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WATER SCIENCE AND TECHNOLOGY BOARD
ANNUAL REPORT 1984

DISCLAIMER

Water Science and Technology Board
Commission on Engineering and
Technical Systems
Commission on Physical Sciences,
Mathematics, and Resources
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The Water Science and Technology Board is a unit of the National Research Council, which serves as an independent adviser to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees.

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CONTENTS

CHAPTER 1

INTRODUCTION

This is the second annual report of the Water Science and Technology Board (WSTB), a unit of the National Research Council (NRC). It summarizes the Board's activities during 1984, ongoing activities (i.e., in 1985), and future plans. Information is included also on Board and study group memberships, program organization, issues of concern, and reports published.

For the Water Science and Technology Board, 1984 was marked by several significant events and achievements, and the Board's program for the year must be considered successful. A number of important new activities were undertaken, including a study of the technical and institutional aspects of state and local ground-water protection programs and an assessment of flood and earthquake criteria to be used in the evaluation of the safety of dams. In cooperation with the Royal Society of Canada, a study committee of the Board is reviewing the Great Lakes Water Quality Agreement, with the report likely to make recommendations for consideration by the U.S. and Canadian governments if they renegotiate the Agreement in 1986. A new, standing Committee on Water Resources Research was established to assist the Department of the Interior, through the U.S. Geological Survey, in carrying out its responsibilities under the Water Resources Research Act of 1984 and to assist the Survey and the Board with other water research-related matters.

The year 1984 also marked completion of the Research Council's long involvement in studies of water supply planning for the Washington, D.C., metropolitan area and an experimental water treatment plant in the Potomac River estuary. Involvement by the NRC in these activities over the years, and the somewhat more diverse water resources program that became established in association with the studies, was in large part central to creation of the Water Science and Technology Board by its parent commissions in 1982.

In its principal role as an adviser to the federal government on water resources matters, the Board responds to fairly well identified agency needs for advice and assistance. Sometimes the Board finds itself concerned with broader, generic issues, even though current needs may be more limited. For example, as is discussed in Chapter 5, the Department of the Interior is initiating a research program designed to help assess and resolve the problem of high levels of

selenium in irrigation return flows in the San Joaquin Valley of California. The Board is looking forward to becoming involved in this assessment because of the opportunity to deal with the specific problem, but also because of the importance of irrigation-related water quality problems to the nation in general.

The Board believes that it has a responsibility to encourage the government and indeed the nation to address continuing issues, as well as to anticipate emerging problems, in water resources science and technology. In this regard, the Board plans to conduct a new colloquia series on emerging issues in water science and technology beginning in 1985. This series is intended to include questions in basic hydrology and related sciences that may not receive adequate attention from the body politic. Sometimes such issues do not relate to existing federal programs and, thus the series should serve as a useful resource to the government and others in planning activities.

This report should provide the reader a basic understanding of the Board's interests, achievements, and capabilities. Board members welcome inquiries and suggestions concerning Board activities, and the staff would be happy to provide more detailed information on any aspect of the Board's work to those interested.

CHAPTER 2

THE WATER SCIENCE AND TECHNOLOGY BOARD

The Water Science and Technology Board was established in 1982 as the focal point for activities within the National Research Council related to water resources. The Board's scope covers the traditional scientific and engineering aspects of water resources and the economic, institutional, legal, educational, and social aspects as well. With such broad and diverse interests, the Board is accountable to and supported by two commissions of the National Research Council--the Commission on Engineering and Technical Systems and the Commission on Physical Sciences, Mathematics, and Resources. While the Board's program is shared equally by the two commissions, each specific technical project or administrative activity is assigned, based on its character, to one or the other commission as appropriate.

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

1. Responding to specific requests by government agencies and others;
2. Reviewing and evaluating water-related research and scientific, engineering, and technological developments;
3. Initiating investigations of issues considered to be appropriate by the Board, its parent commissions, and the Governing Board of the National Research Council;
4. Reviewing research and the state of the art in science, engineering, and technology related to the development and management of water and related resources, especially in relation to national objectives and priorities;
5. Projecting future needs for and capabilities of multidisciplinary water-related research and education in the sciences, engineering, and technology;
6. 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;
7. Fostering communication among members of the professional community in the United States on national and international water resources issues; and

8. Articulating water-related educational issues, including undergraduate, postgraduate, continuing education, and public education programs and the related needs for equipment and facilities.

