
**WATER SCIENCE AND
TECHNOLOGY BOARD**

Annual Report
1993-1994

NATIONAL RESEARCH COUNCIL

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TECHNOLOGY BOARD**

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1993-1994

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DIRECTOR'S MESSAGE: WSTB "PROACTIVITY"

Below, Stephen D. Parker, staff director of the Water Science and Technology Board, explains how many of the board's studies develop through dialogue between board members, federal agency personnel, and other interest groups—often resulting in the forecasting of water resources issues that will become increasingly important in the future. Parker, a hydrologic engineer, has served as staff director since the board's founding in 1982.

When it was founded in 1982, the Water Science and Technology Board (WSTB) was intended primarily to respond to the government's increasing need for advice on water-related issues. The board initially derived its viability from a base of policy-oriented studies concerning water supply, dam safety, and floodplain management.

Founding members of the board convened for the inaugural WSTB meeting in November 1982. They met with a potential constituency of representatives from federal agencies who were friendly to the idea of this new advisory resource but who were also reasonably content with their agencies' program plans and policies and with the state of the relevant sciences and technologies. So, at that first meeting, the WSTB members and agency representatives together began almost immediately to discuss issues that might be classified as "emerging" or "anticipatory," as opposed to those that seemed more immediate or politically driven.

The WSTB's early deliberations were usually lively and irreverent. They sometimes addressed topics that federal managers did not want to hear about, such as alternative approaches to water pricing and water resources systems management, agricultural impacts on water quality, and hydrologic design criteria. These discussions did not always lead to studies, but they did establish a custom that has since characterized the WSTB—a custom of wide-ranging and frank discussions among the board members, agency representatives, and others aimed at anticipating issues that, in the future, will be of concern to the United States (and often other nations). Thus was born a strategic planning process for identifying studies to be pursued by the National Research Council in the interest of the nation.

The WSTB has since carried out dozens of studies originating in many different ways. In relatively few



Stephen D. Parker has served as director of the Water Science and Technology Board since its beginning in 1982.

cases, mainly those involving reviews of federal programs, WSTB activities have been conducted precisely as requested by the federal agencies. At the other extreme, a few ideas for studies have been carried out exactly as envisioned by the board members. Most studies, however, gestate and evolve over time based on suggestions from board members and agency liaison representatives, so that each study ultimately comes to serve the widest constituency in science, technology, policy, management, and academia. WSTB studies are generally of interest and value to a diverse clientele—most of whom contribute in various ways to the study process.

Fruits of Proactive Study Development

Studies resulting from this proactive development process are often slow in getting started, typically because of difficulties in piecing together broad financial support. The tasks themselves are also sometimes quite diffuse at first, until the appointed study groups have had the chance to consider an array of information and issues. Generally, though, on completion such studies are intellectually insightful and of considerable long-term importance. As evidence, since 1990 the National Academy Press has chosen to aggressively market nearly every WSTB publication that

evolved out of WSTB strategic planning. Given this success in the policy "marketplace," it is sometimes perplexing to look back over the inventory of completed, self-generated WSTB projects and try to understand why, without exception, they were so difficult to launch (and finance).

As an example of how WSTB studies evolve, *Ground Water Models: Scientific and Regulatory Applications* (published in 1990) began as a request by the U.S. Army to assess the use of ground water models for apportioning liability for contamination from a specific site in Minnesota. However, in considering this request board members decided the question of how best to use ground water models in making regulatory decisions extended far beyond this site-specific issue and deserved a broader assessment. The report resulting from this broadened study focuses on the scientific basis and regulatory application of ground water models and has become a highly valued reference in the ground water modeling community.

Other examples of WSTB reports that developed through a proactive process are numerous. *Opportunities in the Hydrologic Sciences* (1990) resulted from the board's concern that the scientific base of hydrology is insufficient to address current and emerging water resources problems, which increasingly demand an interdisciplinary approach to science. The report has had many impacts on water science and education, including the establishment of the Hydrologic Sciences Program within the National Science Foundation. *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy* (1992) originated with a staff member's vision of the usefulness and timeliness of such a study, and several National Academy of Sciences members participated in its development. The report lays out an ambitious policy and technical formula for rebuilding the nation's damaged aquatic ecosystems; several pieces of legislation have been introduced as a result of its findings. *Water Transfers in the West: Efficiency, Equity, and the Environment* (1992) was developed because WSTB members recognized the importance of water transfers as a way to increase water management flexibility and anticipated the need for a comprehensive review of possible negative impacts on the environment and third parties. The report recommends ways to ensure that transfers are equitable to all those affected. *Managing Wastewater*

in Coastal Urban Areas (1993) resulted from the board's sense that the nation has reached a level of technological sophistication that allows us to move beyond the "command-and-control" approach to wastewater management mandated more than 20 years ago. The report advocates a new approach—"integrated coastal management"—for dealing comprehensively with coastal water quality problems. *In Situ Bioremediation: When Does It Work?* (1993) was designed by the board because of concern about misuse and misunderstanding of bioremediation technology. It lays out an approach for evaluating the effectiveness of this environmental restoration technology.

Current WSTB studies also include several that developed through proactive dialogue between board members and agency liaisons. One study, concerning use of reclaimed wastewater and sludge in crop production, was initially suggested by an Environmental Protection Agency liaison to the board but was further refined by the WSTB with input from a wide variety of interest groups. Another study, which is evaluating alternative approaches to cleaning up ground water, evolved from discussions at a joint meeting held by the WSTB and the National Research Council's Board on Radioactive Waste Management and was shaped by input from staff members from the Department of Energy and the Environmental Protection Agency, who were concerned about scientific evidence indicating that "pump-and-treat" systems for ground water cleanup may not be effective. Another study, recently initiated, is the culmination of long interest and much WSTB involvement in the general area of irrigated agriculture; the study is taking a broad, long-range look at the future of irrigated agriculture in light of competing demands for water and water quality problems sometimes associated with irrigation. As these examples illustrate, WSTB studies developed through this proactive process are often intellectually and programmatically interconnected, with later projects sometimes exploring in depth an issue turned up in an earlier activity.

The WSTB program has historically included a small international component. Examples of international studies include a project on Great Lakes water quality policy, completed in 1985; a review of international soil and water research needs, completed in 1991; and an assessment of water supply planning for

Mexico City, due to be completed in 1994. The board's interest in international issues stems mainly from its recognition of the increasing importance of a global perspective in environmental sciences and management. In the case of the Mexico City study, the WSTB's agenda in carrying out the project also includes conveying to the Mexican technical and policy communities the usefulness of government/nongovernment collaboration in the National Research Council model.

The Future

Beyond these completed and ongoing studies, the WSTB strategic plan contains a suite of prospective studies related to land use impacts on water quality, interdisciplinary education and research in the water sciences, water resources planning, advancement of innovative ground water remediation technologies, alternative approaches for managing contaminated sediments, and biological aspects of water quality. These proactive studies will not be the only activities carried out by the board, but they will continue to complement the more traditional studies initiated to respond to pressing needs of the government—and which are the primary mission of the National Research Council. A roughly equal mixture of proactive and responsive studies has become the WSTB pattern.

Thus the board will continue to serve the immediate needs of government while, at the same time, helping the nation anticipate and be prepared to deal with emerging issues. It is clear that a tradition of proactive study development by the WSTB has taken root over the past 12 years because it has served the government and the nation well. This tradition will survive into the mid-1990s and beyond. The WSTB will continue to provide a forum where all members of the water community and others can participate in discussions and debates, seeking to improve government programs and heighten the national interest in emerging, long-term issues relevant to water science, technology, and policy.

In summary, one of the principal goals of the WSTB program over its first 12 years has been to help the government and the nation maintain a long-term view for addressing water issues, rising above the many crisis-oriented, budgetary, and other factors working against such an objective. Insofar as we have achieved this goal, we must thank many individuals, too numerous to name, from government, universities, industry, and elsewhere. This has been and remains a team effort in which people of goodwill, with a broad base of expertise and a diversity of interests, come together to share their ideas for the benefit of our nation.

OVERVIEW

This report summarizes the activities of the Water Science and Technology Board during 1993–1994. The WSTB is intended to be a dynamic forum, a mechanism by which the broad community of water science, technology, and policy professionals can help assure high-quality national water programs. We welcome inquiries and suggestions about our work.

Who We Are

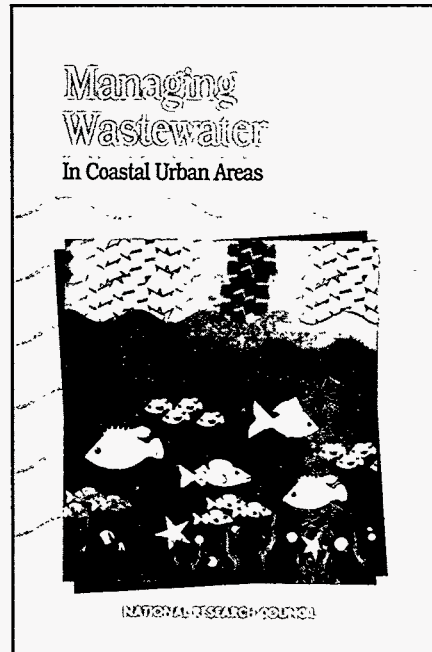
The WSTB is a group of experts available to advise the government on water issues. We are a unit of the National Research Council (NRC), the operating element of the National Academy of Sciences (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM). Together, these organizations comprise the most important independent scientific advisory bodies available to the federal government.

History

The National Academy of Sciences was chartered by Congress in 1863. It was initially composed of 50 of the nation's most eminent scientists. These scientists, in addition to being honored for their achievements, were available to advise the government on technical matters. The Academy's charter specified that the scientists would not be compensated for their labor, only for direct costs incurred in carrying out studies. Since its inception, the Academy's financial and organizational independence from the government have enabled it to provide scientific advice unbiased by political influences.

The onset of World War I increased the government's need for scientific advice. In 1916, the Academy created the National Research Council at President Woodrow Wilson's request to broaden the scientific expertise available to the government. Wilson envisioned an institutional mechanism through which large numbers of scientists and engineers—Academy members and nonmembers alike—could provide impartial technical advice. Today, about 9,000 highly qualified scientists and engineers serve the nation without compensation by participating in National Research Council activities.

The National Academy of Engineering was created in 1964 to recognize the importance of engineering in technological advancement. The Institute of Medicine



*The 1992 WSTB report *Managing Wastewater in Coastal Urban Areas* suggests ways for improving wastewater management to better protect coastal resources.*

was created in 1970 to work on matters affecting the status of medicine and the adequacy of national health services. Today, the two academies and the institute serve as honorary societies, while the National Research Council carries out the work of advising the government.

As the National Research Council grew in response to the increasing need for unbiased scientific information, it was divided into commissions, which were further subdivided into boards, to guide studies in specific scientific disciplines. Reports issued by various units within the National Research Council cover a vast array of topics, from pesticides in the diets of infants and children, to science education standards, to industrial productivity.

The Water Science and Technology Board, created in 1982, oversees studies of water issues. Approximately 20 (the exact number varies) volunteers from universities, government, and industry serve as board members for three-year terms. Several hundred other volunteers serve on study committees, as report reviewers, and as government agency liaisons to the board.

IMPACTS OF WSTB STUDIES

WSTB reports provide tools for structuring national water research and policy. Two examples illustrate the ways in which WSTB reports have influenced the national water agenda:

- In 1992, the WSTB report *Restoration of Aquatic Ecosystems* recommended establishment of a national strategy to restore the nation's degraded wetlands, rivers, streams, and lakes. The report recommended setting goals of restoring 1 million acres of lakes, 400,000 miles of rivers and streams, and 10 million acres of wetlands by the year 2010. In 1994, a member of Congress introduced legislation, the National Aquatic Ecosystem Restoration Act of 1994, that calls for "aquatic ecosystem restoration projects resulting in a net restoration of 10 million acres of wetlands, 400,000 miles of streams and rivers, and 1 million acres of lakes . . . by the year 2010." The bill would establish a trust fund to finance these activities.

