EPA-SABSO-13-001 | December 2012 | www.epa.gov/sab

Science Advice for EPA — A Foundation for a Sustainable Future

The EPA Science Advisory Board Staff Office and Science Advisory Committees Accomplishments Report for Fiscal Years 2009 - 2012

EPA
United States
Environmental Protection
Agency

Message from the Science Advisory Board Chair

It has been an honor to serve as Chair of the EPA Science Advisory Board during the four years summarized in this *Accomplishments Report*. During that time, my colleagues on the SAB, the CASAC and the Council have supported the EPA's efforts to refocus its research enterprise on critical environmental issues and to bring the most relevant science to the table to inform environmental decisions.

We have advocated an integrated approach to EPA's scientific research, and the agency has responded by realigning over a dozen research programs into six integrated topic areas. We have recommended that the EPA develop capacity in social and decision science research so that agency policies, decisions and communications are designed with human behavior and sustainability in mind and the agency has begun to fill this need. We have encouraged the agency to think in integrated ways about multiple pollutants and the agency has taken steps to consider the impacts of pollutant mixtures on air and water quality and on human health. Despite tight research budgets, and declining funding in constant dollars, we have advised that the EPA support scientific innovation among its own scientists and within the broader research community and the agency has responded with internal and external grant programs to support science that is critical to the agency's mission.

This *Accomplishments Report* summarizes the advice provided to the EPA by the SAB, CASAC and Council from Fiscal Years 2009 to 2012. During that time, we responded to requests from Administrator Jackson on questions relating to her priorities to protect public health and the quality of our air, land, and water. The report gives highlights of advice on a range of science issues—from impacts of mountaintop mining and hydraulic fracturing, to restoring the Great Lakes, to evaluating health risks from chemical exposures and setting safe levels of air pollutants. It also describes original SAB studies on managing reactive nitrogen, valuing ecosystem services and integrating science for decision making.

With support from EPA leadership, we believe and hope that our advice has been helpful to the agency in its mission to protect public health and the environment.

Deborah L. Swackhamer, Ph.D., SAB Chair (FY 2009 - 2012)
Professor, Hubert H. Humphrey School of Public Affairs and Co-Director of the Water Resources Center
University of Minnesota, St. Paul, MN

Missions of the SAB, CASAC and Council

The Science Advisory Board (SAB), the Clean Air Scientific Advisory Committee (CASAC) and the Advisory Council on Clean Air Compliance Analysis (the Council) are independent, congressionally mandated advisory committees that provide advice to the EPA Administrator to strengthen the scientific and technical base for the EPA's decisions. The three committees have different charters and missions, but each provides advice to the EPA Administrator through a public process governed by the Federal Advisory Committee Act (FACA). The committees and their panels and subgroups are provided administrative and technical support by the SAB Staff Office, which also serves as the liaison between the committees and the agency and between the committees and the interested public.

The statutory mandates and charters of the three chartered committees dictate the scope of their activities. The majority of committee activities are peer reviews and advice in response to agency requests. Occasionally a committee also will initiate a special study, with the agency's support, to provide advice on an emerging issue or other important scientific subject.

SAB

Congress established the EPA Science Advisory Board (SAB) in its present form in 1978 through enacting the Environmental Research, Development, and Demonstration Authorization Act. This Act gave the SAB a broad mandate to advise the agency on technical matters. The SAB's principal mission includes:

- Reviewing the quality and relevance of the scientific and technical information being used or proposed as the basis for agency regulations;
- Reviewing research programs and the technical basis of applied programs;
- Reviewing generic approaches to regulatory science, including guidelines governing the use of scientific and technical information in regulatory decisions, and critiquing such analytic methods as mathematical modeling;
- Advising the agency on broad scientific matters in science, technology, social and economic issues; and
- Advising the agency on emergency and other short-notice programs.

The SAB has six standing committees: Drinking Water Committee, Ecological Processes and Effects Committee, Environmental Economics Advisory Committee, Environmental Engineering Committee, Exposure and Human Health Committee and Radiation Advisory Committee.

Information about SAB membership, activities and reports is provided at www.epa.gov/sab.

CASAC

The Clean Air Scientific Advisory Committee (CASAC) provides independent advice to the EPA Administrator on the technical bases for EPA's national ambient air quality standards for criteria air pollutants: carbon monoxide, lead, oxides of nitrogen, ozone, particulate matter and sulfur oxides. The Clean Air Act requires periodic review of the science upon which the standards are based and of the standards themselves.

Established in 1977 under the Clean Air Act Amendments of 1977, CASAC also addresses research related to air quality, sources of air pollution, and the strategies to attain and maintain air quality standards and to prevent significant deterioration of air quality.

The CASAC chair serves as a member of the chartered SAB.

Information about CASAC membership, activities and reports is provided at www.epa.gov/casac.

Council

The Advisory Council on Clean Air Compliance Analysis (the Council) was established in 1991 pursuant to the Clean Air Act (CAA) Amendments of 1990 to provide advice, information, and recommendations on technical and economic aspects of analysis and reports that EPA prepared on the impacts of the Clean Air Act Amendments on the public health, economy and environment of the United States.

The Council reviews the data, methods, and cost-benefit analysis conducted by the EPA pursuant to the directive in section 812 of the CAA Amendments of 1990 to evaluate the comprehensive benefits and costs of Clean Air Act programs. Since its formation, the Council has provided advice and input to the Agency's retrospective analysis of CAA benefits and costs from 1970 to 1990, and two prospective analyses of CAA benefits and costs from 1990 to 2020.

The Council chair serves as a member of the chartered SAB.

Information about Council membership, activities and reports is provided at www.epa.gov/advisorycouncilcaa.

Highlights of Advice in Fiscal Years 2009 to 2012

During the four years from fiscal years 2009 to 2012, EPA Administrator Lisa P. Jackson turned to the SAB, CASAC and Council for advice on questions relating to her priorities to improve air quality, respond to climate change, protect the nation's waters, clean up communities, and ensure the safety of chemicals introduced into the environment. This *Accomplishments Report* presents some of the science questions considered by the three committees, and highlights advice to the agency in support of its mission to protect public health and the environment. The report is organized around the Administrator's priorities and the strategic goals that guide the agency's work. All reports, along with background materials, charge questions, and public comments, are available on websites for the SAB (www.epa.gov/sab), the CASAC (www.epa.gov/casac) and the Council (www.epa.gov/advisorycouncilcaa).

Advice on Strategic Research Directions

Research Plans and Budgets

Historically, the SAB has offered advice to the EPA Administrator on research priorities by reviewing the President's annual research budget request for the EPA. The SAB recommended that the primary drivers for the agency's future research should be the overall goal of sustainability, the agency's key priorities and the potential for encouraging innovation. As a complement to this annual look at EPA research priorities, the SAB held a series of discussions with EPA research planners about the strategic directions for EPA's scientific and technology research programs. Prior to 2007, the agency's research program was organized in more than a dozen specific research areas, and the SAB advised the EPA to develop a more integrated program that reflected the interconnections among human and ecological systems, gave greater consideration to feedbacks and focused on the relevant scales of each issue. The SAB also noted the difficulty is maintaining a balance between addressing near-term regulatory needs and emerging future environmental problems, especially in light of ever more serious budget constraints.

In 2011 and 2012, the SAB and the Office of Research and Development's (ORD) Board of Scientific Counselors (BOSC) conducted joint reviews of the agency's new strategic research plans and draft research frameworks. For FY2012, the ORD organized its research efforts in six new programs that

emphasize trans-disciplinary collaboration and coordination across ORD. The SAB and the BOSC strongly supported this consolidation and realignment of ORD research and urged the agency to devote significant resources to sustain the scientific interactions and stakeholder involvement necessary to support a sustainable, systems approach to environmental management.

In recent years, SAB commentaries on the agency's research plans and budgets have included several recurring themes:

- ***Science Integration***: the need to better integrate EPA research and program efforts across scientific disciplines, environmental media and organizational units. This integration is vital to understanding the inter-connections between environmental problems and to supporting a systems approach to environmental protection.
- ***Research Funding Levels:*** the need to restore the budget for research and development at EPA to maintain the United States as an international leader in environmental protection. As of 2012, funding for the Office of Research and Development in real dollars has declined 28 percent from a high in 2004. This long-term decline has limited and will continue to limit the research conducted to support the agency's efforts to protect human health and the environment.
- ***Social Science Research***: the need to integrate social science research and perspectives into problem solving at the agency. Research on human perceptions, values and behavior is essential to the design and implementation of effective policies, programs and communications.
- ***STAR Grants and Fellowships***: the value of EPA's external Science to Achieve Results (STAR) grants to leverage the expertise of the wider scientific community and fellowships as an investment in the next generation of environmental scientists.
- ***Climate Change Research***: the need for research on climate mitigation and adaptation and the environmental and health implications of energy and climate change policies. In FY2012, the Office of Research and Development developed an integrated research topic area to coordinate climate change research across all of its programs.

Oil Spill Research Strategy

On April 20, 2010, a well blowout and explosion on the Deepwater Horizon drilling rig in the Gulf of Mexico killed 11 workers and injured 17 others. In the weeks and months that followed, the nation was transfixed by live footage from underwater cameras showing oil gushing into the Gulf from a broken pipe at the wellhead. The EPA worked with the U.S. Coast Guard and other federal agencies to oversee the response to the ongoing spill, monitoring emissions from *in situ* burning used to remove large volumes of oil from the ocean surface, evaluating the potential toxicity of dispersants applied to oil on and under the water, and monitoring water, sediment and waste generated by cleanup activities. The Deepwater Horizon spill highlighted the need for additional research on spill prevention and response technologies. It raised questions relative to the use of dispersants in oil spill remediation, acute and chronic health effects for spill response workers and the public, whether new innovative technologies were available, and the most effective steps to restore coastal, shoreline and inland areas impacted by spills. To respond to these questions, the EPA developed a research strategy for FY2012 through FY2015 on potential human and environmental risks from oil spills and the application of dispersants, surface washing agents, bioremediation agents and other mitigation measures.

The SAB was asked to review the draft Oil Spill Research Strategy, as to its scope and whether it included key scientific research questions that could improve future oil spill prevention and response activities, including future challenges such as discharges of biofuels. The SAB urged the agency to articulate how coordination on oil spill research objectives would be achieved, both within the EPA and with other agencies. The SAB recommended research on the fate and effects of dispersant/oil mixtures and chemical treatment agents (particularly in cold, high-pressure conditions such as the deep sea), and emerging issues associated with alcohol-based biofuel spills. The SAB also noted that assessments of remediation and restoration efforts require baseline information on ecosystem conditions and functions, such as existing contamination and status of local and regional food webs.

Dr. David T. Allen, Chair, SAB Oil Spill Research Strategy Review Panel
Professor, Department of Chemical Engineering, University of Texas, Austin, TX

Particulate Matter Research Centers

In 1999 and 2004, the EPA used a competitive process to establish five university-based research centers to conduct integrated research on the health effects of particulate matter (PM) in air. In 2008, the SAB was asked for advice on the effectiveness of the current PM Centers Program and for suggestions to improve program structure and strategic directions for the program in the following years. The SAB concluded that the program had been very successful and that its continuation, especially in a form that would advance research into assessments of mixtures of air pollutants, would be of great value. The SAB recommended that future applications for PM Research Centers should

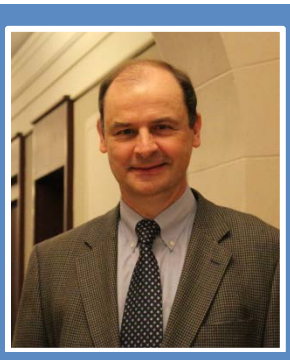
encourage research on multi-pollutant atmospheric transformation, exposure, toxicology and epidemiology, as well as regional differences in pollutant mixtures and health outcomes. To reflect this shift, the EPA is investing nearly $32 million between 2011 and 2016 in four university-based Clean Air Research Centers to conduct research on multi-pollutant air problems such as health effects of air pollution mixtures.

