing on opportunities for major innovations or new approaches which could have large impacts on improving our nation's future understanding of environmental issues and regulatory performance, especially new and emerging environmental problems.

f) Pilot Research Program: EPA will begin a $20M pilot program devoted to research needs determined by EPA's regulatory offices and ORD. In this program, OAR, OW, OPPTS, and OSWER will each be provided with $4.5M, and OPEI $2.0M, to use in a fee-for-service arrangement with the Office of Research and Development to obtain additional research focusing on their own office's specific highest priority research needs. A number of topics have been identified as the focus of this research in FY 2006 (e.g., improved understanding of air toxics sources, distribution and effects; identifying the most significant exposures, risks

and uncertainties for criteria pollutants; epidemiological studies for drinking water contaminations; test methods research and implementation for water quality and drinking water; site remediation, resource conservation, risk analysis and reduction, and waste minimization; aggregate exposure, cumulative risk, and hazard characterization; and environmental economics research and analysis needs).

The Board believes that the new pilot research program is a very interesting development which holds the potential to better serve the immediate research needs of programs and regions. It is innovative and appears to be a good investment that will allow the program offices to purchase research internally from ORD for specific needs.

However, EPA is in the early stages of developing the program and it should carefully consider how it allocates specific funds. On this issue, Board members have a range of views. On the one hand, some members encourage the Agency to implement this as a "customer-driven" initiative, allowing program office needs to clearly drive the process to fill knowledge gaps. They suggest the Agency use peer-review in selecting and awarding specific projects that are funded through this mechanism and caution against potential duplication of efforts and using the funds for operational expenses.

On the other hand, some members question the prior allocation of "office-specific-shares" of the $20M available and suggest that some other strategy might be used to, within some limits, adjust the allocations according to the quality of research questions identified. Members suggested one possible strategy that would make allocations based on submission and evaluation of research proposals with the selection based on EPA-wide scientific merit. A number of factors were suggested to use in assigning preference. These members noted that in any case, it would be important to design the pilot program with specific objectives in mind so that it could be evaluated and improved over time. They also cautioned that it would be important to not allow too large a proportion of ORD's research to become too tightly tied to the day-to-day information needs of agency offices and regulatory schedules, since that could begin to seriously erode the agency's science base and its ability to address new problems and improve future performance.

g) Social Sciences Research: Research on economics and decision sciences within ORD and the National Center for Environmental Economics (NCEE) supports the attainment of all EPA strategic goals. While the agency has made progress in the development of an internal coherent economics research program, there is no evidence of such progress for any of the other social sciences.

EPA has long had insufficient expertise and research in social and behavioral research: research on how best to communicate about risks; on how to better evaluate intangible impacts such as ecological damage; on how to improve the application of benefit-cost and cost-effectiveness methods to setting environmental priorities; or how to develop effective voluntary and participatory programs, etc. In the current review several Board Teams noted what appears to be a further erosion of support for what is already a very inadequate effort in social and behavioral research. If this process can not be reversed it will seriously damage the efficiency and effectiveness of the agency's programs in the future.

One area where this problem is especially apparent is in EPA's new work on **homeland security** for water and building systems. Here EPA does not seem to recognize the need for the systematic use of the research literatures in human factors and ergonomics. Nor is there any apparent commitment to rigorous empirical evaluation of performance under realistic field conditions, with real people, under real time pressures, and, often, real fears. Without this, the Agency will not be able to demonstrate the efficacy or cost-effectiveness of its solutions. Nor will it be able to provide decision makers with the realistic estimates of system performance that are essential to effective planning.

The goals of increased compliance, pollution prevention, and environmental stewardship elucidated in Goal 5 relate fundamentally to social science and/or interdisciplinary questions. EPA was once a leader in supporting **risk communication research** and has produced many publications with risk communication guidance; however, the new generation of risk communication knowledge is significantly underfunded and now appears to be undervalued by much of the Agency. To increase the impact of the agency's research on public policy, a much broader view of risk communication and the sciences that underpin strategic approaches is essential. This cannot be achieved without greater recognition and incorporation of social science knowledge and methods into the agency's research and operating programs.

A major theme running through all the strategic goal descriptions in the EPA 2003 – 2008 Strategic Plan is the need to move forward where possible from the largely command and control regulatory regime that is now the cornerstone of U.S. national environmental policy. For example, the Strategic Plan calls for a move toward pollution prevention (Goals 4 and 5), development of innovative waste management practices (Goal 3), and development of **voluntary programs** of materials management and resource conservation; under the Resource Conservation Challenge (Goal 3). This proposed shift raises two important questions. The first is how to encourage such voluntary actions. The second is determining the proper mix of public sector and privately funded research on improved waste management practices, innovative pollution control technologies, and pollution prevention.

The behavioral, social, and decision sciences necessary to support environmentally effective programs that rely on voluntary incentives are at an early stage of development. In particular, while the literature has identified some effective, targeted programs that have led to real environmental improvement at small scales, there is little or no research supporting the view that costly or major changes in the production processes of firms or individuals can be expected to occur in the absence of major financial incentives. There is also little research to support the provision of guidance on the design of programs to encourage voluntary actions. Understanding incentives and constraints is important in explaining actions and choices of people. If the EPA is to try to increase its use of voluntary mechanisms to achieve increased environmental improvement and compliance, it must significantly invest in the appropriate disciplinary and interdisciplinary research that will provide the bases for the approaches proposed.

There has been an increasing amount of consideration in the literature on the longer-run consequences of environmental shocks to neighborhoods. These effects have an implication to **environmental justice** aspects of EPA's actions. For example, a temporary environmental shock can have effects on community dynamics that are completely reversed when the shock is over, provided that perceptions of risk are not changed permanently by this temporary environmental shock. However, longer-term environmental hazards can set in motion systematic shifts in neighborhood composition that can affect neighborhoods long after the hazard has been removed (as in the case of the identification and clean-up of a Superfund site). An example of sociological research that would be important to this issue is the affect of shocks, and their resolution, on housing prices.

Another example of an area in which additional research is needed is on valuing the non-market **ecosystem benefits** of reducing pollution. For this we need to be able to demonstrate that people are able to perceive differences in ecosystem quality sufficiently to be able to form values that can be measured and incorporated in benefit-cost analyses.

h) Investments in Homeland Security Research: While Homeland Security research should address homeland security as its first priority, many of the issues involved have "dual use" dimensions and can often also be approached so as to serve multiple Agency objectives (e.g., the development of real time sensors will result in products that will have great potential for chemical and microbial monitoring for issues beyond homeland security). Funds allocated to Homeland Security research should address research issues and not be diverted to operational program needs. The dual nature of research applies to many other Agency research programs that are nominally tied to supporting EPA's mission is a specific area (e.g., SDWA, TSCA, CERCLA, FIFRA, etc.). Exploring this dual applicability for activities is important. The Board believes that Homeland Security research should be approached in a manner that helps EPA further develop its research programs in an integrated manner, and with an eye toward obtaining broader utility from specific research efforts when that is possible.