- In 1991, the WSTB report *Opportunities in the Hydrologic Sciences* presented a blueprint for the hydrologic research needed to understand emerging water problems, such as the impacts on water resources caused by tropical deforestation, large-scale irrigation and drainage, acid precipitation, and climate change. Following the recommendations of this report, in 1992 the National Science Foundation established a hydrologic sciences division to provide grants for hydrologic research. The report has influenced the curricula at many universities. Some universities—including the University of California at Davis, the University of Colorado, and the University of Florida—have established degree programs in hydrologic sciences as a result of the report.

Studies

Studies undertaken by the Water Science and Technology Board can be initiated in either of two ways. Some studies are undertaken at the request of a government agency seeking assistance. Alternatively, the WSTB may identify a topic of pressing concern and initiate a study. The principal products of studies are written reports. These reports cover a wide range of water resources issues of current national concern. Three recent examples illustrate the scope of the WSTB's work:

- *Alternatives for Ground Water Cleanup*, to be published in 1994, assesses the degree to which contaminated ground water can be restored with existing technologies.

- *Managing Wastewater in Coastal Urban Areas*, published in 1993, identifies ways to improve management of wastewaters to protect coastal resources such as fisheries, beaches, and estuaries.

- *Water Transfers in the West: Efficiency, Equity, and the Environment*, published in 1992, discusses water transfers as one way to improve management of increasingly scarce water supplies in the western United States.

Symposia and Lectures

In addition to conducting studies and producing reports, the WSTB hosts symposia for discussing current water issues. Examples of past symposia include "Sustaining Our Water Resources" and "Colorado River Ecology and Dam Management." The board also hosts an annual lecture in honor of Dr. Abel Wolman, a pioneer in the water-supply and sanitation field. The 1993 Wolman lecturer, Dr. Helen Ingram of the University of Arizona, discussed water management problems in the U.S.-Mexico border regions.

Meetings

The WSTB generally meets three times each year. At WSTB meetings, the members monitor ongoing projects, do strategic planning, and develop new initiatives. In addition to providing time for WSTB business, the meetings foster communication within the water resources community. Most agencies with water-related responsibilities have liaison representatives who regularly attend the meetings.

Staff

The WSTB is supported by an 11-member staff in Washington, D.C. The staff organizes meetings, helps formulate study topics and select committee members, maintains contact with government agencies, performs limited research, provides editorial guidance for reports, directs outside review of reports, and produces a quarterly newsletter.

Financial Support

In 1993, financial support for the WSTB's activities totalled about \$1.8 million. Support was provided by internal NRC funds and the following sponsors:

- **Federal government agencies:** the Bureau of Reclamation, the Department of Agriculture, the Department of the Army, the Department of Energy, the Department of the Interior, the Environmental Protection Agency, the Federal Emergency Management

Agency, the National Science Foundation, and the U.S. Geological Survey.

- **State and municipal governments and water utilities:** the Association of Metropolitan Sewerage Agencies, the Central and West Basin Water Replenishment District, the Eastern Municipal Water District, and the Orange County Water District.

- **Private foundations:** the Ford Foundation, the Tinker Foundation, and the Water Environment Research Foundation.

- **Corporations and associations:** the American Petroleum Institute, BioGro System Inc., Chevron USA Inc., the Coalition on Superfund, the Irrigation Association, Mobil Oil Corporation, the National Food Processors Association, and N-Viro International Corporation.

- **Research institutes:** the Electric Power Research Institute, the Gas Research Institute, and the National Water Research Institute.

RESPONSES TO WSTB STUDIES

"Were it not for the advice and guidance provided to the U.S. Geological Survey by the WSTB, it is unlikely that we would have gotten the go ahead from both the Administration and Congress to implement the National Water-Quality Assessment Program—a program that strongly reinforces the USGS's role in providing vital water information to the nation."

– Philip Cohen, Chief Hydrologist
U.S. Geological Survey

"My congratulations to the committee involved in producing this excellent study of techniques for assessing ground water vulnerability. This report will be of inestimable value to administrators and researchers involved in the USDA Water Quality Initiative."

– E. E. Finney, Jr., Acting Administrator
U.S. Department of Agriculture,
Agricultural Research Service

"I want to congratulate the Committee on Western Water Management for a job well done. I am very pleased with the final report, its recommendations and the results of the workshops. Much more importantly, the results of your efforts have been well received by a wide range of interests throughout the West and in Washington."

– Cynthia Dyballa, Project Officer
U.S. Environmental Protection Agency,
Office of Policy, Planning, and Evaluation

"I rely extensively on many of the reports that the WSTB has produced in the process of developing new programs in the Water Resources Division and in managing ongoing research. Virtually without exception, any time I am in the process of writing programmatic documents I have one or more reports of the WSTB at my fingertips."

– Robert M. Hirsch, Deputy to the Director
U.S. Geological Survey

PROJECTS COMPLETED IN 1993-1994

In 1993-1994, the Water Science and Technology Board and its committees completed seven reports, including final reports on the results of long-term studies and interim reports from committees that provide continuing program advice to federal agencies. In addition, the board hosted a lecture by Dr. Helen Ingram, director of the University of Arizona's Udall Center for Studies in Public Policy, on the complexities of water resources management along the U.S.-Mexico border. These projects are summarized below.

FINAL REPORTS

Alternatives for Ground Water Cleanup

There may be 300,000 or more waste sites in the United States where ground water and soil are contaminated. Yet recent studies question whether existing technologies can restore contaminated ground water to drinking water standards, which is the goal for most sites and the result expected by the public. *Alternatives for Ground Water Cleanup*, the result of a two-year study, provides guidance on how the nation can balance public health and technological realities when addressing ground water cleanup.

The report concludes that although complete ground water restoration may not be feasible with existing technologies at many sites, existing technologies can still substantially reduce the risks posed by these sites. It recommends policies that are technologically sound while still protecting health and the environment. Included in the document are a listing of approximately 80 contaminated sites that the study committee reviewed and detailed case studies for several of the sites.

Sponsors for this study were the Department of Energy, the Environmental Protection Agency, Chevron USA Inc., and the Coalition on Superfund. Jacqueline MacDonald was the staff officer. Committee members were

Michael Kavanaugh, *Chair*, Montgomery-Watson Inc., Walnut Creek, California

James Mercer, *Vice Chair*, GeoTrans Inc., Sterling, Virginia

Linda Abriola, University of Michigan, Ann Arbor

Charles Andrews, S. S. Papadopoulos & Associates Inc., Bethesda, Maryland

Mary Jo Baedecker, U.S. Geological Survey, Reston, Virginia

Edward Bouwer, Johns Hopkins University, Baltimore, Maryland

Patricia Buffler, University of California, Berkeley

Robert Connick, University of California, Berkeley

Richard Conway, Union Carbide Corporation, South Charleston, West Virginia

Ralph d'Arge, University of Wyoming, Laramie

Linda Greer, Natural Resources Defense Council, Washington, D.C.

Joseph Highland, ENVIRON Corporation, Princeton, New Jersey

Douglas Mackay, consultant, Stanford, California

Glenn Paulson, *Board on Radioactive Waste Management liaison*, Illinois Institute of Technology, Chicago

Lynne Preslo, ICF-Kaiser Engineers, Oakland, California

Paul Roberts, Stanford University, Stanford, California

William Walsh, Pepper, Hamilton & Scheetz, Washington, D.C.

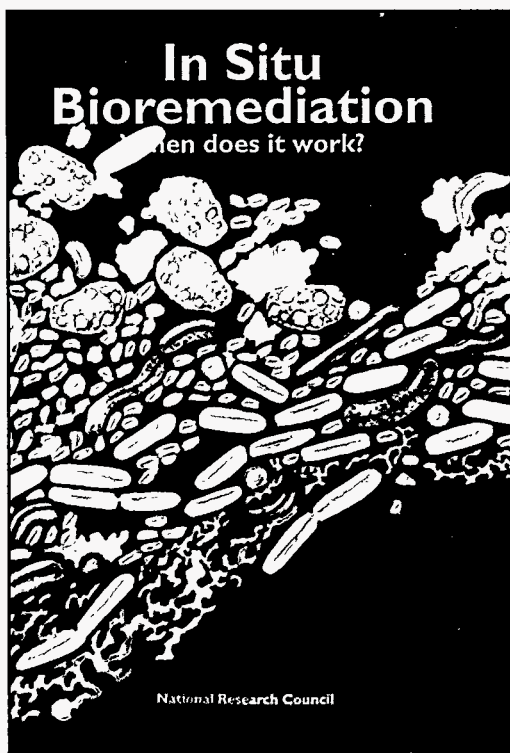
C. Herb Ward, Rice University, Houston, Texas

Marcia Williams, Williams & Vanino Inc., Los Angeles, California

In Situ Bioremediation: When Does It Work?

In situ bioremediation—the use of microorganisms for in-place removal of contaminants—is potentially cheaper, faster, and safer than conventional environmental cleanup methods. But in situ bioremediation is also clouded in uncertainty, controversy, and mistrust. *In Situ Bioremediation: When Does It Work?* provides direction on when this technology is appropriate for cleaning up contaminated ground water and soil.

The report provides detailed explanations of the processes involved in in situ bioremediation, site conditions for which it is most suitable, and methods for evaluating the results of bioremediation projects. It includes case examples showing the successful application of the technology. In addition to this comprehensive review of the technology, the report includes perspective papers by leaders in the bioremediation field from industry, academia, and government.



In Situ Bioremediation: When Does It Work? discusses the capabilities and limitations of in situ bioremediation as an alternative to conventional subsurface cleanup technologies.

Sponsors for this study were the American Petroleum Institute, Chevron USA Inc., the Electric Power Research Institute, the Environmental Protection Agency, the Gas Research Institute, Mobil Oil Corporation, and the National Science Foundation. The staff officer was Jacqueline MacDonald. Committee members were

- Bruce Rittmann, *Chair*, Northwestern University, Evanston, Illinois
- Lisa Alvarez-Cohen, University of California, Berkeley
- Philip Bedient, Rice University, Houston, Texas
- Richard Brown, Groundwater Technology Inc., Trenton, New Jersey
- Francis Chapelle, U.S. Geological Survey, Columbia, South Carolina

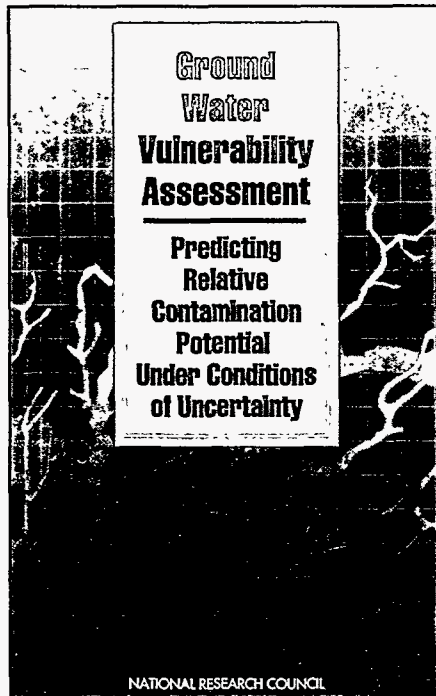
- Peter Kitanidis, Stanford University, Stanford, California
- Eugene Madsen, Cornell University, Ithaca, New York
- William Mahaffey, ECOVA Corporation, Redmond, Washington
- Robert Norris, Eckenfelder Inc., Nashville, Tennessee
- Joseph Salanitro, Shell Development Company, Houston, Texas
- John Shauver, Michigan Department of Natural Resources, Lansing
- James Tiedje, Michigan State University, East Lansing
- John Wilson, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma
- Ralph Wolfe, University of Illinois, Urbana-Champaign

Ground Water Vulnerability Assessment

Recognizing the need to protect ground water from future contamination, scientists and resource managers have been developing techniques for predicting which areas are vulnerable to contamination from activities at or near the land surface. *Ground Water Vulnerability Assessment: Predicting Relative Contamination Potential Under Conditions of Uncertainty* reviews the classes of methods available for identifying areas more likely to become contaminated as a result of surface activities, such as pesticide and fertilizer applications. Because no one assessment method is appropriate for all applications, the report examines the uncertainties associated with each method. It provides guidelines for managers in the selection of an appropriate approach and identifies research important for developing the next generation of ground water vulnerability assessment techniques.