Standing subcommittees of the Board are available to conduct program-level activities (issue evaluation, project development, and report reviews) in three areas: hydrology and hydraulics; water quality and technology; and management, analysis, and planning.

The Board chairman and the chairmen of the three subcommittees comprise the Board's executive committee. Special committees and panels of the Board are established to conduct issue-specific studies when these are requested by federal agencies and others.

The Board meets three times each year. At meetings, issues and research needs are considered, new initiatives are developed, and ongoing projects are monitored. Meetings of the Board serve as a mechanism of communication among the water resources community. Most federal agencies with water resources responsibilities have liaison representatives to the Board. Additional communication is effected among the liaison members, who occasionally meet as a group to discuss Board-related activities, and through a bimonthly newsletter prepared by the Board's staff and the Board's annual report. During 1984, on several occasions, Board members met informally with federal agency representatives to discuss program needs and to plan appropriate activities.

In 1984, financial support for the Board's general and specific project activities was provided by the U.S. Geological Survey, Federal Emergency Management Agency, Bureau of Reclamation, U.S. Department of Energy, Environmental Protection Agency, National Science Foundation, Corps of Engineers, and the William H. Donner Foundation, Inc. The Board's budget for general activities and special studies during 1984 totaled about $500,000.

CHAPTER 3

PROJECT ACTIVITIES COMPLETED IN 1984

Safety of Dams: Flood and Earthquake Criteria

An evaluation of safety criteria for dams was undertaken at the request of the Assistant Secretary of Interior for Water and Science and the Assistant Secretary of the Army for Civil Works. At issue was the appropriate level of design of dams to withstand extreme floods and earthquakes. Initially, an inventory of existing criteria, procedures, and design standards in use by government at all levels and by nongovernmental entities both in the United States and in other countries, with respect to flood and earthquake hazards, was compiled and evaluated. The study committee (see Appendix A) evaluated current practices, and its report (Appendix C) makes recommendations emphasizing that a principal objective in dam safety should be to strike a balance among such considerations as project benefits, construction costs, and public safety, including the possible consequences of a dam failure due to major earthquakes and floods. This activity was initiated in May 1984 and completed with publication of the report "Safety of Dams: Flood and Earthquake Criteria" in January 1985.

Review of the Great Lakes Water Quality Agreement: Phase I

The William H. Donner Foundation, Inc., in consultation with the staff of the International Joint Commission, asked the Water Science and Technology Board (WSTB) to review the Great Lakes Water Quality Agreement. A first phase, which is the subject of published proceedings, "Review of the Great Lakes Water Quality Agreement--Working Papers and Discussion," consisted of a conference in April 1984 to define the details of a major review. Conference participants identified those scientific, technical, and institutional issues upon which an in-depth study, a second phase, should focus. The first-phase report (see Appendix C) contains five formal papers and discussion related to each, as well as a summary chapter prepared by the conference advisory panel. These working papers are being used as background information for the in-depth review currently in progress.

Water for the Future of the Nation's Capital Area--1984

In 1974, Congress mandated the Secretary of the Army, acting through the Chief of Engineers, to "make a full and complete investigation and study of the future water resources needs of the Washington Metropolitan Area...." Congress also directed the Secretary of the Army to "request the NAS-NAE to review and by written report comment upon the scientific basis for the conclusions reached by the Corps investigation." A committee was established in 1977 to accomplish this task. Between then and April 1984, the committee (see Appendix A) issued five letter reports, one interim report, and one final report to the U.S. Army Corps of Engineers (Appendix C).

The final report commends the Corps for certain achievements, such as (1) development of systems management (nonstructural) solutions to problems relative to the metropolitan Washington area future water supply needs, (2) determination and assessment of future water demands by use of improved modeling, (3) development of a wide range of alternative methods of meeting future water resource needs of the metropolitan Washington area, (4) involvement and use of the citizens of the metropolitan Washington area in developing design criteria and recommendations for future actions, and (5) the collection and collation of current and historical data used in the analysis of the metropolitan Washington area study. However, the committee also reported that the Corps study contained a number of deficiencies that detracted from the innovative contributions that characterize the study. These flaws lie in three areas: the reliability of institutional arrangements, the lack of planning for preservation of reservoir sites, and drinking water quality.