2.2 Cross-Goal Issues: Identifying Critical Needs and Opportunities

The Cross-goal Team of the SAB is interested in several types of issues that may not be the sole focus of any one Goal-specific Team as it addresses the FY 2006 science and research budget plans of EPA. One type is the group of issues shared by several programs ("in-common issues"). For these issues, the sum of current science efforts and planning for the future are not able to be adequately addressed by any one program (e.g., information technology, sensing and monitoring networks, linkage to external science programs, the science-policy interface itself). A second type is the group of issues that may serve to connect separate programs ("bridging issues"). Examples of bridging issues include, models, tools, and emerging research and technology that would enable cross-media or multi-program efforts (increasingly, problems in human health and environmental degradation are of this kind). A third type is a group of issues that may "fall through the cracks" ("unnoted issues"). These issues, especially emerging ones, may lie beyond the scope of any one program and may go unseen or be given insufficient attention and investment. Here, time can be important. Although, it is not exclusively "cross-goal," attention to time horizons of planning across all programs is needed. The hope for many of these issues is that they may identify opportunities for science input that might solve problems

at their inception, and thus avoid costly reengineering and control. Failure to notice, inform and invest can create bottlenecks in our nation's advancement of technology and economic growth. The Board notes a number of each of these issues in the following paragraphs.

a) Preparing for Tomorrow: While the agency has been making good progress in developing a more systematic approach to identifying research needs for its normal operations (often referred to as "legacy" issues), it still needs to work on developing strategies for identifying and focusing on opportunities for major innovations or new approaches which could have large impacts on improving our nation's future understanding of environmental issues and regulatory performance, especially new and emerging environmental problems. The Agency has not demonstrated any significant attention and investment in the types of **exploratory research** that would allow it to take advantage of current windows of opportunity to understand and work in the social and technological systems that are now developing in the United States and in the world. This will not only affect EPA's ability to meet its mission of protecting human health and the environment, it also risks influencing the future U.S. economy by opening our products to safety and other challenges from other nations when they compete for a place in the international market. The agency must be more forward looking in its preparation for tomorrow.

b) Cross Cutting Issues: The agency should also increase its attention to cross-cutting issues which now seem to receive too little attention because they "fall between the cracks" in the media-by-media organization of the agency. In calling for increased attention to these issues, the Board is *not* calling for a massive new agency-wide strategic planning effort. Rather, it is urging the agency to put in place a process by which, at any given time, two or three topics of this sort have been identified and are receiving serious analytical attention. While we do not want to prescribe any specific topics for such attention, we can illustrate this need with a few examples:

1) Are the networks, instruments and programs of routine nation-wide monitoring of pollutants in air and water producing time series data which are adequate for the research and regulatory needs which the agency will likely face over the next couple of decades.[1]
2) If an influence diagram was constructed to illustrate all the elements of the processes by which nano-particles and materials could lead to beneficial or negative impacts, which links in that diagram are most critical in understanding the potential health and environmental factors that may be involved? How adequately is ongoing research (in the agency or elsewhere in or outside of the government) likely to be able to address these links in the future as EPA begins to address and deal with these issues.
3) Is the science base that the Department of Energy is currently developing on deep geological sequestration of CO_2 likely to produce the understanding that the EPA will need to implement science-based regulation of this technology if and when that need arises?
4) Can traditional risk assessment methods based upon multiplicative factors now, sometimes, be effectively replaced with probabilistic methods?

[1] We know that something like this has been done in air, it is less clear if it has been done in water where routine monitoring has been far more spotty, or for cross-media issues.

While the need for EPA to look beyond its immediate agenda has existed for some time, it has become more pressing because shrinking budgets tend to force the Agency to concentrate on traditional legacy issues. New and cross cutting issues thus become disadvantaged (e.g., nanoparticles, pollution prevention, ecosystems). Without an ongoing effort to identify important neglected needs and a process for focusing attention on emerging issues, the EPA will not be able to adequately meet its mission of protecting the nation's environmental components, including humans, in the coming years.

c) New Research Pilot on Programmatic Research Needs: The new EPA program to set aside $20-million to support research needs identified by EPA's regulatory offices and ORD is a very interesting development which holds the potential to better serve the immediate research needs of programs and regions. However, it appears that the agency is still in the early stages of figuring out how those funds should be allocated.

Current plans call for $4.5-million for each of several specific programs: air (i.e., OAR), water (i.e., OW), pesticides and toxic substances (i.e., OPPTS), and waste (i.e., OSWER) and $2-million for policy and economics (i.e., OPEI). The agency might do well to think about whether prior allocation of “office-specific shares” is the best strategy or whether, within some limits, the allocation might be adjusted in response to the quality of research questions identified. In the Board’s view it is important to design this pilot program with specific objectives in mind so that it can be evaluated and improved with time.

One strategy that might warrant consideration for application to a pilot research program would be to use an allocation scheme based on EPA-wide scientific merit. This could begin with a request for proposals to be developed by regulatory offices; move to an initial screen with an internal ORD peer review, and then go on to run quick external mail reviews of proposals. Then in making funding decisions the agency would be well advised to give preference to proposals which:

1) Make a strong case that the proposed work involves research, not funding for ongoing operations;
2) Addresses an important programmatic problem for which funding is currently scarce and is receiving too little attention;
3) Provides a specific discussion of how the proposed activity will be evaluated so as to contribute to the overall evaluation of the pilot program;
4) Shows how the proposed research is related to policy development or program decision making; and/or
5) Involves multi-media, cross program and/or multi and cross regional dimensions.

We believe that this program could be very valuable to improving the ability of agency R&D to contribute to the ongoing needs of the agency’s programs. At the same time, we caution that it is important to not allow too large a proportion of ORD's research to become too tightly tied to the day-to-day information needs of agency offices and regulatory schedules, since that could begin to seriously erode the agencies science base and its ability to address new problems and improve future performance.

d) The Importance of Ecosystems: Ecosystem health is an important aspect of the nation's environmental quality. Unfortunately ecosystem research has long received too little attention at EPA, and this review produced strong evidence that the situation is getting worse. Issues such as how best to deal with invasive species, how to protect valuable wetlands and the services they provide to society, and how to protect important ecosystems in the face of changing climate, can not be efficiently and adequately addressed if the Agency does not have a strong base in ecosystem research.

Unlike environmental health, ecosystem health does not have the same level of immediate constituency. But American's have clearly demonstrated that they care about the quality of their wild and managed lands and waters and expect government to provide adequate protection. If the Agency does not improve its research capabilities in this area, it will not be able to meet that public expectation. Nor will it be able to meet its regulatory responsibilities. Cuts in funding ecosystem research programs, such as EMAP, will also have an impact on EPA's ability to meet objectives to protect water quality.

e) Sustaining and Building Social and Behavioral Research: The EPA has long suffered from a deficiency of expertise and research activity in social and behavioral research: research on how best to communicate about risks; on how to better evaluate intangible impacts such as ecological damage; on how to improve the application of benefit-cost and cost-effectiveness methods to setting environmental priorities; or how to develop effective voluntary and participatory programs, etc.

In the current review several Board Teams noted what appears to be a further erosion of support for what is already a very inadequate effort in social and behavioral research. If this process can not be reversed it will seriously damage the efficiency and effectiveness of the agency's programs in the future. This is especially true in the area of homeland security.

The agency does have expertise in economics but it has very limited expertise in other fields of social and behavioral science. As a consequence, when a program realizes that it needs a social dimension in its work, it often does not understand the current state of expertise in the relevant fields, does not know what to ask for, and ends up with less than adequate research designs.

This problem is especially apparent in the Agency's new work in improving homeland security for water and building systems. The descriptions we heard of plans to design and evaluate options (e.g., sensor arrays, decontamination procedures) did not seem to be making any systematic use of the research literatures in human factors and ergonomics. Nor did they seem to have any explicit commitment to rigorous empirical evaluation of performance under realistic field conditions, with real people, under real time pressures, and, often, real fears. If so, then the Agency will not be able to demonstrate the efficacy or cost-effectiveness of its solutions. Nor will it be able to provide decision makers with the realistic estimates of system performance that are essential to effective planning.

The options being developed will provide imperfect signals regarding risks (e.g., has an attack occurred, what is the residual after decontamination). Recommended practice is to couple

risk analysis and risk communication, so that systems produce the information that people need, which is then communicated to them in a cogent, authoritative, and comprehensible way. The program's approach to these issues did not seem to involve either using or conducting research. Communication outward will, apparently, be approached by drafting common sense procedures, without accessing the research relevant to their feasibility and without commitment to empirical evaluation. There was no expressed intention to involve the public and its representatives in questions like acceptable decontamination standards. These were deferred to some other body, which could not be described to us. If this is the case, then the Agency will be producing incomplete, possibly counterproductive solutions, without increasing its own research capacity for topics that arise in many areas of its operations (e.g., water contamination from non-terror sources).

f) The Importance of Sustaining and Nurturing Extramural Research: As EPA's research needs continue to grow and the resources to support this research either remain constant or contract, it is not surprising that the agency may consider moving support out of extramural programs to sustain internal programs. During the course of our review we have seen several indications that such erosion is indeed occurring.

The STAR program and other programs of extramural support operated by the Agency have provided an essential source of new scientific understanding and have played an important role in growing the next generation of environmental scientists all across America. We are troubled that support for these extramural programs has been significantly reduced and urge the agency and the Congress to work hard to protect, restore, and sustain them.