Beginning in 1994, all states are required to prepare ground water management plans, of which one component may be a vulnerability assessment. This volume will be valuable to state resource managers in the development of such plans and to federal policymakers as federal ground water protection policies evolve.

Sponsors for the study were the U.S. Department of Agriculture, the Environmental Protection Agency, and the U.S. Geological Survey. Sarah Connick was the staff officer. Committee members were



This report examines techniques for determining ground water vulnerability to contamination and provides guidance on selecting appropriate assessment methods.

Armando Carbonell, *Chair*, Cape Cod Commission, Barnstable, Massachusetts
 Hugo Thomas, *Chair*, Connecticut Department of Environmental Protection, Hartford (through March 1991)
 William Alley, U.S. Geological Survey, Reston, Virginia
 Lawrence Batten, Environmental Systems Research Institute, Boulder, Colorado
 Cheryl Contant, University of Iowa, Iowa City
 Pamela Doctor, Battelle Pacific Northwest Laboratory, Richland, Washington
 Anthony Donigan, AQUA TERRA Consultants, Mountain View, California
 Robert Dowdy, U.S. Department of Agriculture, Agricultural Research Service, St. Paul, Minnesota
 Donald Siegel, Syracuse University, New York
 P. Suresh Rao, University of Florida, Gainesville
 Gale Teselle, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Roberto Teso, California Department of Food and Agriculture, Riverside
 Scott Yates, University of California, Riverside

Ground Water Recharge

As demand for water increases, water managers and planners will need to identify ways to improve water management and increase water supplies. *Ground Water Recharge: Using Waters of Impaired Quality*, the result of a two-year study, assesses issues associated with augmenting natural recharge of ground water using waters of impaired quality. The report concludes that artificial recharge can be one option in an integrated strategy to optimize total water resource management and that water from sources of impaired quality can be used effectively.

The report addresses source water quality characteristics, pretreatment and recharge technologies, transformations during transport, economic feasibility, and public health implications of artificial recharge. It reviews recharge technologies and the benefits possible, not just for augmenting water supplies but also for controlling seawater intrusion, reducing land subsidence, and maintaining base streamflows. Of the three main types of wastewaters evaluated (stormwater, irrigation return flows, and treated municipal wastewater), treated municipal wastewater was judged to be the most consistent in terms of quality and availability. The report includes descriptions of seven recharge projects.

Support for this effort was from the National Water Research Institute, the Environmental Protection Agency, the Bureau of Reclamation, the Orange County Water District, the West Basin Water Management District, and the Central and West Basin Water Replenishment District. The staff officer was Chris Elfring. Committee members were

Julian Andelman, *Chair*, University of Pittsburgh, Pennsylvania
 Herman Bouwer, U.S. Department of Agriculture, Water Conservation Laboratory, Phoenix, Arizona
 Randy Charbeneau, University of Texas, Austin
 Russell Christman, University of North Carolina, Chapel Hill
 James Crook, Camp, Dresser & McKee Inc., Cambridge, Massachusetts

Anna Fan, California Department of Health
Services, Berkeley

Denise Fort, University of New Mexico,
Albuquerque

Wilford Gardner, University of California, Berkeley

William Jury, University of California, Riverside

David Miller, Geraghty & Miller Inc., Plainview,
New York

Robert Pitt, University of Alabama, Birmingham

Gordon Robeck, consultant, Laguna Hills,
California (through May 1993)

Philip Singer, WSTB Liaison, University of North
Carolina, Chapel Hill

Henry Vaux, Jr., University of California, Riverside

John Vecchioli, U.S. Geological Survey, Tallahassee,
Florida

Marilynn Yates, University of California, Riverside

INTERIM REPORTS

National Water Quality Assessment Program: The Challenge of National Synthesis

The U.S. Geological Survey (USGS) created the National Water Quality Assessment (NAWQA) program in 1984 to describe trends in the quality of the nation's surface and ground water and to provide a scientific understanding of the primary natural and human factors affecting the quality of these resources. The national synthesis portion of NAWQA involves scaling up information from local and regional levels to the national level to obtain a broader picture of water quality phenomena for use in national program decisions and policymaking. This report of the WSTB's Committee on USGS Water Resources Research examines the USGS national synthesis approach and provides recommendations for improvement, some of which the USGS has already been adopted. (See the committee description and membership list on p. 22.)

Glen Canyon Environmental Studies

In 1994, the Committee to Review the Glen Canyon Environmental Studies issued two reports as part of its continuing charge to advise the Bureau of Reclamation on its studies of the effects of the Glen Canyon Dam on the Colorado River (see the committee description



Several WSTB committees provide program advice to federal agencies. This report reviews the USGS's National Water Quality Assessment program.

and membership list on p. 20). The first report, *Review of the Draft Federal Long-Term Monitoring Plan for the Colorado River Below Glen Canyon Dam*, assesses the draft federal long-term monitoring plan for the Colorado River below Glen Canyon Dam. This plan will be of great importance in providing a rational basis for protection of environmental resources in the Grand Canyon. In addition, because of the national and international prominence of the Grand Canyon, the plan may serve as a blueprint for other riverine ecosystem monitoring plans in the United States and other countries. In the report, the committee offers suggestions for improving the plan's design of monitoring requirements. It also offers advice on data collection methods and the use of financial resources.

The second report, *Review of the Draft Environmental Impact Statement on the Operation of Glen Canyon Dam*, recommends the development of a detailed long-term monitoring plan and further study of the proposed flood control and structural changes in the Glen Canyon Dam. It suggests improvements in the analyses of nonuse values and the dam's power resources included in the draft environmental impact statement.



Dr. Abel Wolman, one of the century's leading figures in improving water-supply and sanitation technologies. The WSTB holds an annual lecture in honor of the late Dr. Wolman.

Review of EPA's Environmental Monitoring and Assessment Program

The Committee to Review the EPA's Environmental Monitoring and Assessment Program (EMAP) issued a report, *Review of EPA's Monitoring and Assessment Program: Forests and Estuaries Components*, as part of its review of EMAP (see the committee description and membership list on p. 19). EMAP is designed to assess the distribution and condition of the nation's ecological resources. The report concludes that EMAP's overall purpose and goals are laudable, but it questions the degree to which the EPA can achieve them in a timely and cost-effective manner. The report observes that the program has progressed since the committee issued its first assessment of the program in 1992, although some of the committee's initial questions have not yet been adequately addressed. It provides specific recommendations to help improve the forests and estuaries components of EMAP as well as the overall program in the following areas: indicators use, sampling design, information management, cause-and-effect analysis, temporal trends detection, and overall management and coordination.

WOLMAN LECTURE

Transboundary Water Resources Management: Learning from the U.S.-Mexico Example

In 1993, Dr. Helen Ingram delivered the WSTB's fourth annual lecture in honor of Abel Wolman, a pioneer in water supply and sanitation technologies. Dr. Ingram, director of the Udall Center for Studies in Public Policy at the University of Arizona, discussed the complexities that national borders create in water resources management. She illustrated her talk with the case example of the community of Ambos Nogales, which straddles the Arizona-Sonora border. She described how borders separate the locus of problems from solutions, how they create economic opportunities that encourage irrational development, and how differences in water service at borders aggravate perceptions of inequity. She pointed out the limitations of hierarchical, centralized government to address border issues and emphasized the importance of designing new binational structures to work at the problems on a local level. (See p. 32 for information on ordering a lecture transcript.)

ONGOING STUDIES

The Water Science and Technology Board's most important asset in carrying out studies is its access to the nation's leading experts in water science, engineering, and policy. This network enables the board to address critical water resources problems using the most advanced scientific knowledge available.

Board studies are initiated when the federal government requests advice or when the board identifies a problem requiring critical analysis. Studies are carried out by committees of experts appointed to work under the board's supervision. When a study begins, the board surveys the scientific community for committee member nominations. The board may gather 100 or more names, from which it selects the best-qualified experts. Committee size ranges from fewer than 10 to 20 or more members, depending on the complexity of the problem the committee is asked to address.

Study committees meet several times each year to exchange ideas, discuss the problem they are investigating, and gather information from those knowledgeable about the subject, including representatives of federal, state, and local agencies, private corporations, and public interest groups. At the end of the study, the committee publishes a report. Periodically throughout the study, the committee may also issue brief interim reports on particular elements of the problem. Current WSTB studies cover three broad categories:

- *Natural systems cleanup and protection studies* analyze issues related to the wise stewardship of freshwater resources.

- *Water management and infrastructure studies* address questions related to the management of water supply and sanitation services.

- *Federal program advisory studies* provide continuing advice for federal agency programs.

NATURAL SYSTEMS CLEANUP AND PROTECTION

Wetlands Characterization

In the past few decades, the benefits of the hydrologic and biologic functions of wetlands have become increasingly understood and appreciated. In 1991, proposed changes in the way wetlands are defined focused

attention on scientific and economic factors associated with wetlands management. The services that wetlands provide, such as attenuating floods and providing wildlife habitats, have now been recognized as important to people, wildlife, and ecosystems.

At the request of the Environmental Protection Agency, in April 1993 the WSTB and the Board on Environmental Studies and Toxicology (BEST) appointed a committee to analyze wetlands delineation methods. The committee is evaluating the diverse hydrological, ecological, social, and other functions of wetlands, focusing particularly on irregularly flooded sites. The committee's report, scheduled to be published in September 1994, will provide a scientific basis for rational technical and regulatory approaches to wetlands identification and management.

Financial support for this project is from the Environmental Protection Agency and the Soil Conservation Service. The staff officers are Sheila David, WSTB, and David Policansky, BEST. Committee members are

William Lewis, Jr., *Chair*, University of Colorado, Boulder

Barbara Bedford, Cornell University, Ithaca, New York

Fred Bosselman, Illinois Institute of Technology—Chicago Kent College of Law

Mark Brinson, East Carolina University, Greenville, North Carolina

Paul Garrett, Federal Highway Administration, Washington, D.C.

Constance Hunt, World Wildlife Fund, Washington, D.C.