The Potomac Estuary Experimental Water Treatment Plant

In 1974 under Section 85 of the Water Resources Development Act (P.L. 93-251), Congress authorized the U.S. Army Corps of Engineers to determine the feasibility of using the Potomac estuary waters as a source of water supply for the Washington metropolitan area. In this connection, a two-year pilot plant project was authorized involving the construction, operation, and evaluation of a small water treatment plant. The act also directed the Corps to request the National Academy of Sciences/National Academy of Engineering to provide a review and written report of comments on the scientific basis for the conclusions reached by the Corps. The National Research Council appointed a committee to respond to this request in 1976. Between then and April 1984, the committee (see Appendix A) issued four letter reports, a panel report, and a final report to the Corps of Engineers (Appendix C).

In its final report, the committee commends the Corps study for certain outstanding features, including (1) detailed comparative evaluation of the quality of treated estuary water with that of three major treated water supplies for the metropolitan Washington area, (2) development of a detailed inorganic and organic chemical

characterization of treated estuary water and of local water supplies, (3) development of a data base on microbiological contaminants and toxicological indications, and (4) the demonstrated reliability of advanced treatment processes to provide treated water with relatively consistent quality.

However, the committee also felt that there were limitations to this study and to the conclusions reached. The limitations were that (1) insufficient scientific evidence was provided to evaluate adequately the safety to humans from consumption of treated estuary water, (2) potential changes in the quality of estuary water that might result from biological growth during drought conditions were not adequately addressed, (3) failure to detect viruses in the experimental estuary water treatment plant finished waters cannot be accepted as an indication that they are absent, and (4) the economic evaluation of a Potomac estuary water treatment plant was inadequate as it did not provide a comparative cost with other alternatives.

Student Interns at WSTB

Two teams of students from the Worcester Polytechnic Institute, Washington D.C. Project Center Program worked as interns in the WSTB office during two 7-week periods in 1984. One team completed its assignment and published a report, "Non-Federal Financing of Flood Control Projects: Issues and Alternatives," in October. The report concerns cost-sharing issues and contains a general history of water programs and a summary of legal, financial, and institutional constraints confronting states and localities. A second team addressed the impact of ground-water policies on various sectors and researched generic impacts of environmental regulations on activities that cause ground-water contamination. A report, "Ground-Water Regulation: Its Impacts on Society," was completed in December. It is noted that these activities were not supervised by Water Science and Technology Board members, nor were the resulting reports subject to standard NRC review policies. Rather, the material was developed as background information for the Board.

CHAPTER 4

CURRENT PROJECTS

Review of Great Lakes Water Quality Agreement: Phase II

The Great Lakes Water Quality Agreement (GLWQA) constitutes a comprehensive statement of consensus goals between the United States and Canada for maintaining or improving the integrity of the waters of the Great Lakes Basin ecosystem. Since its enactment, many aspects of the lakes' water quality have improved, but others have deteriorated.

In 1984, at the request of the William H. Donner Foundation, Inc. and the Donner-Canadian Foundation, the Royal Society of Canada and the National Research Council (through the Water Science and Technology Board) initiated a review of the 1978 Great Lakes Water Quality Agreement. The review is to consider goals of the agreement as well as technical questions and institutional instruments that bear on implementing the agreement. It is expected that the study being carried out by a binational committee (Appendix A) will result in one report published jointly in late 1985 by the Royal Society of Canada and the National Research Council. The report will review elements that have worked as well as those that have not been effective under the agreement. The report will look to the future and provide suggestions to both governments on means for improving the present agreement, if it is considered for renegotiation in 1986.

Each of the study topics outlined below is being examined, and for each a recurring set of issues is being considered. The following four issues cut across each of the study topics.

1. Technical knowledge of the chemical, physical, and biological integrity of the waters of the Great Lakes Basin (water quality) and the factors controlling it in an ecosystem context.
2. Capabilities necessary to detect, monitor, and evaluate changes in Great Lakes water levels and in water quality.
3. Assessments of present trends and future actions that would affect water quality throughout the basin.
4. Institutional arrangements required to fulfill the respective water quality responsibilities of state, local, provincial, and federal governments.

The three study topics being considered are as follows.

1. Basinwide and land-lake relationships. Should the GLWQA give increased emphasis to studies of basinwide and land-lake relationships over the Great Lakes Basin ecosystem?

2. Phosphorus control. Examine whether monitoring, analysis of existing data, development of more sophisticated models for evaluating within-year and year-to-year variability, and assessment of phosphorus abatement objectives might be included in an extension of the Water Quality Agreement.