Scientific Workforce Development

The SAB has been a strong advocate for EPA efforts to recognize the achievements of agency scientists and to invest in the development of tomorrow's environmental scientists through extramural fellowship grants. Each year since the program began in 1980, the SAB has been asked to review nominated scientific papers authored by EPA scientists and to make recommendations for the Scientific and Technological Achievement Awards. Continuing this tradition, the SAB reviewed over 100 nominations each year during FY2009-2012 and recommended monetary awards for outstanding published work. SAB recommendations for the highest, Level I awards included research on such diverse topics as routes of children's exposure to the pesticide chlorpyrifos, mercury exposure from imported and domestic seafood, disinfection byproducts mixtures formed under alternative disinfection treatment scenarios, potential exposures to pharmaceutical ingredients in drinking water, and PCB bioaccumulation in a stream food web.

Science Integration for Decision-Making

Today the EPA faces increasingly complex environmental and public health challenges. Effective environmental policy making requires integration of science from many disciplines, including the social sciences, to inform the decision process. With the EPA Administrator's support, the SAB undertook a study to evaluate the practice of science integration at the EPA and to recommend how the agency might strengthen the process and capacity for integrating science into decision making. To understand the scope and practice of science integration at the EPA, members of an SAB committee conducted interviews with EPA program offices, all ten EPA regions, the ORD and other offices supporting decision making. The SAB interviews affirmed that agency staff and managers view science as an important component of decision making at the EPA, whether decisions involve regulatory, enforcement or voluntary programs. However, agency personnel noted the need for additional high quality assessments to translate existing science on a broad range of topics important to decision making at the EPA. The SAB urged EPA managers to be more proactive in promoting science integration, and underscored the need for problem formulation as a means of breaking down the disciplinary and program "silos" at the agency.



The SAB defines science integration as a three-part process: problem formulation – asking the right questions; assessment – combining information and analyses from different scientific fields to address the problem; and decision making and evaluation – application of the science and ongoing evaluation of the outcome of the decision.

The SAB had three principal recommendations for strengthening science integration at the agency:

- *The EPA should explicitly plan for science integration to support environmental decisions.*
- *Managers should be engaged in and accountable for integrating science into decision making, starting with problem formulation and science assessment, in their own organizations and across the EPA.*
- *The EPA should increase and improve support and training for scientists and managers across the agency, especially in programs and regions, to strengthen capacity for science integration.*

Dr. Thomas A. Burke, Chair, SAB Committee on Science Integration for Decision Making
Professor and Associate Dean, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD

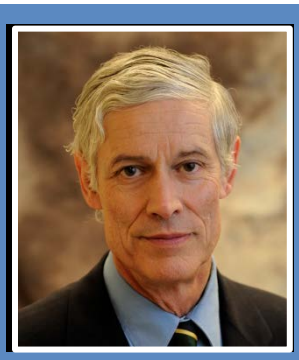
Managing Nitrogen in the Environment

Human activities—from industrial production of ammonia to use of synthetic fertilizers for agriculture to burning of fossil fuels for transportation and electricity generation— are responsible for approximately 80 percent of the reactive nitrogen (Nr) introduced into the environment in the United States. The magnitude of this human alteration of the nitrogen cycle has many consequences for humans and ecosystems. Thus, the SAB Integrated Nitrogen Committee was formed to assist the EPA in its understanding and management of nitrogen-related air, land and water pollution issues. The SAB report, released in 2011, summarized the major sources of newly created Nr in the United States, considered the impacts of Nr on people and ecosystem functions as it cycles through the environment, and evaluated opportunities for integrated nitrogen management and other risk management options that EPA could employ.

Transportation, agriculture and electricity generation account for much of the reactive nitrogen introduced into the U.S. environment each year.

The SAB report recognized that EPA efforts under various programs (e.g., national air quality standards, air emission standards for stationary and mobile sources, and water quality criteria and permits) reduce emissions of Nr to the environment, but the SAB concluded that additional measures are needed to avoid the adverse impacts of excess nitrogen. The SAB recommended that EPA measure, model and report all forms of Nr using an integrated multi-media approach. Further, the SAB recommended that the agency examine the full range of ecosystem responses to Nr, including impacts on ecosystem services, and suggested possible risk management options to reduce Nr emissions (such as farm-level improvements in manure management, actions to reduce atmospheric emissions of Nr, and control of Nr via water management programs). The SAB identified actions that the EPA and others could take to decrease the amount of Nr introduced into the United States by about 25 percent over the next 10 to 20 years.

In response to the SAB report, the agency initiated a major research effort to integrate nitrogen and co-pollutant (e.g., phosphorus and sulfur) research across the agency and developed an EPA Nitrogen Roadmap that draws upon the research, policy and regulatory capabilities of EPA to further sustainable management of nitrogen and co-pollutants. In addition, the agency continued to work with states to improve water quality standards for nitrogen and phosphorus and took initial steps toward an integrated approach to air quality standards for nitrogen and sulfur oxides to protect ecological systems from impacts associated with these compounds.

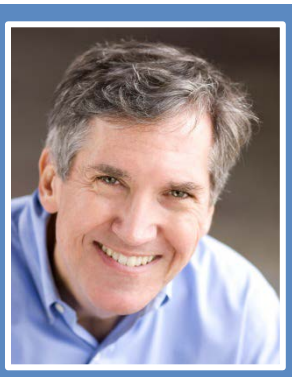


Managing the impacts of reactive nitrogen will require an integrated approach that involves not only the EPA, but also the coordinated efforts of other federal agencies, the states, the private sector, universities and the public. Given the rapid expansion of biofuels, losses of nitrogen from grasslands, forests and urban areas, and the extent of denitrification, the SAB finds that immediate actions should be considered to reduce reactive nitrogen loading and transfer to the environment. Existing proven technologies could be used to reduce emissions of nitrogen oxides from mobile sources and power plants, reduce ammonia emissions from livestock, reduce excess reactive nitrogen from agricultural operations and remove nutrients from sewage.

Dr. Otto C. Doering, III, Chair, SAB Integrated Nitrogen Committee (FY 2010-2011)
Professor, Department of Agricultural Economics, Purdue University, West Lafayette, IN

Valuing the Protection of Ecological Systems and Services

Past EPA efforts to value the agency's protection of ecological systems have tended to focus on a limited set of ecological effects that are easiest to value and the agency historically has used economic methods to monetize these values. In 2009, the SAB released an original study on valuation of ecological systems and services using both economic and non-economic methods. The report presented a conceptual framework for assessing the contributions that ecosystems make to the well-being of human populations, discussed different concepts of value (including economic values, community or societal values, and bio-ecological values), and provided an overview of possible valuation methods. The SAB advised the agency to make greater use of ecological valuation in a variety of contexts, including national rule making, regional partnerships and site-specific decisions. The report recommended ways in which EPA research programs could provide ecological information needed for valuation, develop and test valuation methods, and share data. The EPA's 2012-2016 strategic research plan for Sustainable and Healthy Communities includes efforts to standardize classification and indicators for ecosystem goods and services, including compiling existing ecological production functions and benefits functions and assessment of critical missing data.



The SAB conducted an original study to assess the state of the art and science of valuing the protection of ecological systems and services, assess EPA's needs for valuation to support decision-making, and to identify key areas for improving knowledge, methodologies, practice and research at the agency.

Dr. Barton H. Thompson, Jr, Chair, SAB Committee on Valuing the Protection of Ecological Systems and Services (CVPESS)
Professor in Natural Resources Law, Stanford Law School, Stanford, CA

The SAB recommended the following to improve ecological valuation at the EPA:

- *EPA should focus on valuing all ecological effects that people believe are important, not simply those effects that are easiest to value.*
- *EPA should support efforts to develop new approaches to measure or predict the ecological effects of EPA's actions in ways that can be incorporated by valuation methods.*
- *EPA should consider the use of a broader suite of valid valuation methods.*
- *EPA's research program should help provide the ecological information needed for valuation, develop and test valuation methods, and share data.*

Dr. Kathleen Segerson, Vice-Chair, SAB CVPESS
Philip E. Austin Professor of Economics, University of Connecticut, Storrs, CT

Improving Air Quality

Advice on Science-Based Air Quality Standards

The Clean Air Act (section 109) requires the EPA to set primary air quality standards to protect public health and secondary air quality standards to protect public welfare. These national ambient air quality standards (NAAQS), and the science upon which they are based, are to be reevaluated by EPA every five years. The CAA Amendments of 1977 also established the Clean Air Scientific Advisory Committee (CASAC) to review existing air pollutant criteria and standards and recommend any new or revised criteria and standards as appropriate. The CASAC also is charged to identify needed additional information and research, to offer advice on natural background levels versus anthropogenic sources of air pollutants, and to consider adverse public health and welfare effects that may result from strategies to attain and maintain air quality standards. As part of the NAAQS review cycle for each criteria air pollutant (carbon monoxide, lead, ozone, nitrogen oxides, sulfur dioxide, and particle pollution), EPA develops an Integrated Science Plan (ISA) to summarize available science relevant to policy questions, a Risk and Exposure Assessment (REA) to develop quantitative estimates of exposures and associated risks, and a Policy Assessment (PA) to provide analysis of the scientific basis for various policy options for the NAAQS. CASAC advice is sought at each of these steps in the NAAQS process.

The CASAC has worked with the EPA to develop a consistent process for evaluating the available science to support EPA decisions on levels of air pollutants that will protect the public health with an adequate margin of safety. We supported the approach of preparing a concise summary and analysis of available studies in the Integrated Science Assessment and assessments of risk and exposure for each criteria pollutant, with multiple CASAC reviews of draft documents and public input throughout the process. In 2009, the agency responded to the CASAC recommendation to reinstitute a policy assessment for each criteria air pollutant to provide the scientific rationale for policy options being considered for the NAAQS. The agency's new Health and Environmental Research Online (HERO) system is a useful resource for studies used to develop NAAQS assessments. Looking forward, the CASAC encourages the agency to consider the impacts of air pollutant mixtures on health and welfare, including for at-risk populations, and to support enhanced air quality monitoring networks.

Dr. Jonathan M. Samet, M.D., Chair, Clean Air Scientific Advisory Committee
Professor and Chair, Department of Preventive Medicine, University of Southern California, Los Angeles, CA

From FY2009 to FY2012, the CASAC provided advice on various stages of the NAAQS process for all six criteria air pollutants. CASAC also provided advice on air quality modeling and monitoring networks, including near-road monitoring of nitrogen dioxide and other pollutants, re-engineering of EPA's network of photochemical assessment monitoring stations, and approaches to develop a new federal

reference method for lead in total suspended particulates. Highlights of CASAC advice on criteria air pollutants include:

- **Particulate Matter*:*** Particulate matter (PM) is a mixture of microscopic solids and liquid droplets in air that are emitted by sources (including construction sites, unpaved roads, smokestacks and fires) or formed by chemical reactions in air of chemicals emitted by power plants, industries and automobiles. When inhaled, these small particles are associated with a variety of human health effects, including premature mortality and development of chronic respiratory disease. The CASAC agreed with the agency's current focus on risks associated with exposure to fine particles where the evidence for causality is strongest. The CASAC recommended future research on the health effects of other size fractions of PM and on components of the PM mixture, which can have different effects on health and welfare including effects on climate. The CASAC supported a secondary PM standard based on outdoor visibility, but recommended that future secondary standards consider a broader set of ecosystem and environmental impacts of PM.

- **Oxides of Nitrogen (Primary Standard):** Nitrogen oxides (NO_x) from vehicle emissions and other sources contribute to formation of ground-level ozone, which impairs lung function and exacerbates asthma and other respiratory conditions. To protect susceptible populations from short-term adverse health effects, the CASAC supported the agency's proposal to establish a new 1-hour NAAQS standard to supplement the existing annual standard. The CASAC also supported EPA's plans to establish requirements for an NO_2 monitoring network that will include monitors near major roadways in addition to monitors sited to measure the area-wide NO_2 concentrations that occur more broadly across communities.