Extramural research programs are not elastic programs, as is often suggested. Interruptions and steep reductions in extramural research weaken relationships EPA needs with scientists outside Agency for a strong research program.

g) Investments in Homeland Security Research: While Homeland Security research should address homeland security as its first priority, many of the issues involved have "dual use" dimensions and can often also be approached so as to serve multiple Agency objectives. Also, funds allocated to Homeland Security research should address research issues and not be diverted to Homeland Security operational programmatic needs. The dual nature of research also applies to many other Agency research programs that are nominally tied to supporting EPA's mission under a variety of media- and program-specific statutes (e.g., SDWA, TSCA, CERCLA, FIFRA, etc.). Homeland Security should not undermine the basic research supporting Agency activities, rather it should help EPA further develop its research programs in an integrated manner, and with an eye toward obtaining broader utility from specific research efforts when that is possible.

The analysis presented to the Cross-Goal Team on options for the planned research in this area did not seem to involve any systematic, formal analysis, sufficiently transparent as to be open to peer review. Rather, "analysis" seemed to connote information gathering, followed by an internal deliberative process. If so, then there will be no way to tell if the Agency has fulfilled its homeland security assignments in the best way possible. Nor will there by any growth in the

Agency's core analytical capacity. Such consultative processes may be subject to internal processes and vendor push.

h) Needs for investments in computing hardware, information infrastructure, and management support for science: EPA needs information resources both for internal research support and for participation at a high level in cross Agency and international programs such as GEOSS [spell out]. EPA scientists need access to 21st century information resources to collaborate with scientists in other agencies and universities, make use of models, and take advantage of converging technologies.

The Board believes that EPA must strengthen both its high performance computing abilities for modeling and networking and the more mundane, but still critical, day to day computing needs of the science community. In both cases, the high level of connectivity to the outside world is essential. EPA currently has a low level of access to electronic journals, analytical and other special purpose software, and data-sharing resources, compared to scientists at universities.

i) Morbidity Data: With just a few isolated exceptions, most estimates of the human health benefits of environmental protection have focused on reductions in life expectancies. There has not been sufficient attention to benefits in the form of reduced non-fatal morbidity and reductions in pre-mortality morbidity. People care about their quality of life and about how they die. Research on society's willingness to pay to prevent or limit different types of health consequences through environmental protection has been hampered by the absence of data on the prevalence of different types of illnesses. Mortality data, by cause of death and at a relatively fine level of geographic disaggregation, have been available through the National Center for Health Statistics. Since few diseases are reportable, however, it has been more difficult to assemble comparable data on morbidity in terms of hospital admissions or emergency room visits. Such data are important in risk assessments used in support of standard setting. In terms of collaboration with other agencies, the EPA's efforts to better understand the health inventory, and to make causal connections between environmental quality and this health inventory, are vitally important. Willingness to pay for environmental protection will depend on the types of illnesses prevented, their latencies and endpoints, as well as on the characteristics of the population that would be affected. Research that extends the health benefits estimation effort beyond reliance on just a single one-size-fits-all value of a statistical life (VSL) estimate will be greatly enhanced by the availability of detailed morbidity information.

j) Environmental Justice: On the topic of hot spots and environmental justice issues, there has been an increasing amount of consideration in the literature on the idea of locational equilibrium and what it means for the longer-run consequences of environmental shocks to neighborhoods. A temporary environmental shock can have "impact" effects that are completely reversed when the shock is over, provided that perceptions of risk are not changed permanently by this temporary environmental shock. However, longer-term environmental hazards can set in motion systematic shifts in neighborhood composition that can affect neighborhoods long after the hazard has been removed (as in the case of the identification and clean-up of a Superfund site).

In the case of air quality, there has been some interesting work on the general equilibrium consequences of improved air quality, when such improvements set in motion an adaptation where sensitive populations who previously avoided more polluted areas now find them attractive, moving back in and driving up housing prices in those areas in a manner that will tend to offsets the initial welfare gains to populations that previously suffered more from pollution but were compensated to some extent by lower housing prices. If the Agency's goals are strictly to improve environmental quality, then the subsequent increase in housing prices is of no concern, but in environmental justice cases, one needs to be careful about "giving with one hand while the other one takes away." While it is unlikely that housing price increases that occur upon environmental improvements will be sufficient to completely offset the initial welfare gains from a cleaner environment, the extent to which this happens is an empirical question. Behavioral adaptations to cleaner environments are very important to a complete understanding of the environmental justice consequences of Agency activities.

k) Accountability: Budget items that go toward accountability are important. It is prudent for the Agency to continue to invest in an improved understanding of the actual benefits of its programs and policies. In terms of benefit-cost analysis, these efforts serve to reduce uncertainty about the benefits of environmental management strategies, which in turn reduces uncertainty about the net social benefits of these policies (after social costs are subtracted) and about whether specific policies pass the benefit-cost test. In a budgetary climate where all forms of government expenditure have come under increasing scrutiny, it is more important than ever to be confident that those programs which will inevitably need to be cut are the right ones to cut, and that those to be kept are the right ones as well.

There is also the ever-present need to improve our understanding of discounting and the extent to which it should be employed, especially with stock pollutants. Last year, the SAB commented more extensively on the fact that research providing short-term results was funded preferentially over research with long-term implications.

2.3 Goal 1 – Clean Air and Global Climate Change

2.3.1 Alignment: *Based upon the SAB's knowledge of EPA's science programs, do the planned science activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional offices?*

EPA managers made an important change this year by expanding the position of National Program Manager for Particulate Matter Research to become the National Program Manager for Air Quality Research. An appointment has been made to this more broadly defined position. This is an important step toward a more planning and conducting a more integrated research program to improve air quality. The Board commends EPA for taking this step to develop a more integrated air pollutant research program.

The planned science and research activities reflected in the FY 2006 budget align with the Agency's strategic priorities in Goal 1. While the planned science activities do align with the

strategic priorities for Goal 1, there are unmet needs in the proposal. These are discussed in the paragraphs below.

a) Mercury Monitoring: There is an urgent unmet need for monitoring programs that will provide an appropriate set of background data on mercury. The agency will need to evaluate the effectiveness of the mercury controls on airborne concentrations during its implementation of the Utility Mercury Reductions Rule. There are monitoring systems in place (CASTNet, IMPROVE, NADP) that will permit the evaluation of the changes in sulfate and nitrate concentrations that are expected to change with the implementation of the Clean Air Interstate Rule (CAIR) which is expected to be promulgated soon. However, there are currently no systematic measurements being made on gas phase mercury species. Mercury in wet deposition is being measured in a small supplemental network to the NADP. Monitoring will ensure that the implementation of the cap and trade program is not producing disproportionate benefits to different downwind regions. Even if these regulations are superseded by legislation like Clear Skies, additional coordinated monitoring will be needed to assess the long-term benefits of the legislation.

b) Ammonia Monitoring: Another pollutant for which there is an urgent need for improved monitoring is ammonia. Ammonia has a significant effect on the formation of particulate matter through nucleation of sulfuric acid and water or the formation of ammonium nitrate. Existing emissions inventories for ammonia are poor. There are currently limited measurements being made and the need for improved ammonia monitoring is noted in the National Ambient Air Monitoring Strategy. The SAB encourages EPA to begin this effort soon. This monitoring should occur within the context of the overall nitrogen cycle, and the other cycles with which nitrogen interacts (e.g., sulfur and carbon).

c) Emissions Inventories: Major gaps remain in our quantitative knowledge of emissions and the quality of the resulting emissions inventories. For example, in the case of particulates, the National Research Council (NRC) Committee on Research Priorities for Airborne Particulate Matter highlighted such problems. However, EPA has been able to mount only a limited effort and much of the focus to date has been on Concentrated Animal Feeding Operations (CAFOs). A need remains for up-to-date chemical characterization of emitted materials as well as better estimates of mass emission rates.