Carol Johnston, University of Minnesota, Duluth

Douglas Kane, University of Alaska, Fairbanks

A. Michael Macrander, Shell Oil Company, Houston, Texas

James McCulley, private consultant, Newark, Delaware

William Mitsch, Ohio State University, Columbus

William Patrick, Jr., Louisiana State University, Baton Rouge

Roger Post, Alaska Department of Fish and Game, Fairbanks

Don Siegel, Syracuse University, Syracuse, New York

R. Wayne Skaggs, North Carolina State University,
Raleigh
Margaret Strand, Eckert Seamans Cherin & Mellot,
Washington, D.C.
Joy Zedler, San Diego State University, California

Inland Aquatic Ecosystems

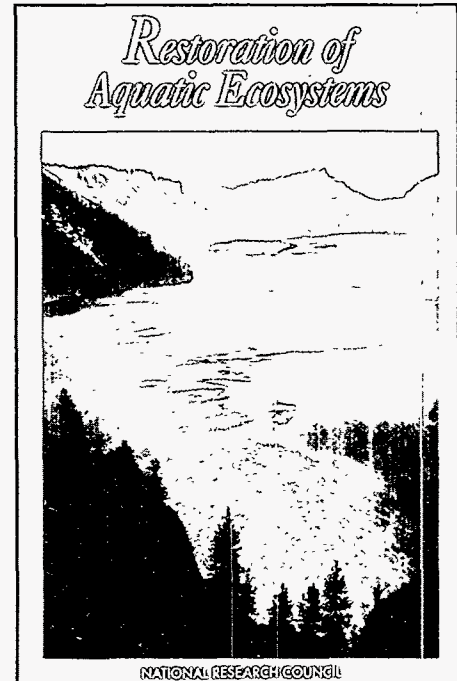
Scientists are increasingly recognizing that solving many of society's emerging environmental problems—from chemical contamination of lakes to climate change—will require an interdisciplinary approach. This interdisciplinary approach is needed to bring together scientists with backgrounds in the wide range of disciplines—from water chemistry to aquatic ecology—required to understand ecosystems as a whole, rather than studying ecosystem components individually. The Committee on Inland Aquatic Ecosystems, in the process of being appointed when this report went to press, will identify the critical emerging problems related to inland waters and how to ensure the conduct of interdisciplinary research and education necessary to solve these problems. The committee will publish a report of its findings in late 1995.

Financial support for this project is from the Environmental Protection Agency, the National Science Foundation, and the National Research Council Fund. The staff officer is Jacqueline MacDonald.

WATER MANAGEMENT AND INFRASTRUCTURE

Mexico City Water Supplies

The problem of a reliable, safe drinking water supply is one of the most important environmental issues currently facing the 18 million inhabitants of the Mexico City metropolitan area. Since the time of the Aztecs, Mexico City residents have depended on the underlying aquifer and related springs for their water needs. The heavy dependence on the aquifer is rapidly depleting its stores. Over the past 100 years, overpumping of the aquifer has resulted in more than 5 meters of land subsidence with some portions of the city sinking at rates up to 5 centimeters per year. Adding to Mexico City's problems, unregulated land disposal of wastes may have contaminated the aquifer. Ground water still pro-



This 1992 report outlines a national program for restoring the nation's degraded lakes, rivers, streams, and wetlands.

vides 80 percent of the city's supply, but the remaining water must be imported at great cost from distant valleys.

As part of the National Research Council's program of collaboration with the Mexican Academia de la Investigación Científica, the WSTB initiated a study with the Mexican Academia de la Ingeniería (ANIAC) on the limitations of the Mexico City aquifer as a water supply resource. The committee is addressing not only the scientific and technical aspects of aquifer water, but also the socioeconomic, public policy, and institutional issues affecting Mexico City's water resources. The committee's work will culminate in a report, in both English and Spanish, scheduled for release in late 1994.

The project is sponsored by the Ford Foundation, the Tinker Foundation, the Environmental Protection Agency, the National Research Council, and the Mexican National Science Foundation. Gary Krauss is the WSTB staff officer, and Alejandro Lozano is the project coordinator for the ANIAC. Committee members are

Charles DuMars, *Co-Chair*, University of New Mexico, Albuquerque
 Ismael Herrera Revilla, *Co-Chair*, Universidad Autónoma Nacional de México, Mexico City
 Irina Cech, University of Texas, Houston
 Randall Crane, University of California, Irvine
 Cristina Cortinas de Nava, Instituto Nacional de Ecología de la SEDESOL, Mexico City
 Richard Engelbrecht, University of Illinois, Urbana-Champaign
 Robert Farvolden, National Ground Water Association, Dublin, Ohio
 Helen Ingram, Udall Center for Studies in Public Policy, University of Arizona, Tucson
 Jesús Kumate Rodríguez, Secretaría de Salud, Mexico City
 Ruben Martinez Guerra, Instituto Mexicano de Tecnología del Agua, Mexico City
 Lucrecia Lozano-García, Instituto Tecnológico de Estudios Superiores de Monterrey, Mexico City
 Juan Manuel Martínez, Construcción y Operación Hidráulica del Distrito Federal, Mexico City
 Carlos Velez Ocon, Instituto Nacional de Investigaciones Nucleares, Mexico City
 David Wilk Graber, consultant, Mexico City

Future of Irrigation

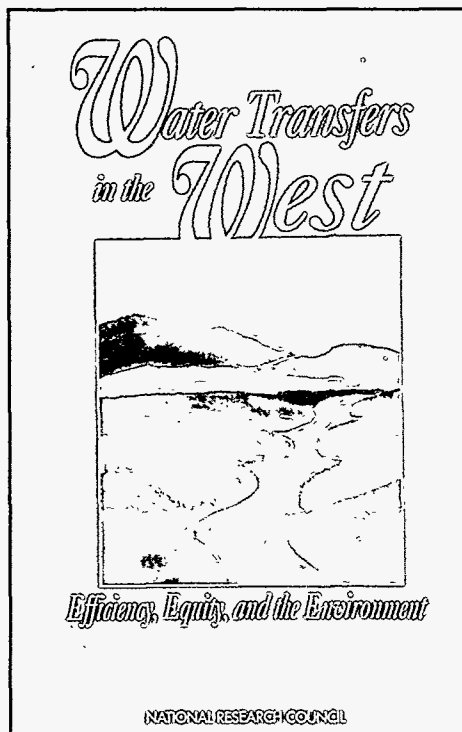
For centuries, irrigation has been important in sustaining human life. Today, agricultural irrigation is being transformed by changing supply-and-demand conditions, growing concerns about the environmental impacts of irrigation, and national and international economic forces. The WSTB established the Committee on the Future of Irrigation in the Face of Competing Demands to conduct a careful study of the pressures affecting the availability of water for irrigation and to identify mechanisms that might facilitate the transition to a world of increasing water scarcity.

The committee is exploring the impacts of changing supply-and-demand conditions and pricing policies on the cost of water and is evaluating current and potential future technologies that might help water users adapt to changing conditions. The committee is assessing short- and long-term problems associated with irrigation, considering regional variations, and will

provide guidance for their mitigation. Issues that the committee may consider include tensions among continued crop production needs, municipal demand, and environmental quality considerations; conflicts about water availability for environmental purposes; water quality problems stemming from agricultural drainage and deliveries of sediment and agricultural chemicals to water bodies; problems arising in rapidly urbanizing areas; and opportunities to induce greater irrigation efficiency and serve competing demands. The committee will publish a report of its findings in early 1996.

The study is sponsored by the U.S. Department of Agriculture, the Bureau of Reclamation, the Ford Foundation, and the Irrigation Association. The staff officer is Chris Elfring. Committee members are

Wilford Gardner, *Chair*, University of California, Berkeley
 Kenneth Frederick, *Vice Chair*, Resources for the Future, Washington D.C.
 Hedia Adelsman, Washington State Department of Ecology, Olympia
 John Boyer, University of Delaware, Lewes
 Chelsea Congdon, Environmental Defense Fund, Oakland, California
 Dale Heermann, U.S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
 Edward Kanemasu, University of Georgia, Griffin
 Ronald Lacewell, Texas A&M University, College Station
 Lawrence MacDonnell, Natural Resources Law Center, University of Colorado, Boulder
 Thomas Macvicar, South Florida Water Management District, West Palm Beach
 Stuart Pyle, consulting engineer, Bakersfield, California
 Lester Snow, San Diego County Water Authority, California
 Catherine Vandemoer, Wright Water Engineers, Denver, Colorado
 James Watson, consultant, Littleton, Colorado
 James Wescoat, University of Colorado, Boulder
 Howard Wuertz, Sundance Farms, Collidge, Arizona



Several WSTB studies focus on water management; Water Transfers in the West discusses one method for meeting water needs in a region of scarce supply.

Use of Treated Municipal Wastewater Effluents and Sludge in Crop Production

The application of treated municipal wastewater and sludge to agricultural lands for irrigation and fertilization is a prime example of an opportunity for resource conservation. Wastewater reuse frees high-quality water for purposes other than irrigation, and fertilizing with sewage sludge recycles valuable organic matter and nutrients while improving soil productivity. These beneficial uses of materials traditionally considered wastes offer alternatives to land and water disposal. While wastewater effluents and sludges are widely applied to agricultural land in the United States, application does not typically occur on land used for the production of food crops. Concerns remain about possible contamination of the food supply with human pathogens, heavy metals, and organic chemicals.

The Committee on the Use of Treated Municipal Wastewater Effluents and Sludge in the Production of Crops for Human Consumption, appointed in early

1993, is focusing on issues associated with using wastewater and sludge in food crop production. The committee is evaluating technologies for treating wastewater and sludge prior to reuse, assessing the human health and environmental risks associated with applying wastes to food crops, reviewing relevant regulations, and identifying potential barriers to reuse and ways to overcome them. The committee's work will result in a report to be published in early 1995.

Sponsors for this project are the Environmental Protection Agency, the Bureau of Reclamation, the National Water Research Institute, the Water Environment Research Foundation, the Association of Metropolitan Sewerage Agencies, the Eastern Municipal Water District of Southern California, the National Food Processors Association, BioGro Technologies Inc., and N-Viro International Inc. The staff officer is Gary Krauss. Committee members are

- Albert Page, *Chair*, University of California, Riverside
- Abateni Ayanaba, Del Monte Corporation, Walnut Creek, California
- Michael Baram, Boston University Law School, Massachusetts
- Gary Barrett, Miami University, Oxford, Ohio
- William Boggess, University of Florida, Gainesville
- Sarah Clark Stuart, environmental consultant, Montpelier, Vermont
- Robert Cooper, University of California, Berkeley
- Richard Dick, Cornell University, Ithaca, New York
- Stephen Graef, Western Carolina Regional Sewer Authority, Greenville, South Carolina
- Thomas Long, Washington State Department of Health, Olympia
- Gerald Orlob, University of California, Davis
- JoAnn Silverstein, University of Colorado, Boulder
- Catherine St. Hilaire, Hershey Foods Inc., Hershey, Pennsylvania
- Paul Waggoner, Connecticut Agricultural Experiment Station, New Haven

Flood Control Along the American River

Flooding problems along the American and Sacramento rivers in California have been a matter of concern for some time. In February 1986, major storms in northern

California caused record flood discharges in the American River basin and significant flood damage. Studies have since shown that a serious flood threat exists in the greater Sacramento area.

The WSTB established the Committee on Flood Control Alternatives in the American River Basin at the request of the U.S. Army Corps of Engineers (USACE) to review investigations of flood control and recreation options for the American and Sacramento river basins. The committee is looking broadly at the USACE's planning process and evaluating its flood control feasibility studies for the watershed, with attention to the contingency assumptions, hydrologic methods, and other analyses supporting each of the seven flood control options considered. While the committee is focusing on the Sacramento area, its insights will be of value to other regions faced with similar complex decisions. The committee is not expected to endorse a particular alternative but will evaluate the scientific and engineering knowledge base on which the selection of a final strategy will ultimately be based and will comment on how to weave scientific understanding into a complex decisionmaking process. The committee will publish its report in early 1995.