- **Oxides of Sulfur (Primary Standard):** Exposure to sulfur oxides (SO_x), primarily emitted from burning of fossil fuels to generate electricity, causes adverse respiratory effects for susceptible individuals such as asthmatic children. The CASAC agreed that the information in the ISA and the REA, which used exposure data from 40 urban areas, supported the need for a 1-hour sulfur dioxide standard to protect public health. The CASAC also agreed that the existing 24-hour and annual standards were not adequate to protect public health, especially in relation to short term exposures to sulfur dioxide by exercising asthmatics. In 2010, the agency issued a new, more protective, 1-hour standard for sulfur dioxide to replace the previous 24-hour and annual standards.

- **Oxides of Nitrogen and Oxides of Sulfur (Secondary Standard):** In addition to health effects, oxides of nitrogen (NO_x) and oxides of sulfur (SO_x) have adverse impacts on public welfare. Nitrogen deposition from air contributes to water quality impairment and the formation of "dead zones" where dissolved oxygen levels are too low to support aquatic life. Sulfur oxides and nitrogen oxides also contribute to acid rain, which causes damage to building surfaces, forests and some aquatic systems. The CASAC in 2009 reviewed the science and exposure assessment for NO_x and SO_x, and in 2011 reviewed the policy assessment for a NO_x/SO_x secondary standard. For the first time, the EPA undertook a joint assessment of these criteria air pollutants because they, and their transformation products, are linked in terms of atmospheric chemistry and environmental effects.

The CASAC supported the agency's first effort to develop an integrated NO_x/SO_x secondary standard based on the ecological impacts of these pollutants, including direct effects of exposure to gaseous NO_x/SO_x on vegetation and deposition-related effects such as acidification and nutrient enrichment in aquatic ecosystems. While recognizing that EPA's current regulatory authority focuses on nitrogen oxides, the CASAC urged the agency to consider deposition of all forms of reactive nitrogen (Nr) in its science assessment for the secondary standard. EPA's policy assessment considered a novel NO_x/SO_x secondary standard based on an Atmospheric Acidification Index (AAI) that would integrate the combined effects of NO_x and SO_x deposition on aquatic acidification. The CASAC found that the AAI provided a framework for developing a secondary standard that linked ambient concentrations to aquatic deposition effects on a regional basis and the committee agreed with the agency's proposal to explore this approach.

Dr. Armistead (Ted) Russell, Chair, CASAC NO_x/SO_x Secondary NAAQS Review Panel
Professor, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA

- **Ozone:** In March 2008, the EPA issued a final NAAQS for ozone with 8-hour standards of 0.075 ppm for both public health and welfare, a level higher than the range previously recommended by the CASAC. In an April 2008 letter to then-EPA Administrator Johnson, the CASAC strongly urged the agency to consider a more protective standard during the next review cycle for the ozone NAAQS, and a secondary (welfare) standard based on cumulative seasonal exposures rather than the 8-hour daily average used for the primary (health-based) standard. For the current NAAQS review, the CASAC reviewed drafts of the ISA and concluded that substantial new evidence since the 2008 NAAQS supports upgrading the findings about the strength of causality between ozone exposure and short-term and long-term health effects, and further clarifies ozone impacts on vegetation and on radiative forcing and climate change.

- **Carbon Monoxide:** During reviews of the EPA draft ISA and REA for carbon monoxide (CO), the CASAC advised the agency to focus on susceptible and vulnerable populations and to expand the health effects considered. The CASAC expressed concern that the existing CO monitoring network may be underestimating human exposures because of the location and detection limit of current monitors. For the EPA policy assessment, the CASAC cautioned the agency not to ignore contemporary epidemiological studies, especially those directed at cardiovascular disease associated with carbon monoxide exposure. Because the scientific evidence shows that effects are associated with levels below the current CO NAAQS, the CASAC recommended that the agency consider lowering the standards to protect public health with an adequate margin of safety.

- **Lead:** The CASAC reviewed drafts of the ISA for lead and recommended ways that the EPA could strengthen the weight-of-evidence assessments for the relationship between adverse health effects and lead exposure in children and adults, and for ecological effects of lead bioaccumulation as it affects ecosystem services. The CASAC recommended that the agency develop a sampler for lead compliance monitoring that is better than the currently deployed high-volume total suspended particulate (TSP) sampler.

Evaluating Residual Risks from Hazardous Air Pollutants

The Clean Air Act requires the EPA to regulate emissions of hazardous air pollutants (HAPs) from stationary sources by developing standards based on the maximum achievable control technology, and to assess health and environmental risks that remain after these technology-based controls have been applied. HAPs include air pollutants such as mercury, dioxin and radionuclides. In 2009, the EPA asked the SAB to review draft approaches for assessing these "residual risks," as illustrated in two case studies: petroleum refineries and Portland cement manufacturing facilities. The SAB found the case studies extremely valuable in illuminating the strengths and limitations of the EPA's proposed residual risk estimation methodology. The SAB found emissions estimates to be one of the most critical inputs to residual risk assessment and an important area needing improvement, noting that emissions reported to the National Emissions Inventory may be an underestimation. In the particular case of radionuclides from Portland cement facilities, isotope-specific emissions information was needed to support the risk assessment. The SAB supported EPA's use of dose-response values from the agency's Integrated Risk Information System (IRIS) and strongly recommended that toxicity values be developed for all HAPs insofar as the data permit. The case studies also illustrated the difficulty in assessing risks from facilities (such as petroleum refineries) that fall into more than one regulatory source category.

Benefits and Costs of Clean Air Act Programs

The Clean Air Act (CAA) Amendments of 1990 required the EPA to conduct a cost-benefit analysis of the impacts of CAA programs on the public health, economy and environment of the United States. The CAA Amendments also called for establishment of the Advisory Council on Clean Air Compliance Analysis (the Council) to review the data, analyses and reports developed by the agency. The Council provided technical advice and review to the agency in over a dozen advisory reports during the 10-year period of the EPA effort to develop the Second Prospective Study of benefits and costs of the Clean Air Act from 1990 to 2020. The Council provided early advice on the agency's plans for estimating emissions and assessing health effects and reviewed draft analyses of air quality scenarios, health and ecological effects, and economic costs and benefits of projected future reductions in air pollution. In March 2011, EPA released the Second Prospective Study estimating the benefits and costs of the 1990 Clean Air Act Amendments, concluding that benefits exceeded costs by a wide margin.

The EPA's Second Prospective Study of the benefits and costs of the Clean Air Act is ambitious in scope, incorporates advances in methods for analysis of the benefits and costs of environmental regulation and should have significant impact on public understanding of the role that the 1990 Clean Air Act Amendments have played in improving our environment and quality of life. The study demonstrates that estimated benefits far exceed costs. The great majority of these benefits are attributed to reduced premature mortality due to lower ambient concentrations of fine particulate matter. The Council noted that, even without considering projected human health benefits, the value of improvements in visibility and crop and forest yields exceed the estimated costs of compliance with CAA provisions. The Council recommended that the EPA stimulate research on methods to quantify additional effects of air quality regulations, including effects of other pollutants (notably Hazardous Air Pollutants) and effects on ecosystems, agriculture, forestry and construction materials.

Dr. James K. Hammitt, Chair, Advisory Council on Clean Air Compliance Analysis (FY 2009 – 2010)
Professor, Center for Risk Analysis, Harvard University, Boston, MA

Taking Action on Climate Change

Assessing the Role of Black Carbon

Black carbon is a mixture of light-absorbing particles that results from incomplete combustion of organic materials such as petroleum fuels or biomass. Scientific studies have shown that these particles, which are a component of particulate matter, have both warming and cooling effects on climate, as well as direct impacts on human health. In 2009, Congress directed the EPA, in consultation with other federal agencies, to summarize the available science on the impacts of black carbon on climate, sources of black carbon emissions, benefits to climate and human health from reductions in those emissions and the cost-effectiveness of available mitigation strategies. The EPA requested the Council to review the draft EPA document, *Report to Congress on Black Carbon,* with respect to its accuracy and clarity in summarizing the available scientific literature, including uncertainties. The Council, augmented with experts in chemistry, modeling and control of black carbon, found that the report summarized much of the relevant scientific literature on the nature of black carbon particles; their formation, transformation and transport in the atmosphere; associated climate and health impacts; and possible mitigation technologies. Nonetheless, the Council recommended that the EPA include a more rigorous treatment of benefits and costs and associated uncertainties of black carbon mitigation options to inform policy. The agency issued the final EPA *Report to Congress on Black Carbon* in March 2012.

Black carbon deposited on snow and ice absorbs sunlight which warms the surface and increases melting.

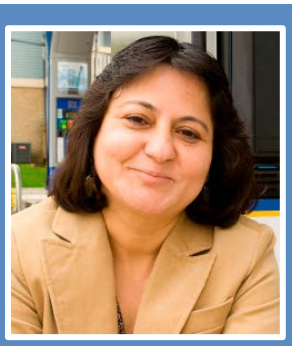
Based on current scientific evidence, the Council agreed that black carbon appears to warm climate and that reductions in black carbon emissions would produce both health and climate benefits. The Council further agreed that black carbon reductions, which could produce climate benefits in the short term, should not be viewed as a substitute for needed reductions in long-lived greenhouse gases (including carbon dioxide and methane) over the long term.

Dr. C. Arden Pope, III, Chair, Advisory Council on Clean Air Compliance Analysis (FY 2011 – 2012)
Mary Lou Fulton Professor of Economics, Department of Economics, Brigham Young University, Provo, UT

Accounting Framework for Biofuels Carbon Emissions from Stationary Sources

EPA has undertaken efforts under the Clean Air Act to regulate emissions of carbon dioxide and other greenhouse gases after finding that these pollutants threaten the public health and welfare of current and future generations. As part of that process, the EPA developed a draft accounting framework for biogenic carbon emissions from stationary sources to support policy analysis of net greenhouse gas emissions from facilities that use biomass fuels.

Biogenic carbon dioxide emissions are defined as emissions from a stationary source directly resulting from the combustion or decomposition of biofuels, i.e., biologically based materials other than fossil fuels. A portion of the released carbon represents modern carbon taken up during growth of the feedstock (plants or microbes that compose the biofuel) in contrast to long-stored carbon contained in fossil fuels. The SAB was asked to evaluate EPA's framework in the context of the carbon cycle and to consider the extent to which onsite carbon emissions from stationary sources should be adjusted to account for changes in off-site terrestrial carbon stocks (in soils, plants, and forests) using a "biogenic accounting factor."



The SAB recognized the difficulties in assessing the greenhouse gas implications of using biomass to produce energy. The methods for estimating these impacts will differ depending on the nature of the biogenic feedstocks. Some feedstocks, such as woody forest biomass, have long growth and regeneration times and others, such as annual agricultural crops or crop wastes, have short rotation times. The estimation of net carbon emissions should consider the time path of emissions with and without the use of biomass for energy generation and should rely on accounting methods that are consistent with those used for fossil fuel emissions.

Scenarios also should reflect the interactions between electricity/fuel markets and agricultural and forestry markets, as well as market-driven shifts in planting, management and harvesting of biomass crops at landscape scales. The SAB recommended that the EPA consider developing default biogenic accounting factors for each feedstock category and region. Regardless of the approach adopted, the SAB recommended that the agency evaluate the costs of compliance and carbon emissions savings likely to be achieved as compared to categorically including or excluding all carbon emissions from burning of biomass at stationary sources.