2.3.2 Coordination: *Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?*

Coordination is evident among EPA offices on Goal #1 issues. However, it is difficult to determine its extent. EPA's organizational structure (i.e., being divided into water, air and research divisions, etc.), while useful for some purposes, creates barriers that make coordination difficult. While EPA staff clearly sees the need for more coordination, these barriers and the increasing expectation that divisions have to do more work with fewer resources, increase the difficulty in gaining greater coordination. As a case in point, CAFOs are recognized as hot spots for losses of nitrogen and other material to the atmosphere and to the water. CAFOs produce

significant quantities of biosolids. However, EPA does not have a systems approach for research on these losses. This approach was recommended in a recent NRC study commissioned by the EPA and the USDA (NRC 2003, Air Emissions from Animal Feeding Operations). Thus, science and research activities among OAR, OW, OSWER, and ORD have the potential to be less complementary than they might be due to the narrower needs of each party. Additional resources would greatly increase the potential for a coordinated and complementary science and research program for this issue.

An example of a data-gathering effort demonstrating good coordination among EPA organizations is the redeployment of monitoring resources in the National Ambient Air Monitoring Strategy program. This effort has the potential for providing the long-term data needed to support health studies on chronic exposure to air pollutants. Part of the plan is to move monitors from urban areas where they are duplicative to rural areas where they can provide additional data on transport, as well as serve as the basis data sources for the more extensive assessment of ecosystem risk. This is an OAQPS endeavor, but the data produced can support a number of possible ORD research initiatives.

2.3.3 Collaboration: ***Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?***

Within the Goal 1 objectives, the SAB sees evidence that coordinated work with other federal partners is progressing. EPA has made a reasonable effort to look for opportunities to partner with other agencies and they have utilized science products from other organizations. Examples of existing cooperation and collaboration, as well as a few examples of additional needs for collaboration, are noted in the following paragraphs.

A good example of collaboration has been the work on CAFOs. Here, the air program has coordinated its efforts with USDA in air quality. There are opportunities to improve coordination with EPA's counterparts in agencies beyond USDA, and as mentioned above within EPA.

Another example of partnering is EPA's contribution to the Advanced Monitoring Initiative (AMI). EPA decided to combine the Tropospheric Ozone and PM Research Program projects into the NAAQS Research Program to allow better integration and coordination of their research. EPA completed work on the development of tools to specifically implement the NAAQS on tropospheric ozone and reallocated funding to the multi-agency AMI effort with NOAA, NASA, DOE and others.

In the area of risk assessment for air toxics, EPA has undertaken a near-roadway exposure health effects assessment. The Department of Transportation has a major role but the partnership between DOT and EPA has not been strong.

A different kind of cooperation has been shown by EPA in the establishment of its Computational Toxicology Center. This Center has been recognized by other agencies as a center of excellence. Genomics and proteomics researchers need this type of center for interpretation of data for risk assessment. The Computational Toxicology Center is important for making progress in developing biomarkers of exposure and effect that will be necessary to link environmental changes to subtle changes in biological systems (people and the environment.) EPA's leadership in establishing the Center has benefited other agencies and enhances cross-agency cooperation on this topic.

An example of an area in which additional cooperation is needed is in the area of quantifying ecosystem endpoints associated with air pollution. Little progress can be made on valuing the non-market benefits of reducing air pollution until we can demonstrate the connections between air pollution and ecosystem structure and functioning. We then need to be able to demonstrate that people are able to perceive differences in ecosystem quality (or at least understand their implications) sufficiently to be able to form values that can be measured and incorporated in benefit-cost analyses.

It is important to keep in mind that giving people more of something than they would choose for themselves, and requiring them to pay for it, does not really improve their welfare. However, if we are paternalistic about the bundle of goods and services (including environmental services) that they consume, we may feel better if they are consuming more environmental quality, even if this forces them to consume less of other things (such as food, clothing, health care, etc.). At a superficial level, it is very easy to think that improved environmental quality for low-income and minority populations will be desirable from an environmental justice standpoint. What is missing from that superficial impression is that there can be important behavioral responses in housing markets that can offset or even overwhelm these initial benefits, especially for disadvantaged groups for whom willingness to pay for environmental quality falls short of what they are forced to pay through higher housing prices. Additional insights into this issue are discussed in section 2.2.j. above.

2.3.4 Emerging Issues: *Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?*

EPA's ability to identify emerging issues in Goal 1 is hampered by funding decreases and inflationary erosion. Over the long-term continued decreases will have serious consequences on EPA's ability to both identify and address emerging issues Additionally, Congress has not removed any of its regulatory mandates, so EPA must continue all of its statutory responsibilities with legacy environmental issues.

A long-term newly recognized issue that needs to be considered is the intercontinental transport of pollutants. It is now clear that such transport from Asia, Africa, and Central America

affect air quality in the United States. This transport can produce a background concentration, especially at continental margins, that reduces the ability of controls to achieve the increasingly stringent air quality standards that are being promulgated to protect public health and welfare. There needs to be additional efforts to quantify the extent of such transport. The use of remote sensing such as is incorporated in the Advance Monitoring Initiative (AMI) is a promising starting point for such efforts. A more comprehensive effort should be mounted to provide the critical information relevant to EPA policy development and as the basis for enabling the United States government to negotiate emissions reductions in pollutants in source areas.

The rapidly growing use of nanotechnologies for a variety of purposes is a potential emerging environmental issue. There is already concern about the presence of ultrafine nanoparticles in ambient air arising from combustion sources or through new particle formation in the atmosphere. The current PM program is positioned to address this issue as an extension of its studies on ultrafine particles. Initial toxicological studies at universities are currently being conducted with support from other agencies. The SAB recommends that the EPA consider partnering with other agencies (e.g., NIOSH, NIH, NSF) to ensure that there is sufficient toxicological testing of nanoparticles to support future statutory evaluations of the need for EPA action. In terms of ambient ultrafine particles, EPA should be deploying particle size monitoring systems in major urban areas to provide the input data for time series epidemiological studies that could inform the Agency about the need of a particle number ambient air quality standard.

2.4 Goal 2 - Clean and Safe Water

2.4.1 Alignment: *Based upon the SAB's knowledge of EPA's science programs, do the planned science activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional offices?*

The Board found good alignment between EPA's science and research activities and the priorities reflected in the Agency Strategic Plan for Program and other offices involved in Goal 2. However, the Board believes that some adjustments should be considered as the Agency plans for its FY 2007 program. Some of the recommendations could also be considered as the FY 2005 and 2006 programs are implemented.

The Board wants to emphasize that there are many research areas in support of EPA's Clean and Safe Water programs that can only be addressed through long-term research. These research areas will suffer in the future if they are held only to short-term criteria and long-term performance criteria are not considered to be important. EPA is the only federal Agency focused on certain water quality and water resource protection topics, such as watershed-based water quality control approaches and tools (e.g., TMDL). If long–term research of this kind is not supported by EPA, it will receive no attention at all in the country.

a) Safe Drinking Water: The Drinking Water research funds are allocated as follows: 1) Regulated Contaminants – 40 percent, Unregulated Contaminants – 52 percent; and Distribution and Source Water Protection – 8 percent. The Board believes that a greater allocation of resources to unregulated contaminants is warranted, particularly for emerging

contaminants (e.g., pharmaceuticals and personal care products that are widely found in surface waters). The Board also believes that resources for Distribution and Source Water Protection are inadequate, particularly for research directed toward microbial growth and corrosion.

b) Water Quality: The Water Quality program is a well established and highly developed component of the EPA research agenda. It focuses on Aquatic Stressors, Sources of Impairment, Restoring and Protecting Aquatic Systems and Biosolids. The criteria development section of the program is mature, and the Board believes it would be prudent to consider advancing the newer areas of the program more aggressively.

The Agency is currently facing a major challenge under the Clean Water Act on Total Maximum Daily Load (TMDL) allocations associated with impaired water bodies. Therefore, the Board believes it would be prudent for the Agency to increase its emphasis on TMDL scientific and engineering research associated especially in the areas of diagnostics for Sources of Impairment and acceptable in-stream conditions. Experience has shown that developments in impairment assessment and protection and restoration inform the process of criteria development. The board believes that the apparent Agency shift from chemical to habitat and biological criteria is appropriate. The board also recommends that EPA consider a greater allocation for restoring and protecting aquatic systems in Goal 2. As an example, the Board noted that Goal 4 research funds allocated to mature Big Water Programs (e.g., Chesapeake Bay, Great Lakes, etc.) are large. There may be merit in reallocating some Big Water resources to research to adapt the science developed from such programs to other regions and localities around the country. Results and lessons learned from these programs need to be leveraged and better disseminated for water quality planning and management across the country.