Funding for this study is from the U. S. Department of Agriculture, the Bureau of Reclamation, the Ford Foundation, and the Irrigation Association. The staff officer is Chris Elfring. Committee members are

Rutherford Platt, *Chair*, University of Massachusetts, Amherst
 Kenneth Potter, *Vice Chair*, University of Wisconsin, Madison
 Leo Eisel, Wright Water Engineers, Denver, Colorado
 James Hall, Oregon State University (*emeritus*), Corvallis
 L. Allan James, University of South Carolina, Columbia
 William Kirby, U.S. Geological Survey, Reston, Virginia
 Nancy Moore, The Rand Corporation, Santa Monica, California
 John Morris, J. W. Morris Ltd., Arlington, Virginia
 Ann Riley, Golden State Wildlife Federation, Berkeley, California

Review of EPA's Environmental Monitoring and Assessment Program



Forests and Estuaries

NATIONAL RESEARCH COUNCIL

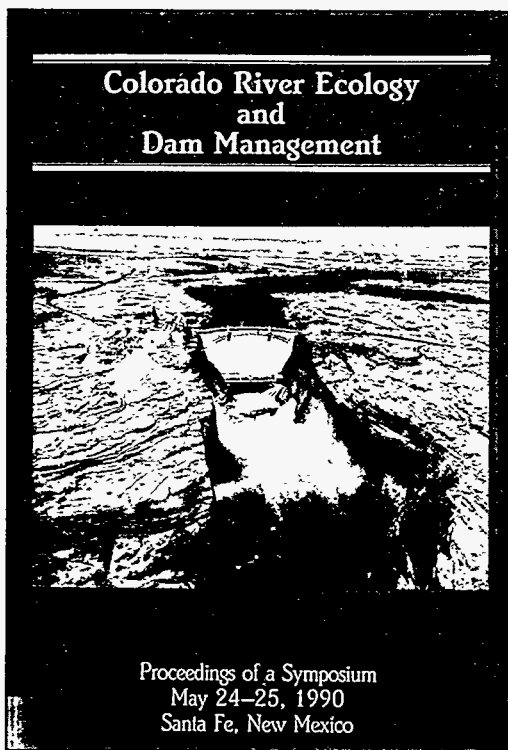
This report of the Committee to Review EPA's Environmental Monitoring and Assessment Program assesses the forest and estuaries component of the program.

Leonard Shabman, Virginia Polytechnic Institute and State University, Blacksburg
 Hsieh Wen Shen, University of California, Berkeley
 Jerry R. Stedinger, Cornell University, Ithaca, New York

FEDERAL PROGRAM ADVICE

Environmental Monitoring and Assessment Program

The Committee to Review the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP), appointed in 1990 by the WSTB and the Board on Environmental Studies and Toxicology (BEST), is reviewing the "EMAP" initiative. The goal of EMAP is to monitor the nation's ecological resources and identify emerging environ-



This report of a colloquium held by the Committee to Review the Glen Canyon Environmental Studies assesses how the Glen Canyon Dam has affected the Colorado River's ecology.

mental problems before they reach crisis proportions. The committee is considering ways to increase EMAP's effectiveness in monitoring eight representative types of resources: near-coastal waters, arid lands, inland surface waters, wetlands, agroecosystems, forests, the Great Lakes, and landscapes. The committee is also reviewing EMAP's overall design, data collection and analysis methods, and indicators used to monitor ecosystem conditions.

In March 1994, the committee released its second report (see p. 14), which reviews the forests and estuaries components of EMAP. The committee will issue a third report, reviewing EMAP's inland surface waters component, in 1994 and a final, comprehensive report by December 1994.

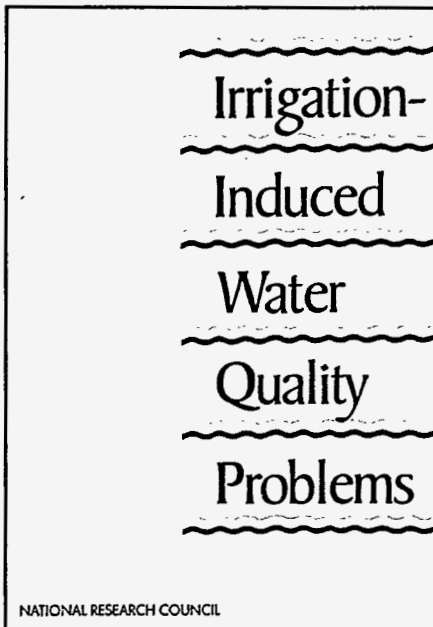
Financial support for this project is from the Environmental Protection Agency. The staff officers are Sheila David (WSTB) and David Policansky (BEST). Committee members are

- Richard Fisher, *Chair*, Texas A&M University, College Station
 Patrick Brezonik, University of Minnesota, St. Paul
 Ingrid Burke, Colorado State University, Fort Collins
 Loveday Conquest, University of Washington, Seattle
 Arthur Cooper, North Carolina State University, Raleigh (*through October 1993*)
 Shirley Dreiss, University of California, Santa Cruz (*through December 1993*)
 Thurman Grove, North Carolina State University, Raleigh
 John Hobbie, Marine Biological Laboratory, Woods Hole, Massachusetts
 Charles Johnson, Jr., consultant, Bethesda, Maryland (*through February 1994*)
 Tim Kratz, University of Wisconsin, Trout Lake Station, Boulder Junction
 Anne McElroy, State University of New York, Stony Brook
 John Pastor, University of Minnesota, Duluth
 James Pitts, consultant, San Clemente, California
 Raymond Price, Queen's University, Ontario, Canada (*through February 1994*)
 Terence Smith, University of California, Santa Barbara
 Susan Stafford, Oregon State University, Corvallis
 Donald Strong, University of California, Bodega Bay (*through February 1994*)
 Michael Wiley, University of Michigan, Ann Arbor

Glen Canyon Environmental Studies

Formed in 1986, the Committee to Review the Glen Canyon Environmental Studies (GCES) provides ongoing advice to the Bureau of Reclamation on the bureau's environmental studies of the lower Colorado River, below Glen Canyon Dam. The committee meets as needed to provide advice and conveys recommendations to the bureau through interim reports, colloquium reports, and formal bound reports reviewing GCES research and related documents.

In 1994, the committee issued two reports. One report reviews the draft federal long-term monitoring plan for the Colorado River below Glen Canyon Dam. The other reviews the bureau's draft environmental impact statement on operation of the dam (see p. 13).



This 1989 report provides guidance on preventing irrigation-related water quality problems like the selenium contamination at Kesterson National Wildlife Refuge.

Irrigation-Induced Water Quality Problems

The WSTB has supported a committee studying aspects of irrigation-induced water quality problems since 1985. The original committee, which existed from 1985 until 1990, provided oversight for the Department of the Interior's San Joaquin Valley Drainage Program in California, which was implemented in response to selenium contamination at Kesterson National Wildlife Refuge. The current committee provides oversight to the Interior Department's National Irrigation Water Quality Program (NIWQP), which is a research and planning program designed to identify and plan remediation for trace element contamination at sites on national wildlife refuges and similar habitats associated with federal irrigation projects in the West.

To date, the NIWQP has evaluated more than 600 sites, with more than 22 sites in 13 states showing high potential for problems and at least 4 sites showing contamination problems severe enough to warrant some sort of mitigation. The committee is particularly concerned with the design of the planning and remediation processes for the 4 sites showing severe contamination. These sites are located in Stillwater, Nevada; Salton Sea, California; Kendrick, Wyoming; and the Middle Green River, Utah. The committee has issued two interim reports evaluating NIWQP and plans to visit the remediation sites for in-depth discussions with the field teams about their research, public participation activities, and processes for developing remediation plans. The committee is scheduled to continue until September 1995.

The project sponsor is the Department of the Interior. Staff officers are Chris Elfring and Gary Krauss. Committee members are

Rolf Hartung, *Chair*, University of Michigan, Ann Arbor
 Hanna Cortner, Water Resources Research Center, University of Arizona, Tucson
 Charles Howard, Charles Howard and Associates, Victoria, British Columbia, Canada
 John Kadlec, Utah State University, Logan
 Richard Krannich, Utah State University, Logan
 Lawrence Libby, University of Florida, Gainesville
 Rosemary O'Leary, Syracuse University, Syracuse, New York
 Albert Page, University of California, Riverside

The committee is scheduled to issue a final, comprehensive report on the Glen Canyon studies by September 1994.

The committee's work is supported by the Bureau of Reclamation. The staff officer is Sheila David. Committee members are

William Lewis, Jr., *Chair*, University of Colorado, Boulder
 Garrick Bailey, University of Tulsa, Oklahoma
 Bonnie Colby, University of Arizona, Tucson
 David Dawdy, consultant, San Francisco, California
 Robert Euler, consulting anthropologist, Prescott, Arizona
 Ian Goodman, The Goodman Group, Boston, Massachusetts
 William Graf, Arizona State University, Tempe
 Clark Hubbs, University of Texas, Austin
 Trevor Hughes, Utah State University, Logan
 Roderick Nash, University of California, Santa Barbara
 A. Dan Tarlock, Illinois Institute of Technology-Chicago Kent College of Law

Ernest Smerdon, University of Arizona, Tucson
Kenneth Tanji, University of California, Davis
Milton Weller, Texas A&M, College Station
Robert Young, Colorado State University,
Fort Collins

USGS Water Resources Research

Formed in 1985, the Committee on U.S. Geological Survey (USGS) Water Resources Research advises the USGS on research issues and matters involving difficult or evolving scientific questions. The committee meets three times each year, rotates one-third of its membership annually, and periodically issues reports transmitting its advice. Topics on which the committee has provided advice include the agency's water quality data and stream gaging networks, National Research Program, institutes and grants programs, and National Water Quality Assessment (NAWQA) program.

Having recently finished a review of the national synthesis component of NAWQA (see p. 13), the committee is turning to the subject of research programs related to hazardous materials science and technology. In support of the USGS's general objective of expanding the body of scientific knowledge relevant to hazardous materials and their behavior in the environment, the committee will help to establish an overall framework for a long-term research plan, identify research priorities for the coming decade, and provide advice on how to improve the involvement of consumers of USGS research in program planning and implementation of results. In addition, the committee anticipates

initiating a review of watershed science programs at the USGS. The committee expects to release reports on these programs in 1995 and 1996, respectively.

Financial support for the committee's work is from the USGS. The staff officer is Sarah Connick. Committee members are

George Hornberger, *Chair*, University of Virginia,
Charlottesville

Lisa Alvarez-Cohen, University of California,
Berkeley

James Biggar, University of California, Davis
Wilfried Brutsaert, Cornell University, Ithaca,
New York

Lenore Clesceri, Rensselaer Polytechnic Institute,
Troy, New York

Robert Davis, University of Colorado, Boulder
Steven Eisenreich, University of Minnesota, Navarre
Dawn Kaback, Colorado Center for Environmental
Management, Golden

Eugene Rasmuson, University of Maryland, College
Park

Frank Schwartz, Ohio State University, Columbus
Mitchell Small, Carnegie Mellon University,
Pittsburgh

James Smith, Princeton University, New Jersey
Richard Sparks, Illinois Natural History Survey,
Havana

Kenneth Weaver, Maryland Geological Survey,
Baltimore

David Woolhiser, Colorado State University,
Fort Collins

FUTURE PLANS

Since its beginning in 1982, the Water Science and Technology Board has become increasingly recognized as a credible source of advice on difficult water resources problems. The number of studies under way at the board has grown annually in response to an increasing number of requests from federal agencies and Congress and greater awareness of the need to safeguard the nation's water resources. Future board studies will continue to break new ground in subjects related to water science, technology, and management. The following brief reviews describe projects the board is considering for 1994 and beyond.