Dr. Madhu Khanna, Chair, SAB Environmental Economics Advisory Committee (FY 2012)
Professor, Department of Agricultural and Consumer Economics, University of Illinois, Urbana, IL

Protecting America's Waters

Under the Clean Water Act, the EPA shares responsibility with the states for protecting the nation's waters from pollutant discharges. Risks to water quality are associated with various human activities, but a common thread for several water quality issues before the SAB in the last four years was managing impacts from energy development. Development of energy resources (e.g., coal, natural gas, oil and uranium) is vital to the U.S. economy, including for electricity generation (Figure 1), but this development requires careful environmental management to avoid impacts to public health and the environment. The SAB provided advice on EPA's assessment of potential impacts to water quality of mountaintop coal mining, hydraulic fracturing of subsurface formations to release natural gas, and uranium mining. In addition, the SAB evaluated approaches to setting nutrient criteria for coastal waters, treatment options for ship ballast water to guard against introduction of non-native species into U.S. waters and provided advice on assessment of risks to drinking water.

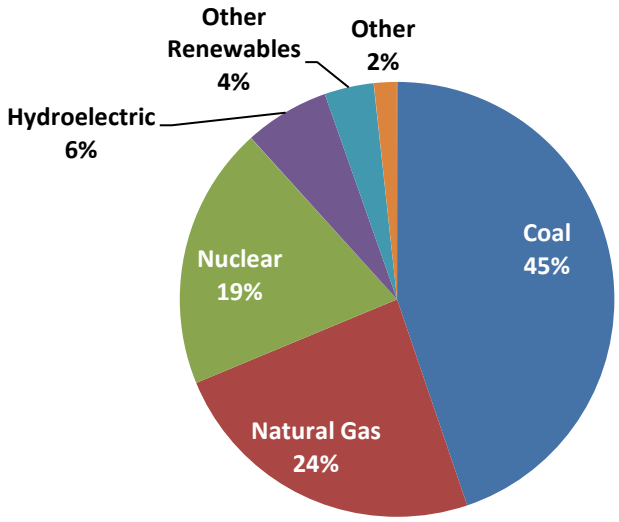
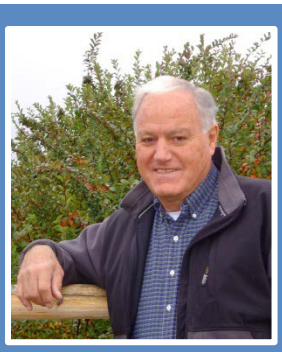


Figure 1. Fuels Used for Electricity Generation in the U.S. in 2010 (Data from U.S. Energy Information Agency)

Advice on Maintaining Stream Health at Mountaintop Mining Sites

Mountaintop coal mining requires the removal of a large volume of crushed rock which is disposed of in adjacent valleys, covering over headwater streams. Waters flowing out of these valley fills may have elevated levels of dissolved ions (primarily salts of sulfate or bicarbonate) that can be harmful to aquatic life in receiving streams. The SAB was asked to evaluate the state of the science on the ecological impacts of mountaintop mining on streams in the Central Appalachian Coal Basin. The SAB also was asked to evaluate an approach for developing an aquatic life benchmark for conductivity, a surrogate measure of total ion concentration in waters, that would protect 95 percent of native genera in Appalachian streams impacted by mountaintop mining and valley fills. The draft EPA technical document proposed an aquatic life benchmark for conductivity of 300 microsiemens per centimeter (µS/cm) in streams of a mountaintop mining region in West Virginia and Kentucky. Following the SAB

review, the EPA issued final guidance in July 2011 suggesting that EPA Regions and states work to assure that discharges from surface coal mining operations in West Virginia and Kentucky are generally not above 300-500 µS/cm.



The SAB applauded the EPA's use of a field-based approach to develop a conductivity benchmark to protect aquatic communities from impacts associated with mountaintop mining. The SAB concluded that the substantial data set from West Virginia and Kentucky provided clear evidence that valley fills are associated with increased levels of dissolved ions (measured as conductivity) in downstream waters, and that these increased levels of conductivity are associated with loss of stream biodiversity. While agreeing that the approach could be applied in other areas with sufficient field data, the SAB cautioned the agency not to apply the benchmark value in areas outside the geographic coverage of the current data set, without additional validation.

Dr. Duncan T. Patten, Chair, SAB Mountaintop Mining Panel
Research Professor and Director, Montana Water Center, Montana State University, Bozeman, MT

Advice on Assessing the Potential Impacts of Hydraulic Fracturing

Hydraulic fracturing (also known as "fracking") is a process whereby water, chemicals and sand are injected at high pressure into subsurface geologic formations to fracture the formations and release oil and/or natural gas for energy use. Over the past decade, the practice increasingly has been used to extract natural gas from shale formations, raising concerns about its potential environmental and health impacts. In response to a Congressional directive, in 2010 the EPA developed a proposed research plan to study the impacts on drinking water resources from all stages of the fracturing process. The SAB was asked to comment on a research scoping document and a draft study plan for hydraulic fracturing. The SAB agreed with the proposal to use available data in conjunction with a handful of retrospective and prospective case studies chosen to represent the range of regional variability of hydraulic fracturing across the nation.

The SAB recommended that the EPA use available data to understand toxicity of selected constituents in hydraulic fracturing fluids, and to focus on potential human exposure to fracking liquids and potential groundwater contamination. The SAB also urged the agency to refine research questions pertaining to environmental justice issues, using demographic information to screen whether hydraulic fracturing disproportionately impacts some citizens near the case study sites. While acknowledging the Congressional directive to focus on drinking water impacts, the SAB noted that longer term research should consider the impacts of hydraulic fracturing on aquatic resources more broadly, including their ability to support fishing and recreation.

Dr. David A. Dzombak, Chair, SAB Hydraulic Fracturing Study Review Panel
Professor of Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA

Advice on Monitoring at Uranium Mining Sites

Uranium is used to fuel nuclear power plants, which account for approximately 20 percent of U.S. electricity generation (see Figure 1), and there are a number of active uranium mines in the United States. The EPA is considering the need to update environmental protection standards for uranium mining, to reflect the growth of a technology for *in-situ* leaching (ISL) of uranium from underground ore bodies. In the ISL process, an extraction fluid is pumped underground through a set of injection wells to solubilize uranium, is retrieved at a central extraction well, and is then processed to remove the uranium and recycle the fluid back into the ground for further uranium extraction. The SAB was asked to provide advice on the design and implementation of groundwater monitoring networks at ISL mining sites, including wells within the production area to compare post- and pre-operational groundwater quality, and wells outside the mine production area to detect possible movement of the leachate solution beyond the production zone.

The SAB concluded that the EPA draft technical report on groundwater monitoring at ISL uranium mines included the relevant considerations, but that much more detail was needed in order to develop monitoring standards. In particular, the SAB recommended that EPA compile and analyze the extensive monitoring data available for ISL uranium mines; apply environmental models to predict the rates at which groundwater constituents approach stable conditions after mining operations cease; describe systematic approaches for determining the optimal number, location, and sampling frequency of monitoring wells; and specify criteria for selecting groundwater contaminants (including radiological and non-radiological constituents) as priorities for monitoring.

Dr. Bernd Kahn, Chair, SAB Radiation Advisory Committee
Professor Emeritus and Associate Director, Envir. Radiation Center, Georgia Inst. of Technology, Atlanta, GA

Water Quality Criteria for Nutrients

Excess nutrient pollution from wastewater, air deposition or runoff from the land remains a leading cause of impairment of water quality and contributes to “dead zones” where dissolved oxygen levels are too low to support aquatic life. The EPA develops guidance and water quality criteria for nutrients (nitrogen and phosphorus) in the nation’s waters, and is working with states to get numeric (rather than narrative) nutrient criteria in place. In 2009, the SAB reviewed the agency’s draft guidance on empirical approaches for deriving nutrient criteria. An empirical stressor-response approach was proposed to quantify the relationship between nutrient concentrations and biological response measures related to the designated use of a waterbody (e.g., drinking water supply, shellfish harvesting, fish and wildlife propagation). The guidance complemented previous EPA guidance on the use of reference conditions for deriving nutrient criteria from distributions of nutrient concentrations and biological responses in minimally disturbed reference waterbodies, and mechanistic modeling to predict the effects of changes in nutrient concentrations using site-specific parameters and equations that represent ecological

processes. The SAB agreed that biologically relevant statistical associations are an important part of a weight-of-evidence approach to establishing nutrient levels that will protect aquatic designated uses. The SAB also reviewed the agency's proposed application of these three approaches for establishing numeric nutrient criteria for waters in southern Florida and in Florida's coastal waters. The EPA has delayed finalizing federal nutrient criteria for Florida coastal and estuarine waters to allow the state to adopt its own numeric limits with a FY2013 target date.

To guide its development of nutrient criteria for Florida estuaries and coastal waters, the EPA proposed a conceptual model that links nitrogen and phosphorus levels in Florida waters to healthy sea grasses, balanced phytoplankton biomass, and balanced faunal communities. Nitrogen and phosphorus may be limiting in different portions of the fresh-to-marine continuum, and in some cases may be co-limiting. Thus, a dual nutrient (nitrogen and phosphorus) strategy is warranted and the SAB agreed with the decision to take this approach. The SAB also recommended that the agency move beyond measures of dissolved oxygen and chlorophyll-a in waters to include direct measures of sea grasses and faunal communities to be protected by the criteria.

Dr. Judith L. Meyer, Chair, SAB Nutrient Criteria Review Panel
Professor Emeritus, Odum School of Ecology, University of Georgia , Athens, GA

Technologies to Treat Ballast Water Discharges

Large ships, including ocean-going tankers and cargo vessels that traverse the Great Lakes, take on and discharge ballast water to compensate for changes in vessel draft and stability as cargo is loaded or unloaded at ports of call. Ballast water contains live organisms and, when discharged, often is a source of non-native species that can alter existing aquatic communities. As the EPA considered changes to its Clean Water Act general permit for discharges from vessels, the SAB was asked to evaluate the effectiveness of existing technologies for shipboard treatment of vessel ballast water. The question at hand was whether existing technologies were sufficient to ensure that ballast water could meet standards for low or no organism concentrations in ballast water discharge. The SAB reviewed information on 51 existing or developmental ballast water management systems provided by the EPA and the public, although detailed data were available for only 15 systems. The Board concluded that a handful of available onboard systems could meet the initial standard proposed by the U.S. Coast Guard, but that existing systems were unlikely to achieve much more stringent or "no organism" standards. Rather than relying solely on a numeric standard, the SAB recommended that the EPA adopt a risk-based approach—including ballast water management, operational adjustments and changes in ship design—to minimize the impacts of invasive species in vessel ballast water discharges.

Lead exposure can cause adverse health effects, including impaired neurodevelopment in children and hypertension and cardiovascular disease in adults. EPA regulates lead levels in drinking water by setting an action level above which water systems must take certain measures. One option is to replace a portion of drinking water service lines in the affected area. In 2011, the SAB was asked to evaluate the available scientific data on whether this approach was effective for resolving elevated exposures to lead in tap water. Although available data were limited, the SAB concluded that partial lead service line replacement was not an effective remedy and actually resulted in elevated levels of lead in tap water for a period of time. The data suggested the potential for harm, as demonstrated by increased blood lead levels in children, rather than benefit in the short term.

Dr. Jeffrey K. Griffiths, Chair, SAB Drinking Water Committee (FY2010 – 2012)
Professor of Public Health and Medicine, School of Medicine, Tufts University, Boston, MA

Protecting Drinking Water

Risks to drinking water quality come in the form of both biological and chemical pollutants. The SAB was asked to evaluate the process for identifying contaminants to include on the third Contaminant Candidate List (CCL) for possible regulatory action under the Safe Drinking Water Act. The SAB concluded that the prioritization and selection process needed to be much more clearly described and the list of 114 contaminants (which included both chemicals and microbial contaminants) was too large to communicate which contaminants might – or might not—be considered for action. The SAB recommended that priority be given to contaminants with a higher degree of certainty about their toxicity, occurrence and treatability. The SAB also provided advice on microbial risks and lead in drinking water.

The SAB reviewed the EPA's proposal to address microbial risks in drinking water by revising the Total Coliform Rule. The rule was revised to move from just reporting violations of a Maximum Contaminant Level to a "find-and-fix" approach where positive E. coli or coliform bacteria monitoring results would prompt an assessment and correction of causes of the sanitary defect. The SAB recommended that the agency consider select pathogen monitoring and alternative indicators in addition to total coliform, and that EPA require more frequent monitoring than proposed in the Agreement in Principle developed by a committee of stakeholders.