Given the scope and scale of biosolids treatment, disposal, and land application on a national basis, the biosolids allocation is inadequate and the Board recommends that it be increased.

The Office of Water (OW) Science and Technology Funds for Homeland Security, are propsed to be $47M in FY 2006. The dual nature of this research has been noted earlier in this report. The development of real time sensors under Homeland Security is a good example of this duality and the products from this program will have great potential for chemical and microbial monitoring. However, the remaining Science and Technology funds are meager.

c) Ecosystem research: Cuts in funding Clean and Safe Water Research areas (e.g., EMAP) and extramural STAR grants in Goal 4 (healthy communities and ecosystems) will have a negative impact on Goal 2's water quality research and will adversely affect the available data to support environmental management decisions. Results of the EMAP program provide quantitative information on the condition of the Nation's aquatic and terrestrial resources and information on causes of impairments. This information is essential to inform the planning and design of water quality research. Extramural grants programs, such as STAR, provide a unique vehicle for rapidly delivering scientific advancements and

capabilities for better environmental management as EPA carries out its mission. For example, the Agency has used the STAR grants program to explore the integration of economics, the social sciences, and the natural sciences. Research results developed in this program have rapidly moved to the applied arena and have been used to advance more effective decision-making on water quality at the watershed level.

2.4.2 Coordination: ***Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?***

Clearly, the science developed by ORD complements other EPA Regional and National efforts. This reflects ORD's planning process and responsiveness to the strategic and implementation needs of National and Regional programs. Nevertheless, there may be regional needs that are not being fully addressed. Examples of Region-specific problems that deserve greater representation in the research budget are 1) invasive species and 2) the impacts of urban development (sprawl). The Board recommends that these issues be incorporated into future agency planning for water quality and that funding efforts in this area be considered for earlier implementation as well. Within the Goal 2 budget there is also a need for identification and exploitation of opportunities for research synergies. For example decision tools developed for the Drinking Water area could also have application in the Water Quality area.

2.4.3 Collaboration: ***Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?***

a) Drinking Water: In the area of Safe Drinking Water, ORD research is generally well coordinated with other national and international research programs. Significant coordination in drinking water research within the U.S. has been in place for some time. More recently, a global effort has been made through the auspices of the Global Drinking Water Research Coalition. This effort has reduced duplication of effort in drinking water research. Areas of collaboration that deserve attention include: better coordination between OW, OSWER, and OAR for contaminants that impact several environmental media; better coordination between drinking water and water quality programs; and better collaboration with FDA on pharmaceuticals and personal care products in source waters.

b) Water Quality: The Water Quality research agenda is more difficult to coordinate. Unlike drinking water, where the EPA is the only federal agency, there are multiple federal agencies addressing this issue. Coordination across these federal agencies does occur. There has been significant coordination between EPA and USDA on Concentrated Animal Feeding Operations. However, there are significant opportunities for additional leveraging of aquatic ecosystem restoration research with USDA and DOI that should be pursued. EPA also coordinates with US Industry through the Water Environment Research Foundation (WERF)

and the American Water Works Association. Research on water quality in the Great Lakes is also a good example of international coordination, but this is at a much lesser level of coordination than that in drinking water. The Board recommends that the Agency take the lead in establishing an organization to coordinate water quality research both at the national and global level following the model that has been used in the drinking water arena.

2.4.4 Emerging Issues: ***Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?***

The Goal 2 budget seems to be relatively inflexible. As a result there appears to be no Agency wide focus on emerging issues. Examples of emerging issues that do not seem to have adequate funding include: 1) Pharmaceuticals and Personal Care Products in water; 2) watershed ecosystem/landscape research; 3) the need for new, cost effective approaches for water and wastewater infrastructure renewal, and 4) urban sprawl impacts and control. EPA appears to be well positioned to serve as a catalyst for collaborative research in these areas. From discussions with ORD and program office staff, it is evident that horizon scanning for emerging issues is given a low priority. The SAB could play a role in providing advice to the Agency on horizon scanning and priority setting.

2.5 Goal 3 – Land Preservation and Restoration

2.5.1 Alignment: ***Based upon the SAB's knowledge of EPA's science programs, do the planned science activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional offices?***

The EPA Contaminated Sites and RCRA Multi-Year Plans, which describe the research needs under Goal 3, were reviewed by a Panel of the Science Advisory Board during FY 2004. The Board agrees that research proposed in the FY 2006 budget for Goal 3, largely aligns with the strategic program priorities relating to legacy issues in waste management (i.e. issues related to site remediation, USTs, and oil spills). While the Board acknowledges that there is much important relevant research that needs to be addressed in these areas, it is dismayed at the lack of research proposed for non-legacy issues. In particular the Board endorses the Agency's long-term vision for transforming environmental policy from a waste-centered to a materials-centered approach. Although the EPA Strategic Plan, and the Resource Conservation Challenge (RCC) Strategic Plan, articulate this vision in a highly inspirational manner, science and research issues important to "transformation of the Nation's current waste handling system and approach towards materials management," is proposed to receive the smallest allocation of S&T dollars.

The Strategic Plan calls for a move toward pollution prevention (Goals 4 and 5), development of innovative waste management practices (Goal 3), and development of voluntary programs of materials management and resource conservation; under the Resource Conservation Challenge (Goal 3). The demise of the economics and decision sciences (EDS), STAR, and overall sustainability budget decreases are inconsistent with such goals. The Board believes it would be desirable to increase funding for research in support of the RCC initiative, even if that

requires reprogramming of current research funds within Goal 3. The areas of needed research are many and varied, and range from material flow studies and data certification, to cooperative ventures with industries (the Board notes and encourages the planned effort with the electronics industries), to appropriate policy instruments to create incentives for materials recycling/reuse/and remanufacturing (this is treated more extensively under the Board's comments under Goal 5).

2.5.2 Coordination: ***Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?***

The science programs in Goal 3 reflect coordination among EPA organizations and these programs do complement one another. The SAB review of the Contaminated Sites and RCRA Multi-Year Plans demonstrated that the regions, program offices and the Office of Research and Development have worked closely with one another. The SAB panelists observed that researchers had an intimate understanding of the problems faced by their colleagues in the regions and the program offices and the research needed to assist them. In addition, their clients were well informed of the research completed and underway that was intended for their benefit. Also, a separate review of the 3MRA modeling system by the SAB demonstrated close coordination across EPA offices (ORD and OSWER).

2.5.3 Collaboration: ***Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?***

There is considerable evidence, albeit anecdotal, that the Agency greatly values cooperative research with other government agencies and organizations outside of government. In the review of the Contaminated Sites and RCRA Multi-Year Plans the Agency documented that they engaged in extensive coordination with other agencies and organizations. Still, the exact amounts of leveraging of Agency S&T dollars, the nature of the cooperative research, and trends over time have not been reported. The Board believes there is a need to quantify the type and amount of support received from other agencies and organizations both inside of and outside of government for specific research. Such information should be made available to the Board routinely as part of the science and research budget advisory and for each such review. It would be helpful if this information would include trends over the preceding 5 fiscal years.

Information on the amount of Agency resource leveraging can be helpful in showing the degree to which environmental research portfolios across the federal government intersect and how well they are coordinated. As noted during the meeting, the EPA S&T research budget accounts for about 7% of the total federal environmental funding. Without a more detailed knowledge of research supported by other agencies, it is difficult for the Board to assess the

impacts of EPA's programmatic cuts and reallocations, in this and other Goals, and how they impact overall Federal research on specific topics (e.g., the de-emphasis of EPA's ecosystem research funding and its impact on other agencies having complementary programs). The Board understands that its purview is limited to EPA's science and research budgets, and it does not suggest that its review be extended to the entire federal environmental research budget, but it is concerned that lack of this additional information might cause it to underestimate the overall national impact of resource changes in EPA's science and research program. The Board also understands that research conducted with other agencies' support, although similar in topical area to EPA's, may lack the nuance needed for EPA which is charged with the responsibility of regulating environmental risk. However, this underscores the need for the Agency to present the Board with much more information on the type of cooperation on research in which they interact across and beyond the government.