STUDIES SOON TO BEGIN

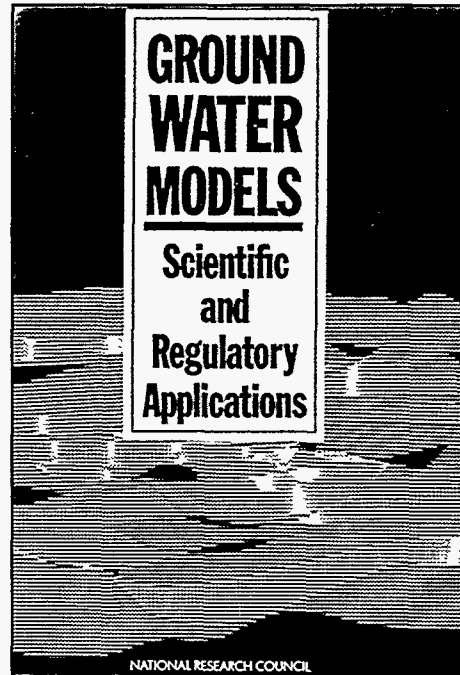
The Future Value of Ground Water

How can policymakers determine the future value of a natural resource to ensure that it is adequately managed and protected for future generations? Current analytical techniques have been criticized for failing to estimate adequately either the full benefits of ground water or the full costs of activities that degrade it. Critics claim that analytical shortcomings may have provided justification for long-term overdevelopment and pollution of ground water for the sake of present gain.

In response to a request from the Environmental Protection Agency (EPA), the WSTB will soon begin a study of approaches for assessing the long-term economic value of ground water and other subsurface environmental resources and the economic impact of contaminating or depleting these resources. The study is sponsored by the EPA and the National Water Research Institute. It will be carried out by a committee of approximately 12 members having expertise in economics, law, water resources planning, ground water hydrology, aquatic chemistry, subsurface ecology, environmental engineering, and natural resources policy.

Innovative Remediation Technologies

Analysts have predicted that the nation will spend \$750 billion over the next 30 years cleaning up the nation's hazardous waste sites. Yet this investment may not



Ground water has been the subject of several WSTB studies, including this 1990 report. A proposed study will assess the future value of ground water.

produce the results society expects. Studies have indicated that existing technologies may be unable to clean up many contaminated sites to a level that allows their unrestricted use. At the same time, use of innovative technologies that could improve prospects for waste-site cleanup has been slowed by numerous barriers, including a lack of the standardized data necessary for designing full-scale cleanup systems.

This study, to begin in late 1994, will provide direction for field testing innovative waste-site cleanup technologies in order to increase their potential for widespread use. The study will have four goals: (1) to provide guidelines for when it is appropriate to move an innovation from the theoretical stage, through the lab and field testing stages, to full-scale application; (2) to establish criteria for assessing claims of success for innovative technologies, including minimum data sets that would allow an innovation tested at one site to be transferred to another site; (3) to develop national guidelines for allowing the testing of innovations at specially designated sites; and (4) to assess the need for

a technology certification program that would help technology users determine the suitability of a technology for a particular site.

Providing Drinking Water to Small Communities

Communities dependent on small drinking water systems (those serving fewer than 3,300 people) frequently cannot afford the technology needed to comply with the Safe Drinking Water Act. While a variety of prefabricated treatment plant technologies appears to offer a cost-effective solution, extensive pilot testing requirements escalate costs significantly. The Environmental Protection Agency has requested that the WSTB carry out a study to help the agency find a balance between regulatory requirements for treatment plant testing, the need to remove contaminants from public drinking water, and affordability. In addition to assessing design and testing requirements for prefabricated treatment plants, the study will explore other opportunities for improving service of the nation's small community water supply systems.

System Navigation Studies of the Upper Mississippi River-Illinois Waterway

In response to a request from the U.S. Army Corps of Engineers (USACE), the WSTB and the Transportation Research Board are planning a project to assess USACE planning studies concerning potential navigation improvements to the Upper Mississippi River-Illinois Waterway. The project will be carried out by a multidisciplinary committee similar in design to the WSTB's long-standing committee on Glen Canyon Environmental Studies.

USACE's preliminary research shows that additions and modifications to the large infrastructure of nearly 40 locks currently in the waterway may be justified. The agency has initiated comprehensive studies of the suggested navigation improvements to assess their engineering feasibility, effects on water management, and environmental and economic impacts. The committee will provide assistance in ensuring that these complex studies are founded on the most current approaches and knowledge in water resources and transportation planning, economics, and environmental sciences.

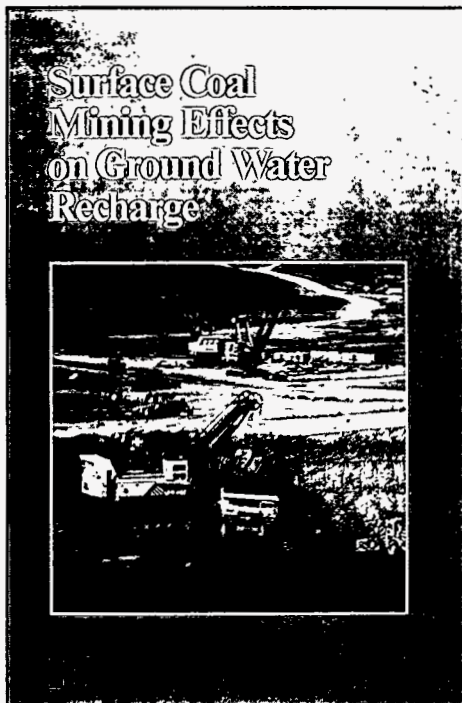
Alluvial Fan Flood Policy

The Federal Emergency Management Agency (FEMA) is under congressional mandate to map flood hazard information to administer the National Flood Insurance Program. In order to receive flood insurance protection, communities must meet certain minimum floodplain management criteria, the development of which requires quantification of a locale's flood risks. Yet in certain areas known as alluvial fans—in which large amounts of loose material have been deposited in the shape of an open fan by various geologic phenomena—predicting flood hazards presents unique problems. Such areas, typically found in semiarid regions of the West, are subject to considerable erosion damage from flash floods, which may inundate an ordinarily dry area in a very short time period. At the request of FEMA, the WSTB is planning a study of methods for delineating hazard areas in alluvial fans.

New Perspectives on Watershed Management

Although watershed management has been a field of interest since the 1930s, managers and planners today must address different (and often more complex) objectives than in the past. The Water Science and Technology Board is planning an investigation of the relationships between activities on land and their impacts on water resources, with emphasis on an ecosystem approach to watershed management.

The study will explore watershed-level processes and problems and identify components of the landscape that are most critical to sustaining the hydrologic system and its aquatic communities. It will review the utility, constraints, and opportunities of a watershed approach to planning, with attention to the specific needs of different ecoregions (i.e., regions with similar soils, water regimes, vegetation, wildlife, climate, geology, physiography, and human influences). The study will investigate instances where failure to take a watershed perspective contributed to water resource problems. It will review current watershed management strategies, assessing whether the scientific information base is available to achieve the stated objectives and helping local, state, regional, and federal managers ensure that activities in watersheds have the least harmful and most beneficial impacts on water resources.



This report discusses the impacts of surface coal mining on ground water recharge. The WSTB is planning a new study of surface and ground water contamination by hard rock mining.

STUDIES IN THE PLANNING STAGES

Seeing Into the Earth

A critical issue for both the nation and the world is the effective management of the earth's surface and shallow subsurface. This so-called near-surface environment, which extends downward for tens to hundreds of meters, supports much of life and yields much of the world's water and mineral resources, but it is also the region most susceptible to contamination and modification from human activities. In order to manage the near-surface environment effectively—to make informed decisions on the impacts of past, present, and future human activities—it is necessary to develop conceptual and quantitative models for the behavior of the "system" represented by the rock, soil, water, life, and air that constitute it. Unfortunately, current methods for characterizing the subsurface used in practice today

are limited and often require destructive drilling and trenching.

The WSTB, in conjunction with the Board on Earth Sciences and Resources and the Geotechnical Board, is planning a study of state-of-the-art techniques for portraying subsurface environments. The study will address questions such as what constitutes adequate characterization, what methods are available for obtaining critical data, where improvements are needed in characterization methods, and what promising new technologies are on the horizon.

Surface and Ground Water Contamination by Wastes from Hard Rock Mining, Milling, and Smelting

Contamination of surface and ground water by wastes from hard rock (metal, as opposed to coal) mining, milling, and smelting is a worldwide problem. Past practices have led to significant environmental damage. Although modern disposal practices can greatly mitigate environmental damage, there remains significant concern among the U.S. public that the environmental impacts associated with the hard rock mining industry are unacceptable. In addition, leaching of mining waste at a large number of abandoned hard rock mining operations throughout the United States continues to impair water quality.

The WSTB, in cooperation with the Board on Earth Sciences and Resources, is exploring the potential need for a study on the prevention and mitigation of surface and ground water contamination by wastes from hard rock mining operations. The study is anticipated to evaluate technical and policy issues faced by federal and state governments and the mining industry as they address contamination problems.

Assessment of Bureau of Reclamation Research Program and Opportunities

In response to a request from the Bureau of Reclamation, the WSTB is planning a study to assess the bureau's current research program and opportunities for the future. For nearly a century, the Bureau of Reclamation has served as the major federal water resources development and management agency in the western United States, focusing primarily on the provision of water supplies to irrigated agriculture and the generation of hydroelectricity in 17 western states. However, since the early 1980s, the agency has been

placing greater emphasis on environmental resources management. The proposed study would assist the bureau in adjusting to this changing focus by providing advice on its overall research strategy and on administrative aspects of the bureau's research programs.

Ecological Impacts of Hazardous Chemical Spills

Every day, hazardous chemicals are released by accident into aquatic environments from sources such as pipelines, trucks, trains, ships, and factories. Unfortunately, the research needed to cope with the environmental and human health risks from chemical spills follows an erratic boom-and-bust cycle. Public and political interest are high after a catastrophic spill, when polluted waterways and dying wildlife are featured in all the media. Later, as acute effects diminish but long-term and less obvious problems persist, public interest fades along with the political will for a sustained research program. The Exxon Valdez accident demonstrated the nation's lack of preparedness for a major spill and the limits of techniques for monitoring the effects of oil spills.

The WSTB is currently planning a study of methods for assessing ecological impacts of hazardous chemical spills in aquatic environments. The study would identify the types of monitoring that are most effective for predicting the spread, potential harm, and long-term consequences of hazardous chemical releases. It would provide guidance on sampling strategies for water and

sediments, chemical analysis methods for contaminants, biological analyses for determining effects on populations, and interpretation of sampling data.

Water Resources Along the U.S.-Mexico Border

Competition for transboundary water resources is increasingly a point of contention on the U.S.-Mexico border. The border rivers are neither plentiful nor clean sources of water. Ground water supplies, which are the only water source for much of the region, are being depleted. The U.S.-Mexico Border Industrial Program, launched in 1965 to stimulate the economy of the border states, has attracted a large number of people to the border region. The proliferation of U.S.-owned industrial plants and the resulting unplanned growth have caused deterioration of scarce water supplies by untreated sewage, industrial wastes, and agricultural and mining wastewater.

As the United States and Mexico develop closer ties, border issues become increasingly important. The WSTB is planning a joint study with the Mexican Academy of Sciences to examine how binational efforts to manage water resources, water quality, and associated health problems can be better coordinated. The study would address public concerns over secure water supplies, the dangers of water-related health problems along the border, and the high level of ongoing and planned activities by both the U.S. and Mexican governments in the border region.

PUBLISHED REPORTS

The Water Science and Technology Board produces reports covering a wide range of water science, technology, and policy matters. This section provides information about reports dating back to 1982, the year the board was formed. These reports are produced in three general formats:

- **Committee reports** are the products of intensive deliberations about critical topics by a committee of experts in the field. These are published in book format.