In a separate review, the SAB recommended enhancements to the agency's draft white paper on microbial risk assessment, noting that while it fell short of being a true protocol, it provided a valuable introduction to quantitative microbial risk assessment (QMRA). EPA has led a multi-agency task force on QMRA and future developments will provide a system to evaluate current and emerging microbial risks.

Dr. Joan B. Rose, Chair, SAB Drinking Water Committee (FY 2009)
Professor and Chair for Water Research, Dept. of Fisheries and Wildlife, Michigan State Univ. , E. Lansing, MI

Cleaning Up Communities

The SAB continued to support the EPA's efforts to help protect communities from the health and environmental effects of natural and man-made disasters. The SAB advised EPA on response planning for intentional releases of anthrax bacteria and made recommendations to enhance risk communication, both directly after emergencies and during post-disaster cleanup. The SAB also advised on plans to protect and restore the Great Lakes and to protect the public from exposure to lead dust in homes and buildings.

Great Lakes Restoration Initiative

In 2009, President Obama announced and Congress later appropriated $475 million in new funding for the Great Lakes Restoration Initiative (GLRI) to "protect and restore the chemical, biological, and physical integrity of the Great Lakes." To guide the restoration efforts of the GLRI, the EPA and an interagency task force developed a multi-year Action Plan that identified goals, objectives, ecological targets, and specific actions to respond to chemical and biological pollution as well as to restore habitats and protect wildlife. The SAB was asked to review the Action Plan's adequacy to accomplish the GLRI's remediation and restoration goals and provide accountability for program funds and results.

The SAB agreed that enough is known about the issues confronting the Great Lakes, as well as the underlying causes and potential remedies, to initiate action and found that the Action Plan identified most of the important actions that should be taken. To strengthen the scientific basis for future efforts under the program, the SAB recommended that the EPA and its interagency partners develop an integrated science framework, develop peer review criteria for program outputs, and establish a standing science panel to provide input on design, implementation, monitoring and evaluation efforts.

Dr. James Sanders, Chair, SAB Panel on the Great Lakes Restoration Initiative Action Plan Review
Director and Professor, Skidaway Institute of Oceanography, Savannah, GA

Advice on Lead Dust Standards in Buildings

Human exposure to lead may cause a variety of adverse health effects, particularly in children. Under the Toxic Substances Control Act, the EPA sets hazard standards to identify dangerous levels of lead in paint, dust and soil. In 2010, the SAB was asked to review EPA's proposed approach to revise hazard standards for lead dust on floors and windowsills of homes and to set standards for public and commercial buildings, including daycare facilities. The agency used empirical and biokinetic modeling to predict blood lead concentrations associated with different candidate lead dust standards. The SAB recommended that the agency select the lower levels to protect against adverse effects in children. Because the hazard standard is for dust, the SAB recommended that the analysis use an incremental risk

approach that would consider just the exposures from lead dust rather than total exposures including from air, water, soil and diet.

Economic Analysis

Updates to the Economic Analysis Guidelines

In 2009, the SAB was asked to comment on draft revisions to the EPA guidelines for preparing economic analyses of regulatory and non-regulatory environmental policies. The SAB applauded the agency's efforts to revise the guidelines, but recommended that additional guidance be provided on valuing the protection of ecological systems and services (including non-monetized benefits). The SAB also urged that the guidelines anticipate the changing role for economics with respect to climate change and other global processes, noting the daunting analytical challenges associated with forecasting greenhouse gas emissions under various policy scenarios and valuing mitigation options. The revised final EPA guidelines were released in December 2010.

Valuing Risk Reduction

Reductions in mortality risk often are the largest quantifiable category of benefits associated with EPA rules and regulations. As such, mortality risk estimates — society's willingness to pay for small changes in risk — are an important input to the EPA's benefit-cost analyses. In 2010, the SAB was asked to comment on an EPA draft white paper on valuing mortality risk reductions for environmental policy, in which EPA proposed to replace the "value of statistical life" (VSL) terminology.

The SAB agreed that the term VSL often has been misinterpreted, and recommended a term like "value of risk reduction" which would better communicate the notion that value is derived from reducing risks rather than from the risks themselves. In addition, the SAB strongly endorsed the agency's proposal to update its estimates of value of risk reduction, many of which depend on studies that are twenty or more years old, and recommended criteria for selecting studies to include in EPA's database of mortality risk reduction values. The SAB encouraged the agency to devote resources to research on valuing children's risk reductions since current estimates are based on adults.

Dr. Catherine L. Kling, Chair, SAB Environmental Economics Advisory Committee (FY 2009 – 2011)
Professor, Department of Economics, Iowa State University, Ames, IA

Risk Assessment

The EPA requested advice on a range of risk assessment issues, including proposals to strengthen ecological risk assessment; to estimate human health risks from radionuclides, mercury, and asbestos fibers; and to characterize uncertainties.

Advice on the Use of Expert Elicitation

Scientific uncertainty is a fact of life. Whether extrapolating evidence from one location to another, from one species to another, or from effects of single chemicals to effects of those chemicals combined in a mixture, EPA decision-makers often must act using the best available information, with knowledge of the uncertainties. The SAB, CASAC and Council consistently recommend that EPA technical analyses characterize the nature of uncertainties to inform agency managers and the public. In 2009, the SAB was asked to review an EPA draft white paper on the potential use of expert elicitation (EE), an approach to characterize uncertainties by seeking the informed judgments of relevant experts. The SAB found the white paper to be a comprehensive overview of expert elicitation, its strengths and limitations, and issues relevant to its use at the EPA. The SAB recommended that EE be compared to other methods for aggregating information (including meta-analysis and expert committees), that EPA consider methods to evaluate and ensure the quality of elicited judgments, and discuss whether and how to combine judgments across experts. The SAB encouraged the agency to continue to explore the use of EE, to support research on the performance of EE and alternative approaches, and to conduct additional studies to evaluate the potential use of EE at the EPA.

Estimating Radiogenic Cancer Risk

Naturally occurring sources of ionizing radiation, referred to as background radiation, include radon gas, radioactive materials in rocks and soils, and cosmic radiation. Other sources of exposure include medical or dental X-rays and nuclear medicine, and production of electricity from coal or nuclear power. The EPA is the primary federal agency charged with protecting people and the environment from harmful and avoidable exposure to radiation. In 2008, the EPA proposed to update its radiogenic cancer risk models and projections for risks due to low doses of ionizing radiation for the U.S. population (the “Blue Book”). Estimates of cancer risk are based primarily on epidemiological data from atomic bomb survivors at Hiroshima and Nagasaki, patients exposed to medical radiation, and studies of radiologists and nuclear workers exposed to low levels of radiation over extended periods. EPA uses its risk assessment results to set protective limits on radioactive emissions to air, water and soil, and to develop guidance for cleaning up radioactively contaminated Superfund sites. The SAB reviewed the draft revised Blue Book and found it impressively researched and scientifically sound. The SAB supported the agency’s use of an improved model that considers the survival rate of breast cancer patients and agreed that nonfatal skin cancer risk estimates should be addressed separately to avoid distorting the overall cancer morbidity and mortality risk estimates.

Ecological Assessments

In response to recommendations in a 2007 SAB Report, *Advice to EPA on Advancing the Science and Application of Ecological Risk Assessment in Environmental Decision-Making*, the EPA Risk Assessment Forum held an EPA ecological assessment colloquium and developed an action plan for integrating ecological assessment and decision-making at EPA. The action plan proposed a set of science policy and technical practice initiatives to improve the quality, scope, and application of EPA's ecological assessments. EPA's Office of the Science Advisor requested the SAB to provide advice on the technical merit and implementation of proposed initiatives. The SAB found that the proposed actions in the plan are responsive to previous SAB recommendations and that the plan is a solid starting point for EPA's efforts to integrate ecological risk assessment and decision-making. The SAB encouraged the agency to continue to develop more detailed plans for enhancing EPA ecological assessments.

The SAB concluded that three of the initiatives in the EPA ecological assessment action plan may have the greatest likelihood of advancing the agency's goals in the near term: guidance on using weight-of-evidence approaches in ecological risk assessments; methods to improve communication of ecological assessment issues and results to decision-makers; and guidance on incorporating ecosystem services into ecological risk assessment methods. The SAB encouraged the EPA to incorporate input and perspectives from other entities, including other U.S. natural resource agencies, other countries, nongovernmental organizations and social scientists as it elaborates the current brief action plan into more detailed project plans.

Dr. Ingrid Burke, Chair, SAB Ecological Processes and Effects Committee
Director, Haub School of Environment and Natural Resources, University of Wyoming, Laramie, WY

National-Scale Mercury Risk Assessment

The SAB was asked to review the agency's draft risk assessment for mercury emitted from electricity generating units (EGU). Coal contains small amounts of mercury and this mercury is released to the air when coal is burned at power plants. The risk assessment used air quality modeling to estimate mercury transport and deposition to watersheds and evaluated the potential health impacts of resulting concentrations of methylmercury in freshwater fish consumed by subsistence fisher populations. The SAB found that the analyses were appropriate to support a national-scale determination of hazards to public health from EGU mercury emissions, given the limited data, but recommended that the final risk assessment provide critical missing details about both the analytical methods and the results.

IRIS Toxicology Assessments

The EPA's Integrated Risk Information System (IRIS) is an online database containing EPA assessments of the potential human health risks from long-term exposure to environmental contaminants. The IRIS assessments are based on a synthesis of available scientific studies with opportunities for public comment. The EPA has sought advice for IRIS assessments from both the National Academy of Sciences and the SAB, and on several occasions has asked the SAB to evaluate the agency's responsiveness to NAS comments. During 2009 to 2012, the SAB reviewed EPA's toxicological assessments for four priority IRIS chemicals: acrylamide; trichloroethylene (TCE); inorganic arsenic; and dioxin. The SAB also was asked to review an approach to estimating cancer risk for a mixture of compounds (polycyclic aromatic hydrocarbons), a step forward from traditional chemical-by-chemical assessments.

In response to recommendations from the National Research Council in 2011, the agency committed to improvements in the IRIS program to streamline assessment documents, discuss how scientific studies were selected for derivation of toxicity values, and weigh the overall evidence for each human health effect. In addition, the EPA is forming a new Chemical Assessment Advisory Committee (CAAC) under the auspices of the SAB to coordinate SAB reviews of IRIS chemical assessments in coming years.

The EPA proposed an approach to estimating the cancer risk for polycyclic aromatic hydrocarbon (PAH) mixtures by summing doses of component PAHs after scaling the doses relative to the potency of an index PAH (i.e., benzo[a]pyrene, or BaP). Given the current lack of mixtures data, the SAB agreed with the agency's practical decision to use a relative potency, rather than whole mixtures, approach to assess cancer risk from PAH mixtures and supported the use of BaP as the index PAH. The SAB urged the agency to complete the revision of the IRIS assessment for BaP so that an updated cancer slope factor for BaP would be available. The SAB also recommended that the EPA pursue a whole mixtures approach, which could validate the relative potency approach and potentially replace it in the future.

Dr. Nancy Kim, Chair, SAB PAH Mixtures Review Panel
Program Specialist, Health Research, Inc., Troy, NY

Concluding Remarks from the SAB Director

It has been my privilege to work with the many advisors who have served on the SAB, CASAC and Council over the past four years. I thank them for their dedicated service to the EPA. Without them, the advice highlighted in this *Accomplishments Report* would not have been possible. During this period, the agency benefitted from the advice of hundreds of nationally renowned, independent experts working under the auspices of the three chartered committees, who provided advice to the EPA on a wide range of science issues.

I thank the many members of the public who provided valuable technical comments and helped us strengthen public involvement in the advisory process. Public nominations of expert candidates and comments on candidates under consideration were vital to the EPA's establishment of advisory committees and peer review panels.