2.5.4 Emerging Issues: ***Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?***

The SAB believes that EPA's science programs in support of strategic Goal 3 are not well positioned to address the nation's emerging waste management issues. The distribution of Goal 3 funds is heavily weighted towards legacy problems, in part because this is a requirement of the trust funds that have traditionally supported many of these programs. This is inconsistent with the visionary environmental plan presented in the Resource Conservation Challenge, which is an effort within the Agency that engages various stakeholders in voluntarily examining their material flows with the aim of identifying opportunities to limit waste without diminishing profits. Currently, few resources exist to address emerging environmental issues relating to waste management. One possible use of a portion of the $20 million set aside in the new pilot project to support Program Office initiated research within ORD, would be to invest in structuring a framework for identifying and addressing emerging environmental issues across all five goals.

The Board believes that the transformation of environmental policy will require significant investment in education, as specified in the RCC. The Agency may wish to consider, as part of its research portfolio, the funding of innovative environmental education programs beyond the STAR graduate fellowships, perhaps in partnership with the Department of Education or National Science Foundation.

Finally, in support of emergent Goal 3 research needs, the Board recommends that the Agency undertake a long-term project on the establishment of National Material Flow Accounts, and relate this information to existing national income accounts (GDP, etc) and/or economic input/output tables. Such information could provide benefits to the Nation in three essential areas:

a) Improvement of economic, trade and national security, and technology development policy by enhancing our understanding of the material basis of the economy.

b) Improvement of natural resource policy (minerals, forest products, fuel, etc.) by enriching system-wide, life-cycle information on the status and trends of materials sources and uses,

final disposition and other aspects of supply/demand.

c) Improvement of environmental policy by helping to identify categories of pollution sources, develop materials-based and product-based environmental strategies and promote reuse of what is currently discarded.

Allocation of resources for such a project would be an important advance and represent a tangible commitment toward the stated goal (Goal 3) of transitioning US environmental policy to a material flow basis. Many countries (including the U.S.) already collect most of the information necessary for MFA (for various other purposes), but most do not routinely assemble the information into material flow accounts.

2.6 Goal 4 – Healthy Communities and Ecosystems

2.6.1 Alignment: *Based upon the SAB's knowledge of EPA's science programs, do the planned science activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional offices?*

The FY 2006 science and research budget aligns with many of EPA's strategic priorities. However; there are some areas where this alignment fails, and the cause of this failure is largely the continued erosion of EPA science and research resources that need to be applied to critical areas of EPA's mission to protect human health and the environment.

The request related to human and ecosystem health, in support of Strategic Goal 4, is very similar to the President's requested budget for 2005 (US EPA SAB, 2004). Thus most of the Board's comments on that budget apply to the current request. While the Board recognizes the limited resources available for domestic spending, this budget continues the pattern of essentially level-funding for most programs, resulting in a gradual erosion of EPA research capacity due to inflation. As in the 2005 budget request, there is significantly reduced funding for ecosystems science and research, in particular in the Agency's extramural funding (STAR program). The fact that the funding for STAR extramural grants in the area of ecosystems health was not included in this year's request continues to be troubling, for reasons that are discussed later in this section. Below, we also discuss some aspects of significant programs that are identified in the FY 2006 science and research budget.

a) The Advanced Monitoring Initiative (AMI): The FY 2006 request includes a new program, the AMI. Initiatives proposed such as the AMI and the nanotechnology program are laudable and address EPA strategic priorities and hold great potential to advance environmental health science (see additional discussion of the AMI in section 2.3.3 above). Integrating EPA AMI activities into a recognizable program will strengthen the ability of EPA to leverage the use of other agencies' data to address EPA needs. Unfortunately the EPA AMI is clearly funded by realignment of funds currently supporting other EPA strategic priorities such as mercury, air quality standards and persistent, bioaccumulative toxic chemical (PBT) research.

The AMI leads a trend toward more observational and less basic research activities. Although the overall funding in Goal 4 is nearly level, the goal includes considerable programmatic change implemented via a budgetary strategy of funding realignments. This strategy allows the agency to propose new or expanded initiatives without new funds. However, the Agency should carefully consider whether an extensive realignment strategy may have unintended negative consequences. The SAB cautions that there may be little or no net gain as the potential utility of any scientific advances may be offset by the loss of the activities previously supported by the realigned funds. Many of the sources of realigned funds in Goal 4 come from core strategic priorities. The disruption of current programs by realignment may result in a net research activity loss, especially as consolidation decreases diversity and creates additional imbalances in the research portfolio.

b) Disparities Between the Budget and Priorities; Mercury and Endocrine Disruptors: Some of the Agency's most important programs have been progressively reduced over the last few years. These programs include the mercury research program, the endocrine disruptors program, and the STAR research program (including the exploratory research program). Endocrine disruptors and mercury are among the agents that may have the greatest impacts on ecosystem and human health and the SAB is concerned that the reduction of the programs is not in accord with the Agency's stated goals. These programs have been progressively reduced in funding even though they are already funded at relatively low levels. Given the high priority of mercury as a contaminant, and the fact that not enough is known about its sources, fate, transport, and health effects, we caution the Agency to prioritize the research needs for mercury and continue to address them aggressively (see section 2.3.1 above for additional comments on mercury research).

c) Ecosystems Research: Among the major elements of the Agency's strategic plan is a commitment to "protect, sustain, and restore the health of natural habitats and ecosystems." Fundamental to this objective is creation of scientific tools to assess the current condition of the nation's ecosystems, and then apply these tools to assemble a coherent picture of the state of our ecological systems. The importance of this objective is underscored by the conclusions of the Agency's Report on the Environment (EPA SAB, 2004b), as well as the independent "State of the Nation's Ecosystems" report of the Heinz Center (The Heinz Center, 2003), that most of the information required to characterize and track changes in ecosystem health is not currently available nationwide. This research not only informs Goal 4 objectives, but also supports efforts under EPA's other strategic Goals. For example, the ecological indicators that were being developed under ecosystems research were to be the next generation of integrated indictors for use by the States to meet their assessment requirements under the Clean Water Act (303 listings). Yet, the FY 2005 budget made deep cuts in the programs related to ecosystem assessment (e.g. ecological indicators) and the FY 2006 budget request makes even deeper cuts, including nearly $5M from Western EMAP, National Coastal Assessment, and Regional Vulnerability Assessment programs. These cuts appear emblematic of a broader trend to cut ecosystem research, despite its fundamental importance to the Agency's mission. To some degree, the erosion in ecosystem research may be due to the

unfortunate mismatch between governmental accountability evaluations that seem to emphasize near-term results and the long-term nature of ecological research. We strongly urge the Agency to reverse the erosion in ecological research, determine the most effective ways to proceed with ecological assessment, and reinstate funds to pursue them.

d) Extramural Research: The Science to Achieve Results (STAR) grants programs corresponding to ecological indicators, endocrine disruptors, and mercury that were eliminated in the FY2005 EPA science and research budget are also not included in the FY 2006 budget. The Board restates its belief that the sacrifice of extramural research programs comes at a significant and long-term cost to the Nation's need for knowledge on important issues that will permit the development of environmental policy and that will be necessary for informing international debates on U.S. products that compete in the international market place.