- **Colloquium proceedings** contain papers presented at colloquia and an overview prepared by an expert committee. These are published in book format.

- **Wolman lectures** are transcripts from the Water Science and Technology Board's annual lecture in honor of Dr. Abel Wolman, pioneer in the water supply and sanitation field. Written transcripts and videotapes of the lectures are available.

Reports are available from one of the following three sources:

National Academy Press
2101 Constitution Avenue, N.W.
P.O. Box 285
Washington, D.C. 20055
(800) 624-6242
(202) 334-3313
Fax (202) 334-2451

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Water Science and Technology Board
2101 Constitution Avenue, N.W.
Room HA 462
Washington, D.C. 20418
(202) 334-3422
Fax (202) 334-1961

To order the reports described in the following list, contact the source indicated. Note that information about interim reports—brief reports conveying the short-term assessments of committees involved in long-term projects—is not included here.

FINAL COMMITTEE REPORTS

National Water Quality Assessment Program: The Challenge of National Synthesis

This report examines the U.S. Geological Survey's national synthesis approach to water quality assessment and provides recommendations for improvement. *Committee chair:* George Hornberger, University of Virginia.

1994

6x9, 51 pages, paperbound

Order from Water Science and Technology Board

No charge—limited quantities

In Situ Bioremediation: When Does It Work?

In situ bioremediation—the use of microorganisms for in-place removal of contaminants—is potentially cheaper, faster, and safer than conventional environmental cleanup methods. This report provides direction for decisionmakers and offers detailed explanations of the processes involved in in situ bioremediation, circumstances in which it is best used, and methods for evaluating the results of bioremediation projects. *Committee chair:* Bruce Rittmann, Northwestern University.

1993

6x9, 208 pages, hardbound

Order from National Academy Press

\$29.95

Ground Water Vulnerability Assessment: Predicting Relative Contamination Potential Under Conditions of Uncertainty

This report reviews the classes of current ground water vulnerability assessment methods. It examines the uncertainties associated with various approaches, provides guidance in the selection of an approach, summarizes relevant data bases available in the United States, and identifies areas of research important for the development of future assessment techniques. *Committee chair:* Armando Carbonell, Cape Cod Commission.

1993

6x9, 204 pages, hardbound

Order from National Academy Press
\$29.95

Managing Wastewater in Coastal Urban Areas

This report examines the problems of wastewater and stormwater management in coastal urban settings, where water quality issues are often complex. The report recommends a system of integrated coastal management for wastewater and stormwater. It describes the fundamental basis for an integrated coastal management system, spells out crucial elements, and provides significant technical information on how such an approach can be implemented. *Committee chair:* John Boland, Johns Hopkins University.

1993
6x9, 448 pages, hardbound
Order from National Academy Press
\$49.95

**Restoration of Aquatic Ecosystems:
Science, Technology, and Public Policy**

This study outlines a national strategy for restoring the nation's rivers, streams, wetlands, and lakes. It features case studies of aquatic restoration activities around the nation and offers practical recommendations for implementing a long-term, comprehensive strategy for restoring the nation's aquatic ecosystems. *Committee chair:* John Cairns, Jr., Virginia Polytechnic Institute.

1992
6x9, 485 pages, hardbound
Order from National Academy Press
\$39.95

**Water Transfers in the West: Efficiency, Equity,
and the Environment**

Water resource planners in the arid West face increasing competition for water. This report examines one response to the pressures on water supplies: water transfers. It evaluates the impacts on the environment, rural communities, and other "third parties" that result when water is transferred from agricultural to other uses. *Committee chair:* A. Dan Tarlock, Chicago-Kent College of Law.

1992
6x9, 359 pages, hardbound
Order from National Academy Press
\$39.95

Opportunities in the Hydrologic Sciences

This work presents a comprehensive assessment of scientific hydrology. The report covers research frontiers, data needs, education in the hydrologic sciences, and resources for future work in this field. *Committee chair:* Peter Eagleson, Massachusetts Institute of Technology.

1991
6x9, 348 pages, hardbound
Order from National Academy Press
\$29.95

**Preparing for the Twenty-First Century:
A Report to the USGS Water Resources Division**

This report outlines a plan for improved management of the U.S. Geological Survey's Water Resources Division. It covers the agency's organization, research priorities, data collection systems, and external outreach. *Committee chair:* Walter Lynn, Cornell University.

1991
6x9, 40 pages, paperbound
Order from National Academy Press
\$10.00

**Toward Sustainability: Soil and Water Research
Priorities for Developing Countries**

This report highlights soil and water research critical to fostering sustainable agricultural practices for developing countries. *Committee chair:* Leonard Berry, Florida Atlantic University.

1991
6x9, 65 pages, paperbound
Order from National Academy Press
\$9.95

**Ground Water Models: Scientific and Regulatory
Applications**

This work provides advice on the use of ground water flow and contaminant transport models in the regula-

tory process. *Committee chair:* Frank Schwartz, Ohio State University.

1990
6x9, 302 pages, hardbound
Order from: National Academy Press
\$29.95

Managing Coastal Erosion

This report discusses natural coastal erosion processes and how they are affected by human activity. It advises the Federal Emergency Management Agency on erosion management strategies and how to administer them through the National Flood Insurance Program. *Committee chair:* William Wood, Purdue University.

1990
6x9, 182 pages, hardbound
Order from National Academy Press
\$24.50

A Review of the USGS National Water Quality Assessment Pilot Program

This report reviews the U.S. Geological Survey's program to evaluate surface and ground water quality, the National Water Quality Assessment Program. *Committee chair:* Richard Engelbrecht, University of Illinois.

1990
6x9, 153 pages, paperbound
Order from National Academy Press
\$15.00

Surface Coal Mining Effects on Ground Water Recharge

This volume assesses techniques for quantifying ground water recharge in surface-mined areas. *Committee chair:* Herman Bouwer, Water Conservation Laboratory, U.S. Department of Agriculture.

1990
6x9, 159 pages, paperbound
Order from National Academy Press
\$17.00

Irrigation-Induced Water Quality Problems

This report addresses how irrigation can impair water quality. It advises how to mitigate existing irrigation-

induced water quality problems and prevent future problems. *Committee chair:* Jan van Schilfgaarde, U.S. Department of Agriculture, Agricultural Research Service.

1989
6x9, 157 pages, hardbound
Order from National Academy Press
\$24.95

Estimating Probabilities of Extreme Floods: Methods and Recommended Research

This report evaluates techniques for characterizing rare floods. It includes a general overview and detailed analyses of statistical and runoff modeling approaches. *Committee chair:* Jared Cohon, Johns Hopkins University.

1988
6x9, 141 pages, paperbound
Out of print

River and Dam Management: A Review of the Bureau of Reclamation's Glen Canyon Environmental Studies

This report provides recommendations to the Bureau of Reclamation about the Glen Canyon Environmental Studies (GCES). It reviews the bureau's planning and management of this project; the integration of the GCES results into a decision-making report; and the utility of the GCES results for management of the Glen Canyon Dam. *Committee chair:* G. Richard Marzolf, U.S. Geological Survey, Boulder, Colorado.

1988
6x9, 203 pages, hardbound
Order from Water Science and Technology Board
No charge—limited quantities

Ground Water Quality Protection: State and Local Strategies

This report reviews ground water protection strategies in ten states and three local areas of the United States. The report provides a model for those looking to establish or improve ground water quality protection programs. *Committee chair:* Jerome Gilbert, East Bay Municipal Utility District, Oakland, California.

1986
8½x11, 296 pages, paperbound
Order from National Academy Press
\$29.95

A Review of the U.S. Army Construction Engineering Research Laboratory Program for Recycling and Reuse of Laundry and Shower Wastewater

This study evaluates the U.S. Army's Construction Engineering Research Laboratory program for reusing field laundry and shower wastewater. *Committee chair:* Richard Engelbrecht, University of Illinois.

1986
6x9, 104 pages, paperbound
Order from National Technical Information Service
Accession number: PB 87-157467
\$18.95

The Great Lakes Water Quality Agreement:

An Evolving Instrument for Ecosystem Management
This report reviews the 1978 Great Lakes Water Quality Agreement between the United States and Canada. The report covers nutrient enrichment, toxic contamination, and institutional arrangements and sustainable development for preserving water quality. *Committee co-chairs:* Orié Loucks, Holcomb Research Institute, and Henry Regier, University of Toronto.

1985
6x9, 224 pages, paperbound
Order from National Technical Information Service
Accession number: PB 87-186292
\$24.95

Safety of Dams: Flood and Earthquake Criteria

This volume assesses design levels for withstanding extreme floods and earthquakes at new and existing dams. The report includes a thorough inventory of safety criteria for dams in use in the United States and internationally. *Committee chair:* George Housner, California Institute of Technology.

1985
6x9, 224 pages, paperbound
Order from National Academy Press
\$24.95

The Lake Erie–Niagara River Ice Boom: Operations and Impacts

This report responds to a request from the International Joint Commission of the United States and Canada to help resolve issues associated with the ice boom at the entrance to the Niagara River. *Committee chair:* Harry Hamilton, Jr., State University of New York, Albany.

1984
8½x11, 74 pages, paperbound
Order from National Technical Information Service
Accession number: PB 84-129709
\$11.50

Potomac Estuary Experimental Water Treatment Plant

This report is the culmination of an eight-year review of the U.S. Army Corps of Engineers study to determine the feasibility of using Potomac estuary waters as a water-supply source for metropolitan Washington, D.C. *Committee chair:* Perry McCarty, Stanford University.

1984
6x9, 135 pages, paperbound
Order from National Technical Information Service
Accession number: PB 84-195643
\$16.00

Water for the Future of the Nation's Capital Area

This report reviews the Army Corps of Engineers' determination of future water resources needs for metropolitan Washington, D.C. *Committee co-chairs:* Daniel Okun, University of North Carolina, and Walter Lynn, Cornell University.

1984
6x9, 78 pages, paperbound
Order from National Technical Information Service
Accession number: PB 84-195585
\$11.50

Safety of Existing Dams: Evaluation and Improvement

This report addresses dam safety issues and provides guidance for achieving improvements in the safety of

existing dams. *Committee chair*: Robert Jansen, consulting engineer, Bellingham, Washington.

1983
6x9, 384 pages, paperbound
Order from National Academy Press
\$19.95

A Levee Policy for the National Flood Insurance Program

This report provides recommendations for integrating structural and nonstructural flood mitigation in the National Flood Insurance Program. *Committee chair*: L. Douglas James, Utah State University.

1982
8½x11, 187 pages, paperbound
Order from National Technical Information Service
Accession number: PB 83-217992
\$17.50

Safety of Nonfederal Dams: A Review of the Federal Role

This report evaluates state and federal roles in enhancing dam safety programs. *Committee chair*: Robert Jansen, consulting engineer, Bellingham, Washington.

1982
6x9, 53 pages, paperbound
Order from National Technical Information Service
Accession number: PB 82-188855
\$9.00

COLLOQUIUM PROCEEDINGS

Colorado River Ecology and Dam Management

For more than 30 years, critics have raised questions about how the Glen Canyon Dam on the Colorado River affects the river's ecology, especially along the portion flowing through the Grand Canyon National Park. The proceedings from this colloquium review existing information about the Colorado River ecosystem and how the dam has affected it. *Steering committee chair*: G. Richard Marzolf, U.S. Geological Survey, Boulder, Colorado.

1991
6x9, 276 pages, paperbound
Order from Water Science and Technology Board
No charge—limited quantities

Managing Water Resources in the West Under Conditions of Climate Uncertainty

Western water managers are beginning to consider whether and how climate change may affect the region's already over-stressed water supplies. The papers in these proceedings examine the scientific basis for and the management options available for responding to climate change. *Steering committee chair*: Stephen Burges, University of Washington.