Last, but not least, I thank my staff whose efforts made possible the body of work summarized in this report. The SAB Staff Office provided exceptional technical and administrative support to the committees and their panels as they conducted nearly 250 public meetings and prepared over 100 advisory reports. The Staff Office held the advisors to high federal standards for ethics and conflict of interest to ensure the credibility of advice from the committees.

I take pride in the fact that the SAB Staff Office went beyond the FACA requirements to enhance public involvement in activities of the SAB, CASAC and Council and to ensure a robust and transparent discussion of the technical issues before the committees.

Vanessa T. Vu, Ph.D.
Director, Science Advisory Board Office

SAB Staff Office, FY 2009 to 2012

Dr. Vanessa Vu, *Director*
Dr. Anthony Maciorowski, *Deputy Director (2009-2011)*
Mr. Thomas Brennan, *Deputy Director (2012)*

Dr. Thomas Armitage, *Environmental Scientist*

Ms. Kyndall Barry, *Environmental Scientist*

Ms. Wanda Bright, *Ethics Official*

Ms. Lisette Brooks, *Management Analyst*

Mr. Thomas Carpenter, *Biologist*

Ms. Alisa Fisher, *Management Analyst*

Dr. Iris Goodman, *Biologist*

Mr. Edward Hanlon, *Environmental Scientist*

Dr. K. Jack Kooyoomjian, *Environmental Engineer*

Mr. Thomas Miller, *Environmental Scientist*

Dr. Angela Nugent, *Environmental Protection Specialist*

Ms. Carolyn Osborne, *Management Analyst*

Ms. Diana Pozun, *Management Analyst*

Dr. Resha Putzrath, *Physical Scientist*

Ms. Debra Renwick, *Management Analyst*

Dr. Marc Rigas, *Physical Scientist*

Dr. Ellen Rubin, *Environmental Scientist*

Ms. Stephanie Sanzone, *Physical Scientist*

Dr. Suhair Shallal, *Environmental Scientist*

Dr. Holly Stallworth, *Economist*

Ms. Patricia Thomas, *Management Analyst*

Ms. Priscilla Tillery-Gadson, *Information Management Specialist*

Ms. Vivian Turner, *Environmental Scientist*

Ms. Kathleen White, *Environmental Engineer*

Ms. Mary Winston, *Management Analyst*

Dr. Diana Wong, *Toxicologist*

Mr. Aaron Yeow, *Physical Scientist*

Membership on Chartered Committees and SAB Standing Committees, FY 2009 to 2012

Alberini, Anna
Associate Professor
University of Maryland
College Park, MD
SAB Environmental Economics Advisory Committee (FY 2009)

Alexeeff, George
Director
CA Environmental Protection Agency
Oakland, CA
BOARD (FY 2011-2012)
SAB Drinking Water Committee
(FY 2010-2012)

Allen, David T.
Professor
University of Texas
Austin, TX
BOARD
(FY 2009-2012)

Allen, George A.
Senior Scientist
Northeast States for Coordinated Air Use Management (NESCAUM)
Boston, MA
CASAC
(FY 2011-2012)

Allen-King, Richelle
Professor and Chair
University at Buffalo
Buffalo, NY
SAB Ecological Processes and Effects Committee (FY 2009)

Alvarez, Pedro
Department Chair and
George R. Brown Professor of Engineering
Rice University
Houston, TX
BOARD
(FY 2012)

Amar, Praveen
Senior Advisor
Clean Air Task Force
Boston, MA
COUNCIL
(FY 2012)

Andersen, Melvin
Director
The Hamner Institutes for Health Sciences
Research Triangle Park, NC
SAB Exposure and Human Health Committee
(FY 2009)

Aneja,Viney
Professor
North Carolina State University
Raleigh, NC
SAB Environmental Engineering Committee
(FY 2009-2010)

Arvai,Joseph
Svare Chair in Applied Decision Research
University of Calgary
Calgary, Alberta
BOARD
(FY 2012)

Autenrieth, Robin L.
Senior Associate Dean for Academic Affairs, and
A.P. & Florence Wiley Professor III
Texas A&M University
College Station, TX
SAB Environmental Engineering Committee (FY 2009-2012)

Bailar,John
Scholar in Residence
The National Academies
Washington, DC
COUNCIL
(FY 2009-2011)

Bailey, Susan M.
Associate Professor
Colorado State University
Fort Collins, CO
SAB Radiation Advisory Committee
(FY 2009-2012)

Balbus, John
Senior Advisor for Public Health
National Institute of Environmental Health Sciences
Bethesda, MD
BOARD
(FY 2009-2010)

Bell, Michelle
Professor
Yale University
New Haven, CT
COUNCIL
(FY 2009-2012)

Benfield, Ernest F.
Professor of Ecology
Virginia Tech
Blacksburg, VA
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Benitez-Nelson, Claudia
Full Professor and Director
Marine Science Program
University of South Carolina
Columbia, SC
BOARD
(FY 2009-2012)

Benjamin, Mark
Professor
University of Washington
Seattle, WA
SAB Drinking Water Committee
(FY 2009-2012)

Biddinger, Gregory
Managing Director
Natural Land Management
Houston, TX
BOARD (FY 2009)

Borak, Thomas B.
Professor
Colorado State University
Fort Collins, CO
SAB Radiation Advisory Committee
(FY 2009 - 2012)

Borchardt, Mark
Director
Public Health Microbiology Laboratory
Marshfield Clinic Research Foundation
SAB Drinking Water Committee
(FY 2009-2010)

Boyle, Kevin
Professor and Department Head
Virginia Tech
Blacksburg, VA
COUNCIL
(FY 2011-2012)

Brain, Joseph D.
Cecil K. and Philip Drinker Professor of Environmental Physiology
Harvard University
Boston, MA
CASAC
(FY 2009-2011)

Brandt, Sylvia
Associate Professor
University of Massachusetts
Amherst, MA
COUNCIL
(FY 2010-2012)

Buckley, Timothy J.
Professor and Chair
The Ohio State University
Columbus, OH
BOARD
(FY 2009-2012)

Buck-Louis, Germaine
Chief and Senior Investigator
National Institutes of Health
Rockville, MD
SAB Exposure and Human Health Committee (FY 2009)

Buffler, Patricia
Professor of Epidemiology and
Dean Emerita
University of California
Berkeley, CA
BOARD
(FY 2011-2012)

Bui, Linda
Associate Professor
Brandeis University
Waltham, MA
COUNCIL
(FY 2010-2012)

Burke, Ingrid
Director
University of Wyoming
Laramie, WY
BOARD (FY 2011-2012)
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Burke, Thomas
Professor and
Jacob I. and Irene B. Fabrikant Chair in Health, Risk and Society
Associate Dean for Public Health Practice
Johns Hopkins University
Baltimore, MD
BOARD
(FY 2009-2012)

Burton, G. Allen
Professor and Director
University of Michigan
Ann Arbor, MI
SAB Ecological Processes and Effects Committee (FY 2009-2011)

Burtraw, Dallas
Senior Fellow
Resources for the Future
Washington, DC
COUNCIL
(FY 2009-2010)

Bus, James
Director of External Technology
The Dow Chemical Company
Midland, MI
BOARD
(FY 2009)

Chambers, Douglas B.
Vice President and Director of Risk & Radioactivity
SENES Consultants, Ltd.
Richmond Hill, Ontario
SAB Radiation Advisory Committee (FY 2012)

Chapman, Peter
Principal and Senior Environmental Scientist
Golder Associates Ltd.
Burnaby, British Columbia
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Chen, Celia
Research Professor
Dartmouth College
Hanover, NH
SAB Ecological Processes and Effects Committee (FY 2012)

Chen, Shih-Yew
Senior Environmental Systems Engineer
Argonne National Laboratory
Argonne, IL
SAB Radiation Advisory Committee
(FY 2009-2012)

Clements, William
Professor
Colorado State University
Fort Collins, CO
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Colford, John (Jack)
Professor
University of California
Berkeley, CA
SAB Drinking Water Committee
(FY 2009-2011)

Connolly, John P.
Senior Technical Advisor and
Principal Engineer
Anchor QEA, LLC
Montvale, NJ
SAB Environmental Engineering Committee (FY 2009-2012)

Conquest, Loveday
Professor
University of Washington
Seattle, WA
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Corcoran, George
Professor and Chairman
Wayne State University
Detroit, MI
SAB Exposure and Human Health Committee (FY 2009)

Cory-Slechta, Deborah
Professor
University of Rochester
Rochester, NY
BOARD (FY 2009-2010)
SAB Exposure and Human Health Committee (FY 2009-2010)

Cowling, Ellis B.
University Distinguished Professor
At-Large Emeritus
North Carolina State University
Raleigh, NC
CASAC
(FY 2009)

Crapo, James
Professor of Medicine
National Jewish Medical and Research Center
Denver, CO
CASAC
(FY 2009)

Cressie, Noel
Distinguished Professor of Mathematical and Physical Sciences
The Ohio State University
Columbus, OH
SAB Exposure and Human Health Committee (FY 2009)

Crittenden, John C.
Professor
Georgia Institute of Technology
Atlanta, GA
SAB Environmental Engineering Committee (FY 2009)

Daniel, Terry
Professor of Psychology and Natural Resources
University of Arizona
Tucson, AZ
BOARD
(FY 2009-2012)

Daston, George
Victor Mills Society Research Fellow
Procter & Gamble
Cincinnati, OH
BOARD
(FY 2010-2012)

Davidian, Marie
William Neal Reynolds Professor
North Carolina State University
Raleigh, NC
SAB Exposure and Human Health Committee (FY 2009-2012)

Davis, Faith G.
Professor and Chair
University of Alberta
Edmonton, Alberta
SAB Radiation Advisory Committee
(FY 2009-2012)

Denson, Costel
Managing Member
Costech Technologies, LLC
Newark, DE
BOARD
(FY 2010-2012)

Di Giulio, Richard
Professor
Duke University
Durham, NC
SAB Ecological Processes and Effects Committee (FY 2011-2012)

Diaz, Robert
Professor
College of William and Mary
Gloucester Pt., VA
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Diez-Roux, Ana
Professor of Epidemiology
University of Michigan
Ann Arbor, MI
CASAC
(FY 2012)

Dodd, Brian
Independent Consultant and Principal
BD Consulting
Las Vegas, NV
SAB Radiation Advisory Committee
(FY 2009)

Doering III, Otto C.
Professor
Purdue University
W. Lafayette, IN
BOARD
(FY 2009-2012)

Dourson, Michael
President
Toxicology Excellence for Risk Assessment
Cincinnati, OH
BOARD
(FY 2012)

Driscoll, Jr., Charles T.
Professor
Syracuse University
Syracuse, NY
COUNCIL
(FY 2009)

Ducoste, Joel
Professor
North Carolina State University
Raleigh, NC
SAB Drinking Water Committee
(FY 2009-2012)

Dzombak, David A.
Walter J. Blenko, Sr. University Professor of Environmental Engineering
Carnegie Mellon University
Pittsburgh, PA
BOARD (FY 2009-2012)
SAB Environmental Engineering Committee (FY 2009-2010)

Ehrenfeld, Joan
Professor
Rutgers University
New Brunswick, NJ
SAB Ecological Processes and Effects Committee (FY 2010-2011)

Eighmy, T. Taylor
Senior Vice President for Research
Texas Tech University
Lubbock, TX
BOARD (FY 2009-2012)
SAB Environmental Engineering Committee (FY 2009)

Elliott, Herschel
Professor
Pennsylvania State University
University Park, PA
SAB Environmental Engineering Committee (FY 2009-2012)

Emond, Claude
Adjunct Clinical Professor
University of Montreal
Montréal, Quebec
SAB Exposure and Human Health Committee (FY 2009-2012)

Fan-Cheuk, Anna
Chief
CA Environmental Protection Agency
Oakland, CA
SAB Exposure and Human Health Committee (FY 2011-2012)