Extramural research provides four essential functions, which are lost when such funding is diminished. Extramural research: a) allows access to expertise outside of the Agency; b) invigorates the science being conducted and prevents in-bred or stale research from taking hold; c) provides a flexible mechanism to identify and address emerging issues; and d) allows EPA to leverage funds with other agencies or partners. Thus reducing extramural funds has both direct and indirect effects, and can be equated to spending one's investment principal.

e) The Exploratory Research portion of the STAR program within Goal 4 (historically funded at approximately 10% of the total STAR budget) provides a small but important pool of funding for innovative and cutting-edge research that intends to provide EPA programs with knowledge and understanding that anticipates issues of concern for the future. Exploratory grants have served as the Agency's long-term investment in exploring future emerging issues, in contrast to the current STAR program, or the new Research Pilot program efforts, which are both largely focused on nearer-term solutions to already identified problems. The Exploratory Research program has been cut in half in the FY 2006 budget, (about $5M), and the remaining $5M will be dedicated to research related to nanotechnology. While research on nanotechnology is a clear priority and at the cutting edge of environmental science, there are severe limits to funds to explore other emerging issues **(some limited exceptions are discussed in section 2.6.4 below).**

The Board believes that this situation makes the Agency more vulnerable to being blindsided by future issues or challenges, and will place EPA further behind in its ability to use and/or evaluate new technologies and new problems. This gap in exploratory research will not be filled by the private sector; in fact a recent survey showed that when the government invests less in basic research, the private sector follows suit.

f) The Pilot Research Program: The new Pilot Research program is innovative and appears to be a good investment, allowing the program offices to purchase research internally from ORD for specific needs. We support the overall concept and encourage the Agency to use peer-review in the selection and awarding of projects that are funded by this mechanism. We encourage the Agency to implement this as a "customer-driven"

initiative, allowing the program office needs to clearly drive the process to fill knowledge gaps, and to not duplicate efforts or use the funding to replace operational expenses.

g) Climate Change: The Board applauds the continued support of the Climate Change Science Program. It is encouraged to learn that the CCSP program has done an internal budget analysis across the participating agencies, including EPA, and note that while the Climate Change program has been asked to expand their activities, there funding is similar to last year.

2.6.2 Cooperation: *Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?*

Over the years that the SAB has reviewed the EPA science and research programs it has seen a steady improvement in the coordination between EPA administrative units and the alignment of the extramural research funding to complement research at EPA. EPA science and research coordination are a model other agencies should emulate. This approach has allowed EPA research to remain highly productive in the face of stagnant or decreasing funding. Examples of successful intra-Agency collaboration include the endocrine disruptors research program, the computational toxicology program, and the genomics program. The Board notes that the leveraging of extramural research programs and partnerships can be readily quantified; however, this has not been done and thus the full extent of intra-Agency cooperation is not as transparent as it might be.

The increased emphasis within the Agency on expressing research outcomes rather than outputs also underscores the need for improved coordination within and outside of the Agency. For example, the Office of Water may need the results from specific Regional office REMAP projects to demonstrate the effectiveness of an outcome measure, or evaluation of the NHANES data from CDC may assist the Agency in assessing the effectiveness of a given rule aimed at reducing exposures to pollutants.

2.6.3 Collaboration: *Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?*

EPA has not only organized its programmatic and research efforts to align with the agency strategic goals, but also is a leader in partnering with other federal agencies with shared interests. These highly successful partnerships have provided results of utility to EPA far beyond what could have been anticipated had they attempted to build the programs alone. The proposed AMI effort and the EPA participation in the National Children's Study continue this tradition.

The EPA's research program complements specific programs in many other federal agencies (NIH, CDC, NASA, NOAA, and others), state agencies, University-based programs and industrial research programs. An excellent example includes the endocrine disruptors program, which partners with other Federal agencies, industry, and funds extramural research with academia. These coordinated efforts allow the EPA to leverage their limited funds to conduct more of the necessary research required to make science based regulatory decisions.

Another excellent example of these coordinated activities is EPA's leveraging funds with other agencies including NIH and CDC and universities in the support of the Children's Centers for Environmental Health Disease Prevention programs and the National Children's Study. In addition, the Agency has begun to work with industry in establishing basic and clinical research endeavors. Other examples include the EMAP program, which collaborates with the States by transferring statistical designs for probabilistic monitoring to their agencies; the collaboration of EPA with NIOSH and NIST on nanotechnology research; and the collaboration of EPA with NIEHS and DOE on computational toxicology. Such programs, when conducted with the highest scientific and ethical standards, provide an opportunity to leverage EPA research needs and industry and other resources and research needs to protect the environment and human health. In complementing and coordinating their research programs the EPA captures a broad array of scientific products (data and technology). The Agency understands that, with limited resources, they must complement, coordinate, and encourage the entire community of stakeholders including the Federal and State agencies, universities and local communities, and industry.

The SAB recognizes that the cooperative efforts of all stakeholders will be greatly facilitated with additional efforts to enhance the ability of the Agency and other stakeholders to access and share data that each agency may have, such as EPA environmental data, CDC NHANES data, and health disease tracking and local registries of cancer, autism or other diseases. The Board strongly encourages the Agency to pursue such collaborative ventures to maximize leverage of limited resources, including joint extramural research programs, cosponsored initiatives, and the like.

2.6.4 Emerging Issues: *Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?*

The Agency is losing ground in its ability to address emerging issues, and its current efforts are at the margins. In the past, EPA steadily improved its capacity to anticipate and respond to emerging issues in part by maintaining a strong science program that included a substantial commitment to "core" or long-range research. The ability to outsource research on emerging issues also helped the Agency to nimbly investigate new issues without permanently building in-house capacity. This positive trend appears jeopardized, however, by the current budget environment in which significant cuts have been made to long-range ("core") research in areas such as ecosystem condition and the outsourcing programs (i.e. competitive research grants under STAR). The Board noted last year that cuts in the STAR program, particularly in the area of ecological indicators, weakened the Agency's ability to address new issues and we reiterate that concern again this year.

To its credit, the Agency has identified many emerging issues that are important (e.g., the promise and potential threats associated with nanomaterials, the ecological disruption caused by invasive species, the non-linear dose response of low level exposures of endocrine disrupting chemicals, and the effects of genetically modified organisms on natural systems). Activities in these areas are ongoing within the Agency, although at a relatively low and static funding level that is not conducive to developing a strategic response that ultimately can address the challenge. In the case of nanomaterials, the Agency has dedicated $5M in Exploratory Research grants to the issue which we view as a minimally appropriate level of extramural funding; as with the other emerging issues, the internal Agency effort in both science and strategic planning appears inadequate to the challenge.

The SAB stresses the need for the Agency to develop and support a mechanism for addressing emerging issues, one that is integral to the Agency's operations. The current budget erodes, rather than enhances, this capability. The SAB recommends that the Agency develop a new strategy for addressing not only legacy issues, but also to addressing issues for the future.

2.7 Goal 5 – Compliance and Environmental Stewardship

2.7.1 Alignment: *Based upon the SAB's knowledge of EPA's science programs, do the planned science activities included in EPA's FY 2006 budget align with the Strategic program priorities identified by EPA's Research, National Program, and Regional offices?*

A major reorganization of the science and research funding areas in Goal 5 is planned for FY 2006, attributed at least in part, to the U.S. government's performance assessment system. In particular, funding for the pollution prevention (P2) and green chemistry programs (as well as a few others) have been reassigned to "Economic and Decision Sciences" and "Sustainability." Concurrent with this reorganization is a major cut in funding. The S&T portion of this area is to decrease from $50.5 million to $43.8 million. The total science and research dollars attributed to the goal is to decrease from $69.6 million to $57.9 million. Specific Board comments on Goal 5 science and research are in the following paragraphs.

a) Voluntary Programs and Incentives: A major theme running through all the strategic goal descriptions in the EPA 2003 – 2008 Strategic Plan is the need to move forward where possible from the largely command and control regulatory regime that is now the cornerstone of U.S. national environmental policy. For example, the Strategic Plan calls for a move toward pollution prevention (Goals 4 and 5), development of innovative waste management practices (Goal 3), and development of voluntary programs of materials management and resource conservation; under the Resource Conservation Challenge (Goal 3). This proposed shift raises two important questions. The first is how to encourage such voluntary actions. The second is determining the proper mix of public sector and privately funded research on improved waste management practices, innovative pollution control technologies, and pollution prevention.

The Strategic Plan expresses the hope that voluntary actions by individuals and industry can be relied upon to improve the state of the nation's environment. However, the behavioral,

social, and decision sciences necessary to support environmentally effective programs that rely on voluntary incentives are at an early stage of development. In particular, while the literature has identified some effective, targeted programs that have led to real environmental improvement at small scales, there is little or no research supporting the view that costly or major changes in the production processes of firms or individuals can be expected to occur in the absence of major financial incentives. There is also little research to support the provision of guidance on the design of programs to encourage voluntary actions. Understanding incentives and constraints is important in explaining actions and choices of people. A useful analogy is the volunteer army: while it is true that volunteers can staff an army, much higher incentives (wages and benefits) are needed than when the army is conscripted. The move to a voluntary army was undertaken only after a substantial body of research on the labor market and the potential supply of labor to the military.