1991
6x9, 344 pages, paperbound
Order from Water Science and Technology Board
No charge—limited quantities

Ground Water and Soil Contamination Remediation: Toward Compatible Science, Policy, and Public Perception

These proceedings focus on how science influences policy and public perceptions related to cleanup of ground water and soil contamination. The report describes the scientific constraints that should influence soil and ground water cleanup policy. *Steering committee chair*: Richard Conway, Union Carbide Corporation.

1990
6x9, 261 pages, paperbound
Order from National Academy Press
\$19.00

Great Lakes Water Levels: Shoreline Dilemmas

These proceedings address hydrometeorological, engineering, land-management, and policy issues related to fluctuations in Great Lakes water levels. *Steering committee chair*: John Boland, Johns Hopkins University.

1989
6x9, 167 pages, paperbound
Out of print

Hazardous Waste Site Management: Water Quality Issues

This collection of papers covers ground and surface water cleanup levels at hazardous waste sites. *Steering committee chair:* Michael Kavanaugh, James M. Montgomery Consulting Engineers.

1988
6x9, 212 pages, paperbound
Order from National Academy Press
\$24.50

National Water Quality Monitoring and Assessment

These proceedings discuss the need for a national water quality monitoring and assessment program. *Steering committee chair:* Richard Engelbrecht, University of Illinois.

1987
6x9, 108 pages, paperbound
Order from National Technical Information Service
Accession number: PB 87-157467
\$18.95

Drought Management and Its Impact on Public Water Systems

The papers in these proceedings address drought management and its impact on public water systems. *Steering committee chair:* Robert Smith, University of Kansas.

1986
6x9, 127 pages, paperbound
Order from National Academy Press
\$22.00

Review of the Great Lakes Water Quality Agreement: Working Papers and Discussion

This report conveys the results of a conference to evaluate the Great Lakes Water Quality Agreement. *Steering committee chair:* Orie Loucks, Holcomb Research Institute.

1984
8½x11, 174 pages, paperbound
Order from National Technical Information Service

Accession number: PB 85-110807
\$17.50

Cooperation in Urban Water Management: Conference Proceedings

These proceedings assess the barriers to efficient management of urban water supplies. *Conference chair:* David Marks, Massachusetts Institute of Technology.

1983
8½x11, 187 pages, paperbound
Order from National Technical Information Service
Accession number: PB 83-217992
\$17.50

WOLMAN LECTURES

Transnational Water Resources Management: Learning from the U.S.-Mexico Example

In this 1993 lecture transcript, Dr. Helen Ingram, director of the Udall Center for Studies in Public Policy at the University of Arizona, discusses the complexities that national borders create in water resources management, as illustrated along the U.S.-Mexico border. She suggests new cooperative approaches for finding solutions to water management problems in border regions.

1993
8½x11, 15 pages, photocopied
Order from Water Science and Technology Board
No charge

Irrigation: A Blessing or a Curse?

In this 1992 lecture transcript, Jan van Schilfgaarde, associate deputy administrator of the U.S. Department of Agriculture Agricultural Research Service, outlines the consequences of irrigation, from its critical role in food supply to its potential negative environmental impacts.

1992
8½x11, 18 pages, photocopied
Order from Water Science and Technology Board
No charge

Meeting the Need for Water and Sanitation for Urban Populations

In most cities in Africa, Latin America, and Asia, water is undrinkable and sanitation services are inadequate or nonexistent. In this 1991 lecture transcript, Dr. Daniel A. Okun, Kenan Professor of Environmental Engineering, Emeritus, at the University of North Carolina, Chapel Hill, outlines a plan for expanding the water-supply and sanitation capacity in cities in the developing world.

1991
8½x11, 14 pages, photocopied
Order from Water Science and Technology Board
No charge
Videotapes available on loan

Ethos, Equity, and the Water Resource

Fragmentation among U.S. water management institutions may be exacerbating the continued deterioration of the nation's water resources, contends Dr. Luna Leopold, professor of geology, emeritus, at the University of California, Berkeley, in this 1990 lecture transcript. Dr. Leopold discusses the need for an ethos—guiding beliefs—and equity—consideration of all the competing interests—in water resources management.

1990
8½x11, 21 pages, photocopied
Order from Water Science and Technology Board
No charge
Videotapes available on loan

TERMS OF REFERENCE

The Water Science and Technology Board's terms of reference establish the board's operating policies: how study topics are selected, how committee members are nominated, and how board studies are managed. The terms of reference were adopted on November 29, 1982, and modified on December 13, 1990.

Introduction and Purposes

The Water Science and Technology Board was established in the National Research Council to provide a focal point for studies related to water resources accomplished under the aegis of the National Academy of Sciences and the National Academy of Engineering. The board's objective is to improve the scientific and technological basis for resolving important questions and issues associated with the efficient management and use of water resources.

In carrying out its responsibilities and to serve the national interest, the board responds to requests for evaluations and advice concerning specific and generic issues in water resources, influences action by initiating studies of issues that merit consideration by public agencies and others, identifies issues and topics of research related to water resources, and cooperates with other units of the National Research Council and groups with mutual interests outside the National Research Council.

The board's scope covers all aspects of water resources, including science, engineering, economics, institutions, relevant laws, educational issues, and social aspects.

Areas of Interest

To pursue its objectives, the board is concerned with:

- basic hydrologic and related sciences and their applications in water resource systems, including analyses of the hydrologic cycle, measurement of water quantity and quality, data analysis, and forecasting;
- planning, analysis, and operation of water systems, including resource management, water quality and quantity for all uses, public health and environmental protection, aquifer and watershed protection and management, economic analysis, design standards, modeling methods, risk assessment, system analysis techniques, and management systems;
- nonstructural water resources issues, such as

floodplain management, supply-demand relationships, water reallocation and reuse, effects of human activities on water resources, legal-institutional issues, ecosystem effects, and cultural and aesthetic values;

- structural and traditional engineering aspects of water projects, such as dams and other water control structures, renovation-retrofit technologies, and treatment processes; and
- the health and vitality of the nation's water-related science and engineering establishment, including its educational aspects.

General Activities

The board strives to accomplish its purposes through the following means:

- responding to specific requests for advice from government agencies and others;
- initiating investigations of issues considered to be appropriate by the board, its parent commissions, and the Governing Board of the National Research Council;
- reviewing research and the state-of-the-art in science, technology, and social sciences related to the development and management of water and related resources, especially in relation to national objectives and priorities;
- projecting future needs for and capabilities of multidisciplinary research and education in the water sciences, and technologies;
- disseminating the results of its studies, serving as a repository of scientific and engineering knowledge, and providing a forum for the exchange of information on water science and technology;
- fostering communication among members of the professional community in the United States on national and international water resources issues; and
- evaluating and articulating relevant educational issues, including undergraduate, postgraduate, continuing education, and public-education programs and the related needs for equipment and facilities.

Criteria for Activities

Proposed projects or other activities are individually evaluated by the board according to the following criteria (though there may be cases where for good reason not all of the criteria are met):

- generic applicability of the issues to the nation relative to its water needs and quality;
- important scientific and/or technological questions to be addressed;
- involvement of significant institutional and public policy issues, such as resource allocation, risk management, conflicting regulations, and inter-media tradeoffs;
- relevance of the work to the board's areas of interest and competence and its long-range objectives;
- availability of expert volunteers from relevant disciplines who can ensure that the board's contribution will be appropriate, effective, and timely;
- involvement of key policymakers and other interested parties to ensure that the board's response will have a significant audience; and
- uniqueness of the WSTB to conduct the study because of its breadth and independence as a National Research Council board.

Governance and Relationship with Parent Bodies

The board, although responsible for its own immediate governance, is accountable to and supported by two commissions of the National Research Council: the Commission on Engineering and Technical Systems (CETS) and the Commission on Geosciences, Environment, and Resources (CGER). CETS is primarily concerned with the development and application of engineering disciplines to technological systems and their relationship to societal problems, while CGER is primarily concerned with the sciences and policies relevant to resource identification and development and environmental management. For each of its specific technical, project, or administrative activities, the board or its study groups will be responsible to and supported by either CETS or CGER.

The board may undertake activities related to its mission, such as colloquia and seminars. It may collaborate with professional associations and other groups as may be necessary to fulfill its goals.

The board may recommend to the chair of the National Research Council and to the commissions such changes in the purposes, responsibilities, size, and functions of the board as it believes desirable.

Board Membership

To meet its broad needs, the board consists of about 15 to 18 members. Members are chosen for their

expertise and experience as well as for their familiarity with appropriate scientific, technological, and policy issues. While serving on the board, each member, insofar as possible, participates in at least one study conducted under the auspices of the board. Additionally, members normally participate in a variety of project development and oversight efforts.

Terms of appointment are normally for three years. Members are not eligible for more than two consecutive three-year terms. The board chair and a vice chair are appointed by the chair of the National Research Council for a period not to exceed three years. The board nominates individuals for its own continuing membership.

When appropriate, the board may invite federal agencies and organizations to nominate individuals to serve as nonvoting liaison representatives to the board and any of its work groups.

Study Group Activities

The principal operating units of the board are its separately appointed and individually mandated study groups. The board, assisted by its staff, manages the activities of these units. The scope of the board's activities will vary commensurate with the topic and need. Types of activities range from lectures, seminars, workshops, and colloquia to extended multiyear, carefully deliberated studies. In some cases, study groups will interact very closely with those receiving advice; in other cases, a more independent approach will be more effective.

The board exercises its oversight responsibility for ongoing studies by receiving reports from the chairpersons or staff and meeting with them as it deems appropriate.

The board originates or reviews and approves nominations for membership on the study group committees and transmits its recommendations to the appropriate commission.

The board chair, with the approval of the chair of the appropriate commission and the chair of the National Research Council, appoints members of committees of the board.

In recommending nominations for committees, the board seeks advice from within and outside the National Research Council. Normally, members of committees or panels serve for the duration of a given study.

Reports

The board's principal products are its reports. These range from "letter" reports, generally focused on particular agency programs and read by a limited, but important, audience of government managers, to major reference-type publications distributed by the thousands by the National Academy Press that address more general areas of water science, technology, and policy.

The board reviews all reports that develop from its program in accordance with procedures and requirements established by the appropriate commission and by the Report Review Committee of the National Research Council. All members of the board are routinely invited to participate in report reviews.

Additionally, the board's staff produces an annual report and quarterly newsletter, both of which communicate information about the board's interests, plans, accomplishments, and other activities relevant to the program.

Board Meetings

The board normally meets three times each year. Additional meetings are held as the board deems necessary to carry out its responsibilities for planning, oversight, and review including, but not limited to, review and assessment of current activities; consideration and approval of new projects, proposals, and proposed memberships; technical and programmatic briefings; and discussions with government decision-making and policy personnel.

Program Planning

Periodically, the board develops and reviews a strategic program plan, indicating general objectives and desired study initiatives for the subsequent three- to five-year period. The board then formulates programs and requests funds in support of undertakings deemed to be logical, appropriate extensions of its program plan, subject to appropriate approvals by National Research Council commissions and the Governing Board.

The board reviews all proposals for new activities that require the use of outside funds. Proposals must be approved by the board before a request for authorization to receive funds is submitted to the appropriate commission and the Governing Board.

Staff

The board director is responsible to the chair for the general management of the board's program and to the executive directors of CETS and CGER. The director has the authority to hire additional staff members and consultants necessary to assist in overall management of the board's program, subject to National Research Council administrative policies and financial constraints.

Expenses

Expenses of the board (core support) and its study groups (project funding), including support of its staff and meetings, are ordinarily financed by contracts, grants, or cooperative agreements from federal or state agencies, private foundations, or industries.