Faustman, Elaine
Professor and Director
University of Washington
Seattle, WA
BOARD
(FY 2010-2012)

Fenner-Crisp, Penelope
Independent Consultant
North Garden, VA
SAB Drinking Water Committee
(FY 2009)

Fenske, Richard
Professor
University of Washington
Seattle, WA
SAB Exposure and Human Health Committee (FY 2009)

Fernandez, Ivan J.
Professor
University of Maine
Orono, ME
COUNCIL
(FY 2010-2012)

Field, R. William
Professor
University of Iowa
Iowa City, IA
SAB Radiation Advisory Committee
(FY 2009-2012)

Fischhoff, Baruch
Howard Heinz University Professor
Carnegie Mellon University
Pittsburgh, PA
BOARD
(FY 2009)

Flores, Nicholas
Professor
University of Colorado
Boulder, CO
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Ford, Russell
Deputy Global Service Leader for Drinking Water Infrastructure
CH2M HILL
Parsippany, NJ
SAB Drinking Water Committee
(FY 2011-2012)

Franzblau, Alfred
Professor
University of Michigan
Ann Arbor, MI
SAB Exposure and Human Health Committee (FY 2009-2012)

Frey, H. Christopher
Professor
North Carolina State University
Raleigh, NC
CASAC
(FY 2009-2011)

Fry, Shirley A.
Independent Consultant
Indianapolis, IN
SAB Radiation Advisory Committee
(FY 2009)

Fuentes, Montserrat
Professor
North Carolina State University
Raleigh, NC
SAB Exposure and Human Health Committee (FY 2009)

Galloway, James
Sidman P. Poole Professor of Environmental Sciences
Associate Dean for the Sciences
University of Virginia
Charlottesville, VA
BOARD
(FY 2009)

Galvez, Maida
Assistant Professor
Mount Sinai School of Medicine
New York, NY
SAB Exposure and Human Health Committee (FY 2009-2012)

Gayer, Ted
Associate Professor
Georgetown University
Washington, DC
SAB Environmental Economics Advisory Committee (FY 2009)

Gennings, Chris
Professor
Virginia Commonwealth University
Richmond, VA
SAB Exposure and Human Health Committee (FY 2009-2012)

Gerking, Shelby
Professor of Economics
University of Central Florida
Orlando, FL
COUNCIL
(FY 2009-2012)

Giesy, John P.
Professor and Canada Research Chair
University of Saskatchewan
Saskatoon, Saskatchewan
BOARD
(FY 2009-2012)

Ginsberg, Gary
Toxicologist
Connecticut Department of Public Health
Hartford, CT
SAB Exposure and Human Health Committee (FY 2009-2012)

Gitterman, Benjamin
Associate Professor of Pediatrics & Public Health
Children's National Medical Center
Washington, DC
SAB Exposure and Human Health Committee (FY 2009)

Goble, Robert L.
Research Professor
Clark University
Worcester, MA
SAB Exposure and Human Health Committee (FY 2009-2012)

Grant, Stanley B.
Professor
University of California, Irvine
Irvine, CA
SAB Drinking Water Committee
(FY 2009)

Gray, Wayne
Professor
Clark University
Worcester, MA
COUNCIL
(FY 2009-2012)

Griffith, William C.
Associate Director
University of Washington
Seattle, WA
SAB Radiation Advisory Committee (FY 2009)

Griffiths, Jeffrey K.
Professor
Tufts University
Boston, MA
BOARD (FY 2010-2012)
SAB Drinking Water Committee
(FY 2010-2012)

Hammitt, James K.
Professor
Harvard University
Boston, MA
BOARD (FY 2009-2012)
SAB Environmental Economics Advisory Committee (FY 2009)
COUNCIL (FY2009-2010)

Hansen, D. Alan
Independent Consultant
Fremont, CA
COUNCIL
(FY 2010-2012)

Harper, Barbara L.
Risk Assessor and Environmental-Public Health Toxicologist,
Confederated Tribes of the Umatilla Indian Reservation
West Richland, WA
BOARD
(FY 2012)

Harris, Cynthia M.
Director and Professor
Florida A&M University
Tallahassee, FL
SAB Exposure and Human Health Committee (FY 2009-2012)

Hauser, Russ
Frederick Lee Hisaw Professor
Harvard School of Public Health
Boston, MA
SAB Exposure and Human Health Committee (FY 2009-2012)

Haws, Laurie
Principal Health Scientist
ToxStrategies, Inc.
Austin, TX
SAB Exposure and Human Health Committee (FY 2009-2012)

Hood, Darryl
Professor
Meharry Medical College
Nashville, TN
SAB Exposure and Human Health Committee (FY 2009-2012)

Horvath, Arpad
Associate Professor
University of California
Berkeley, CA
SAB Environmental Engineering Committee (FY 2009-2012)

Johnson, Jr., James H.
Professor and Dean Emeritus
Howard University
Washington, DC
BOARD
(FY 2009)

Johnson, Lucinda
Center Director
University of Minnesota Duluth
Duluth, MN
SAB Ecological Processes and Effects Committee (FY 2011-2012)

Jones, Kimberly L.
Professor and Chair
Department of Civil Engineering
Howard University
Washington, DC
BOARD
(FY 2012)

Kahn, Bernd
Professor Emeritus and
Associate Director
Georgia Institute of Technology
Atlanta, GA
BOARD (FY 2009-2012)
Radiation Advisory Committee
(FY 2009-2011)

Kane, Agnes
Professor and Chair
Brown University
Providence, RI
BOARD
(FY 2009-2012)

Karol, Meryl
Professor Emerita
University of Pittsburgh
Pittsburgh, PA
BOARD
(FY 2009)

Kehrer, James
Dean
Washington State University
Pullman, WA
SAB Exposure and Human Health Committee (FY 2009)

Kenski, Donna
Data Analysis Director
Lake Michigan Air Directors Consortium
Rosemont, IL
CASAC
(FY 2009-2010)

Keohane, Nathaniel
Chief Economist
Environmental Defense Fund
New York, NY
COUNCIL
(FY 2010-2011)

Khanna, Madhu
Professor
University of Illinois at Urbana-Champaign
Urbana, IL
BOARD (FY 2011-2012)
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Kiel, Katherine
Associate Professor
College of the Holy Cross
Worcester, MA
COUNCIL
(FY 2009)

Kim, Nancy K.
Senior Executive
Health Research, Inc.
Troy, NY
BOARD
(FY 2010-2012)

King, Gary
Professor of Microbial Biology
Louisiana State University
Baton Rouge, LA
SAB Drinking Water Committee
(FY 2009-2010)

Kling, Catherine
Professor
Iowa State University
Ames, IA
BOARD (FY 2009-2011)
SAB Environmental Economics Advisory Committee
(FY 2009-2011)

Korrick, Susan
Assistant Professor of Medicine
Harvard Medical School
Boston, MA
SAB Drinking Water Committee
(FY 2009-2012)

Koshland, Catherine
Vice Provost of Academic Planning and Facilities and Professor
University of California, Berkeley
Berkeley, CA
SAB Environmental Engineering Committee (FY 2009)

Kuenzli, Nino
Associate Professor
University of Southern California
Los Angeles, CA
COUNCIL
(FY 2009)

Lambert, George
Associate Professor of Pediatrics
Robert Wood Johnson Medical School-UMDNJ
Belle Mead, NJ
BOARD
(FY 2009)

Landis, Wayne
Professor and Director
Western Washington University
Bellingham, WA
SAB Ecological Processes and Effects Committee (FY 2009-2011)

Landolph, Jr., Joseph R.
Associate Professor
University of Southern California
Los Angeles, CA
SAB Drinking Water Committee
(FY 2009)

La Point, Thomas W.
Professor
University of North Texas
Denton, TX
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Lawler, Desmond F.
Nasser I. Al-Rashid Chair in Civil Engineering
University of Texas
Austin, TX
SAB Drinking Water Committee
(FY 2009-2012)

Lee, Cindy M.
Professor
Clemson University
Anderson, SC
SAB Environmental Engineering Committee (FY 2009-2012)

Lee, Kai
Program Officer
David & Lucile Packard Foundation
Los Altos, CA
BOARD
(FY 2010-2011)

Levy, Jonathan
Professor
Boston University School of Public Health
Boston, MA
COUNCIL
(FY 2010-2012)

Lifset, Reid
Director
Industrial Environmental Management Program
Yale University
New Haven, CT
SAB Environmental Engineering Committee (FY 2009)

Links, Jonathan M.
Professor and Deputy Chair
John Hopkins University
Baltimore, MD
SAB Radiation Advisory Committee
(FY 2009-2011)

Lipoti, Jill
Director
New Jersey Department of Environmental Protection
Trenton, NJ
BOARD
(FY 2009)

List, John
Professor
University of Chicago
Chicago, IL
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Loge, Frank
Professor
University of California-Davis
Davis, CA
SAB Drinking Water Committee (FY 2009-2012)

Love, Nancy
Professor and Chair
University of Michigan
Ann Arbor, MI
SAB Drinking Water Committee (FY 2009-2012)

Lue-Hing, Cecil
President
Cecil Lue-Hing & Assoc. Inc.
Burr Ridge, IL
BOARD
(FY 2010-2012)

Malveaux, Floyd
Executive Director
Merck Childhood Asthma Network, Inc.
Washington, DC
BOARD
(FY 2010-2012)

Mauzerall, Denise
Professor
Princeton University
Princeton, NJ
COUNCIL
(FY 2011-2012)

McMullen, Lee D.
Water Resources Practice Leader
Snyder & Associates, Inc.
Ankeny, IA
BOARD
(FY 2009-2011)

Meyer, Judith L.
Professor Emeritus
University of Georgia
Athens, GA
BOARD (FY 2009-2012)
SAB Ecological Processes and Effects Committee (FY2009-2010)

Mihelcic, James R.
Professor
University of South Florida
Tampa, FL
BOARD (FY 2011-2012)
SAB Environmental Engineering Committee (FY 2009-2012)

Milford, Jana
Professor
University of Colorado
Boulder, CO
BOARD
(FY 2009-2011)

Miller, Mark
Public Health Medical Officer
CA Environmental Protection Agency
Oakland, CA
SAB Exposure and Human Health Committee (FY 2009)

Mitch, William
Associate Professor
Yale University
New Haven, CT
SAB Drinking Water Committee (FY 2009-2012)

Moe, Christine
Eugene J. Gangarosa Professor
Emory University
Atlanta, GA
BOARD
(FY 2009-2012)

Moo-Young, Horace
Dean and Professor
California State University
Los Angeles, CA
BOARD (FY 2011-2012)
SAB Environmental Engineering Committee (FY 2009-2012)

Morandi, Maria
Research Professor
University of Montana
Houston, TX
SAB Exposure and Human Health Committee (FY 2009)

Morgan, William F.
Director of Radiation Biology and Biophysics
Pacific Northwest National Laboratory
Richland, WA
SAB Radiation Advisory Committee
(FY 2009-2012)

Moysich, Kirsten
Professor of Oncology
Roswell Park Cancer Institute
Buffalo, NY
SAB Exposure and Human Health Committee (FY 2009-2012)

Murphy, Eileen
Director of Research and Grants
Rutgers University
Piscataway, NJ
BOARD
(FY 2010-2012)

Nance, Earthea
Assistant Professor of Environmental Planning and Hazard Mitigation
University of New Orleans
New Orleans, LA
SAB Environmental Engineering Committee (FY 2009-2012)

Napier, Bruce A.
Staff Scientist
Pacific Northwest National Laboratory
Richland, WA
SAB Radiation Advisory Committee
(FY 2009-2012)

Opaluch, James
Professor and Chair
Department of Environmental and Natural Resource Economics
University of Rhode Island
Kingston, RI
BOARD (FY 2012)
SAB Environmental Economics Advisory Committee (FY 2009)

Oris, James
Professor
Miami University
Oxford, OH
SAB Ecological Processes and Effects Committee (FY 2009-2010)