If the EPA is to try to increase its use of voluntary mechanisms to achieve increased environmental improvement and compliance, it must significantly invest in the appropriate disciplinary and interdisciplinary research to provide the basis for this approach. This research would need to assess the magnitude and form of incentives, such as tax breaks, direct payments, non-financial compensation, information provision, etc., necessary to achieve increased environmental performance by a broad variety of private sector agents (industries, households, farmers, etc.). Previous STAR grant projects have made useful contributions to our knowledge about these issues. For example, studies that: 1) identify the sectors where voluntary programs will be most effective, 2) identify community actions that effectively motivate firms to improve environmentally performance, and 3) develop communication methods to improve the management of hazardous waste by households at lower costs. But, there is much to learn and more of this kind of research is needed.

b) Public vs. private research funding: The Goal 5 Team questions the appropriate mix of private and public and spending on research for pollution prevention. In designing both its research programs the Agency should consider where and/or who is better placed to do successful research leading to innovation and technological change for pollution prevention – is it the private sector with its knowledge of its own production processes, or are others who might know less about these processes able to do meaningful research on innovations? The Board believes that the need is for stronger incentives that will induce more private sector research on pollution prevention. There is a special need for market-based incentives that reward pollution prevention with lower costs and higher profits. These incentives could take the form of cap and trade programs, taxes on pollution discharges, deposit-refund systems, disposal fees, and so forth. The Board believes that the Agency should devote more of its own resources to research on market mechanisms and incentives aimed specifically at rewarding pollution prevention. This could be done by some combination of increased support for the market mechanisms and incentives component of the Economics and Decision Sciences program under ORD and additional support for the National Center for Environmental Economics.

c) Strategic Approaches to Risk Communications: A strategic approach to risk communication is crucial to ensuring that the agency's investments in data collection and research have public value. The goals of increased compliance, pollution prevention, and

environmental stewardship elucidated in Goal 5 relate fundamentally to social science and/or interdisciplinary questions. Yet, social science research and genuine interdisciplinary efforts that span the social and hard sciences, and thereby yield new conceptualizations, remain vastly underfunded and underutilized.

Risk communication serves various purposes and takes on different forms throughout the risk evaluation and management process (PCCRAM 1997; CSA 1997). It is integral to defining a risk issue, gathering the data to assess the technical and societal dimensions of the issue, selecting the risk management option/s, and evaluating the impacts of the option implemented. Effective risk communication is more than applying a set of skills – e.g., crafting a message, segmenting an audience, and writing a brochure or public service announcement. Strategic risk communication relies on a comprehensive systems orientation and is based on scientifically derived facts – not guesses – about risk perception, social dynamics, linked contexts, and cultural views. The sciences that contribute to strategic risk communication approaches include but are not restricted to the decision sciences, psychology, behavioral sciences, sociology and anthropology. Unfortunately, although EPA was once a leader in supporting risk communication research and has produced many publications with risk communication guidance, the new generation of risk communication knowledge is significantly underfunded and now appears to be undervalued by much of the Agency. To increase the impact of the agency's research on public policy, a much broader view of risk communication and the sciences that underpin strategic approaches is essential. This cannot be achieved without greater recognition and incorporation of social science knowledge and methods into the agency's research and programs.

d) Enforcement: Another area in which EPA's research does not align effectively with EPA priorities is the enforcement area. One of EPA's strategic objectives is to "strengthen the scientific evidence and research supporting environmental policies and decisions on compliance, pollution prevention, and environmental stewardship." Yet this strategic objective is undercut by deficiencies in research funding regarding enforcement. The first set of research deficiencies results from inadequately framed objectives. Subobjective 5.1.3, for examples, calls for a 5% increase in "enforcement actions," but a recent article in ***Environment Law Review*** (2000) indicates that agency enforcement actions in the previous several years have decreased. As a consequence, there is a resulting decrease in enforcement related research. The second set of research deficiencies are inadequate data. For example, a series of GAO reports indicate that inadequate enforcement activity is undertaken by the Agency due to budget limitations. This leads to less data for research on these problems. Third, deficient S&T research funding and transfer of about 18% of NEIC investigation agents to homeland security issues has caused a drop in non-homeland security research at the NEIC, and a drop in criminal referrals to NEIC. Again, this limits the ability of the NEIC to provide the necessary science and technology base for effective enforcement.

2.7.2 Cooperation: *Do the science programs of EPA's National, Regional, and Research Offices reflect coordination among EPA organizations and do they complement one another?*

The funding of the science and research supported by the NCEE as well as the "Economics and Decision Sciences" within ORD supports the attainment of goals 1-4 as well as goal 5. While the agency has made progress in the development of an internal coherent economics research program by establishing the NCEE, there is no evidence of such progress for any of the other social sciences. Expanding EPA's science and research activities in social sciences to include more than environmental economics, through enhanced collaboration and program establishment is essential if EPA is to position itself to address emerging environmental issues in our changing culture.

Agency staff, across offices, described information sharing actions on research activities during their discussions with the SAB at its February 2005 meeting. However, it is difficult to know the full extent to which offices coordinate their research programs for generating knowledge, tools or methods. Agency scientists, trained in different though complementary disciplines, and who work on different pieces of the same problem and who have occasional interactions to share their individual progress provides only a very limited cross-disciplinary and/or cross-mission integration of EPA's scientific program. The problem with this *ad hoc* approach is briefly discussed in the following paragraph.

The more complex the environmental issue the more urgent it is to address the related problems using a comprehensive, systems-based approach and inter- or trans-disciplinary models (pp. 3-4 of Stokols et al, 2003). The number and complexity of emerging environmental concerns (e.g., global warming, ecosystem degradation, and water source protection) demands a meaningful re-conceptualization of the agency's research enterprise to addresses these issues. Full integration of diverse sciences, with appropriate structures and incentives to sustain that integration, is difficult but essential. New knowledge about effective ways to initiate and implement scientific collaborations should be utilized by the agency (Rhoten, 2004; Stokols et al, 2003). Without redesigning the agency's approach to such research activities, scientific progress will be too slow to effectively address these combined legacy and emerging environmental problems.

2.7.3 Collaboration: ***Based on EPA's presentations to the SAB, and Board members' own knowledge of efforts in the broader scientific community, how well does EPA's science program appear to complement environmental science programs elsewhere? Is there evidence that EPA's efforts are coordinated with the science efforts of other governmental organizations and relevant organizations outside of government? Is there evidence that EPA has an approach for capturing the science products from these other organizations? Are there ways the Board could suggest that will enhance this coordination?***

EPA should think in broader terms about ways to leverage their research resources within the research community outside of EPA. One approach may be to partner more extensively with other public agencies and private, nonprofit entities to jointly fund research, especially in the social sciences area. Both the NIH and the CDC have followed such strategies. EPA's own ETV program is a good model, though it is limited to technology transfer. Partnering with private sector resources may be useful as well. While it is important to recognize that in some areas, EPA will be the exclusive source of science because of EPA's specific mandates

and authorities, private research can be effective in developing cost saving methods for pollution reduction and/or prevention.

The Pollution Abatement Control Expenditures (PACE) survey is the sole source of significant amounts of information concerning the costs of meeting environmental regulations. It is developed through the collaboration of the EPA's NCEE and the Bureau of the Census and it has been responsible for developing a useful time series of data on this topic. It is critical that EPA's funding for this critical survey be continued.

2.7.4 Emerging Issues: ***Based upon the SAB's knowledge of EPA's science programs, are those programs positioned to address the nation's emerging environmental issues in the coming years?***

With the growing U.S. population, increased demands for environmental resources, changing standards of living, and performance expectations, as well as the increasingly complex nature of emerging environmental issues (noted in section 2.7.2 above), there is a need to increase our understanding of people's views and responses to environmental concerns. Thus, increased research in the social sciences is essential to understand organizational, individual, and group concepts and behaviors associated with environmental issues.

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