Owen, Christine
Water Quality Assurance Officer
Tampa Bay Water
Clearwater, FL
SAB Drinking Water Committee
(FY 2009)

Ozonoff, David M.
Professor
Boston University
Boston, MA
SAB Exposure and Human Health Committee (FY 2009-2010)

Palmer, Karen
Senior Fellow
Resources for the Future
Washington, DC
SAB Environmental Economics Advisory Committee
(FY 2009-2012)

Parsons, George
Professor
University of Delaware
Newark, DE
SAB Environmental Economics Advisory Committee
(FY 2009-2012)

Patten, Duncan
Director, Montana Water Center
Research Professor, Hydroecology Research Program
Montana State University
Bozeman, MT
BOARD
(FY 2009-2012)

Peters, Catherine
Associate Professor
Princeton University
Princeton, NJ
SAB Environmental Engineering Committee (FY 2009-2012)

Poirot, Richard L.
Environmental Analyst
Vermont Agency of Natural Resources
Waterbury, VT
COUNCIL
(FY 2010-2012)

Polasky, Stephen
Fesler-Lampert Professor of Ecological/Environmental Economics
University of Minnesota
St. Paul, MN
BOARD
(FY 2010-2012)

Pope, III, C. Arden
Professor
Brigham Young University
Provo, UT
BOARD (FY 2011-2012)
COUNCIL (FY 2010-2012)

Popp, David
Associate Professor of Public Administration
Syracuse University
Syracuse, NY
COUNCIL
(FY 2009)

Post, Gloria
Research Scientist
New Jersey Department of Environmental Protection
Trenton, NJ
SAB Exposure and Human Health Committee (FY 2009-2012)

Powers, Susan E.
Associate Dean and Professor
Clarkson University
Potsdam, NY
SAB Environmental Engineering Committee (FY 2009)

Preston, Dale L.
Principal Scientist
Hirosoft International
Eureka, CA
SAB Radiation Advisory Committee
(FY 2009-2012)

Rabeni, Charles
Research Professor
University of Missouri
Columbia, MO
SAB Ecological Processes and Effects Committee (FY 2009)

Randtke, Stephen
Professor
University of Kansas
Lawrence, KS
SAB Drinking Water Committee
(FY 2009-2012)

Rauh, Virginia
Professor and Deputy Director
Department of Population and Family Health
Columbia University
New York, NY
SAB Exposure and Human Health Committee (FY 2009-2012)

Reible, Danny
Bettie Margaret Smith Chair of Environmental Health Engineering, and Director, Center for Research in Water Resources
University of Texas
Austin, TX
SAB Environmental Engineering Committee (FY 2009-2012)

Rejeski, David
Director
Woodrow Wilson International Center for Scholars
Washington, DC
BOARD
(FY 2009)

Roberts, A. Lynn
Professor
Johns Hopkins University
Baltimore, MD
SAB Drinking Water Committee
(FY 2009-2012)

Roberts, Stephen M.
Professor
University of Florida
Gainesville, FL
BOARD
(FY 2009-2012)

Rodewald, Amanda
Professor of Wildlife Ecology
The Ohio State University
Columbus, OH
BOARD (FY 2010-2012)
SAB Ecological Processes and Effects Committee (FY 2009-2012)

Rood, Mark
Professor
University of Illinois
Urbana, IL
SAB Environmental Engineering Committee (FY 2009)

Rose, Joan B.
Professor and
Homer Nowlin Chair for Water Research
Michigan State University
East Lansing, MI
BOARD (FY 2009-2010)
SAB Drinking Water Committee
(FY2009)

Roy, Sujoy
Director
Tetra Tech Inc.
Lafayette, CA
SAB Environmental Engineering Committee (FY 2009-2012)

Russell, Armistead (Ted)
Professor
Georgia Institute of Technology
Atlanta, GA
CASAC (FY 2009-2012)
COUNCIL (FY 2009-2012)

Ryan, P. Barry
Professor of Exposure Science and Environmental Chemistry
Emory University
Atlanta, GA
SAB Exposure and Human Health Committee (FY 2009-2012)

Sakaji, Richard
Manager
East Bay Municipal Utility District
Oakland, CA
SAB Drinking Water Committee
(FY 2009-2011)

Salame-Alfie, Adela
Research Scientist and Acting Director
New York State Department of Health
Troy, NY
SAB Radiation Advisory Committee
(FY 2011-2012)

Samet, Jonathan M.
Professor and Flora L. Thornton Chair
University of Southern California
Los Angeles, CA
BOARD (FY 2009-2012)
CASAC (FY 2009-2012)

Sanders, James
Director and Professor
Skidaway Institute of Oceanography
Savannah, GA
BOARD (FY 2009-2012)
SAB Ecological Processes and Effects Committee (FY 2009)

Sayler, Gary
Beaman Distinguished Professor
University of Tennessee
Knoxville, TN
SAB Drinking Water Committee
(FY 2009)

Schnatter, Robert
Senior Scientific Advisor
ExxonMobil Biomedical Sciences
Annandale, NJ
SAB Exposure and Human Health Committee (FY 2009)

Schnoor, Jerald
Allen S. Henry Chair Professor
University of Iowa
Iowa City, IA
BOARD
(FY 2009-2012)

Sedlak, David
Professor
University of California-Berkeley
Berkeley, CA
SAB Drinking Water Committee
(FY 2009)

Segerson, Kathleen
Philip E. Austin Professor of Economics
University of Connecticut
Storrs, CT
BOARD
(FY 2009-2011)

Shannon, Mark A.
Professor and Director
Water CAMPWS Center
University of Illinois
Urbana, IL
SAB Environmental Engineering Committee (FY 2009-2012)

Shaw, Bryan
Commissioner
Texas Commission on Environmental Quality
Austin, TX
SAB Environmental Engineering Committee (FY 2009)

Shortle, James
Professor
Pennsylvania State University
University Park, PA
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Shrader-Frechette, Kristin
O'Neil Professor of Philosophy
University of Notre Dame
Notre Dame, IN
BOARD
(FY 2009)

Skadsen, Janice
Environmental Scientist
CDM
Ann Arbor, MI
SAB Drinking Water Committee
(FY 2009-2012)

Smith, John R.
Division Manager
Alcoa Inc.
Alcoa Center, PA
SAB Environmental Engineering Committee (FY 2009)

Smith, Richard
Professor
University of North Carolina
Chapel Hill, NC
COUNCIL
(FY 2012)

Smith, V. Kerry
W.P. Carey Professor of Economics
Arizona State University
Tempe, AZ
BOARD
(FY 2009-2010)

Solomon, Gina
Deputy Secretary for Science and Health
CA Environmental Protection Agency
Sacramento, CA
BOARD (FY 2012)
SAB Drinking Water Committee
(FY 2009-2010)

Steinberg, Laura
Dean and Professor
Syracuse University
Syracuse, NY
SAB Drinking Water Committee
(FY 2009)

Stram, Daniel O.
Professor
University of Southern California
Los Angeles, CA
BOARD (FY 2012)
SAB Radiation Advisory Committee
(FY 2009-2012)

Stubblefield, William
Senior Research Professor
Oregon State University
Corvallis, OR
SAB Ecological Processes and Effects Committee
(FY 2011-2012)

Suh, Helen
Associate Professor
Northeastern University
Boston, MA
CASAC
(FY 2010-2012)

Swackhamer, Deborah L.
Professor
Hubert H. Humphrey School of Public Affairs and Co-Director of the Water Resources Center
University of Minnesota
St. Paul, MN
BOARD
(FY 2009-2012)

Taylor, Herman
Director, Principal Investigator
University of Mississippi Medical Center
Jackson, MS
BOARD
(FY 2010-2011)

Taylor, Laura
Professor
North Carolina State University
Raleigh, NC
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Teefy, Susan
Principal Engineer
Water Quality and Treatment Solutions, Inc.
Canoga Park, CA
SAB Drinking Water Committee
(FY 2009)

Theis, Thomas L.
Director
University of Illinois at Chicago
Chicago, IL
BOARD
(FY 2009)

Thomas, Valerie
Anderson Interface Associate Professor
Georgia Institute of Technology
Atlanta, GA
BOARD
(FY 2009)

Thompson, Jr., Barton H. (Buzz)
Robert E. Paradise Professor in Natural Resources Law
Stanford University Law School
Stanford, CA
BOARD
(FY 2009-2011)

Thompson, Timothy
Senior Environmental Scientist
Science and Engineering for the Environment, LLC
Seattle, WA
SAB Ecological Processes and Effects Committee (FY 2009)

Thorne, Peter S.
Director, Envir. Health Sciences Research Center
Professor and Head
University of Iowa Sciences Research Center
Iowa City, IA
BOARD
(FY 2012)

Tolbert, Paige
Professor and Chair
Department of Environmental Health
Emory University
Atlanta, GA
BOARD
(FY 2010-2012)

Twiss, Robert
Professor Emeritus
University of California-Berkeley
Ross, CA
BOARD
(FY 2009)

van Heerden, Ivor
Director
Louisiana State University
Baton Rouge, LA
SAB Ecological Processes and Effects Committee (FY 2009-2011)

Vena, John
Univ. of Georgia Foundation Professor in Public Health and
Head, Department of Epidemiology and Biostatistics
University of Georgia
Athens, GA
BOARD (FY 2011-2012)
SAB Exposure and Human Health Committee (FY 2010-2012)

Walcek, Chris
Senior Research Scientist
State University of New York
Albany, NY
COUNCIL
(FY 2009)

Wallsten, Thomas S.
Professor and Chair
University of Maryland
College Park, MD
BOARD
(FY 2009-2011)

Walsh, Michael
Independent Consultant
Arlington, VA
COUNCIL
(FY 2009-2012)

Watts, Robert
Professor of Mechanical Engineering Emeritus
Tulane University
New Orleans, LA
BOARD
(FY 2010-2012)

Weathers, Kathleen
Senior Scientist
Cary Institute of Ecosystem Studies
Millbrook, NY
CASAC
(FY 2010-2012)

Weaver, Virginia
Associate Professor
Johns Hopkins University
Baltimore, MD
SAB Drinking Water Committee
(FY 2011-2012)

Weisel, Clifford
Professor
University of Medicine and Dentistry of New Jersey
Piscataway, NJ
SAB Exposure and Human Health Committee (FY 2009-2012)

Westerhoff, Paul
Professor and Associate Dean for Research,
Ira A. Fulton Schools of Engineering
Arizona State University
Tempe, AZ
SAB Environmental Engineering Committee (FY 2009-2012)

Wilcoxen, Peter J.
Associate Professor
Syracuse University
Syracuse, NY
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Wright, Robert
Associate Professor of Pediatrics
Harvard School of Public Health
Boston, MA
SAB Exposure and Human Health Committee (FY 2009-2012)

Wu, JunJie
Emery N. Castle Professor of Resource and Rural Economics
Oregon State University
Corvallis, OR
SAB Environmental Economics Advisory Committee (FY 2009-2012)

Yates, Marylynn
Professor of Environmental Microbiology
University of California-Riverside
Riverside, CA
SAB Drinking Water Committee
(FY 2009-2012)

Yost, Michael
Professor
University of Washington
Seattle, WA
SAB Exposure and Human Health Committee (FY 2009-2012)

Young, Thomas M.
Professor
University of California-Davis
Davis, CA
SAB Environmental Engineering Committee (FY 2009-2012)

Zeise, Lauren
Chief
CA Environmental Protection Agency
Oakland, CA
BOARD
(FY 2009)

Zhao, Jinhua
Professor
Michigan State University
East Lansing, MI
SAB Environmental Economics Advisory Committee
(FY 2009-2012)

Zilberman, David
Professor
University of California - Berkeley
Berkeley, CA
SAB Environmental Economics Advisory Committee
(FY 2009-2012)

Zoeller, R. Thomas
Professor
University of Massachusetts
Amherst, MA
BOARD (FY 2011-2012)
SAB Exposure and Human Health Committee (FY 2009-2012)