3. Toxic chemicals. Areas to be considered include the data base, modeling, research on dose/response, hazard and tolerances, and the research infrastructure. One issue being examined is whether the current level and scope of the research meets the obligations under the existing agreement. Other issues include adequacy of the geographic coverage, continuity, and quality assurance of measurements of these chemicals; whether predictive models are adequate to meet the requirements of the agreement; and whether adequate information is available on loadings of toxic chemicals, their toxicity, and the exposure information for the human population.

Programs for the Prevention of Ground-Water Contamination in the United States

A committee (see Appendix A) has been established to assess state and local ground-water protection. The committee is reviewing twelve selected programs with respect to their scientific bases, performance over time, administrative requirements, and institutional, legal, and economic frameworks. A technical guide/report will be prepared that is designed to help strengthen states' capabilities to protect ground-water resources. This report will summarize the committee's reviews of case studies and assess applicability of technical and institutional features (e.g., classification and permitting) that can be effectively extrapolated as models to improve developing programs. The study is expected to be completed in March 1986.

U.S.G.S. Water Resources Research

In response to a request from the U.S. Geological Survey, a new standing Committee on U.S.G.S. Water Resources Research was established in January 1985. The committee includes 15 members (see Appendix A) whose expertise generally covers all aspects of water resources. The committee's principal purpose is to assist the U.S. Department of the Interior through the Geological Survey in carrying out provisions of Title I of the Water Resources Research Act of 1984 (P.L. 98-242) authorizing the Secretary of Interior to make grants for (1) support of one water resources research institute in each state, (2) water resources-related research by the state institutes and others, and (3) water-related technology development projects by educational institutions and others. The committee will assist in

setting research priorities and providing advice to the Department of the Interior relevant to this legislation. This committee will also assist the Geological Survey and the Board with other water resources research-related activities, as appropriate.

CHAPTER 5

PLANNED PROJECTS

Following are short discussions of some new activities the Board expects to initiate in 1985.

Irrigation-Induced Water Quality Effects, Consequences, and Remedies

Water quality deterioration in streams fed by irrigation drainage gives rise to concerns about the long-term viability of irrigated agriculture in the West. An example is selenium in the Central Valley/San Joaquin River in California. Selenium problems in the valley are in fact so severe and have such great implications that the state of California and the Department of the Interior are about to embark on a large, interdisciplinary ($32 million) research program designed to improve understanding of the problem and to identify solutions. As the data and information obtained must be highly reliable, the State and Interior requested, on December 3, 1984, that an oversight group be formed under the WSTB's management. The Board is presently planning for this important, multi-year activity.

Recycling, Reuse, and Conservation in Water Management for Arid Areas

In response to a request from the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL), the Board will be undertaking a review and assessment of current concepts and knowledge of recycling, reuse, and conservation technologies with respect to meeting the water needs of arid areas. The effort will include an initial review of these concepts as presented in several relevant reports to be provided by CERL. This review will focus on the engineering concepts and technologies, as well as health requirements, and will be useful in planning water supply logistics for military units operating in harsh (i.e., desert) environs and for other areas that may experience shortages of acceptable quality water.

Colloquium Series

Beginning in 1985, the Board will convene a colloquium series "Emerging Issues in Water Science and Technology," in conjunction with two of its three annual meetings. The series will be designed to focus attention and debate on water science and technology issues.

These colloquia will provide a limited public forum for discussions of issues identified by the Board, and opportunities for the Board to interact with the community of scientists and engineers on various aspects of water resources.

Each colloquium will be chaired by two Board members who will submit synopses of the discussions and recommendations for future actions. Initial topics may deal with issues such as drought management and a national ground-water assessment.

CHAPTER 6

RESEARCH NEEDS IN WATER SCIENCE AND TECHNOLOGY

The planned activities described in Chapter 5 represent topics that are (1) of high priority, (2) appropriate as Board initiatives, and (3) being planned at the request of the federal government or through the Board's initiative. Other activities that the Board believes should be undertaken or expanded are described briefly in this chapter. Some of these topics were highlighted in the 1983 annual report of the Board and are repeated here as continuing important research needs.

HYDROLOGIC SCIENCE

Scientifically Based Estimation of the Probabilities of Extreme Hydrologic Events

Development of water resources leads inexorably to greater dependence on the projects that have been developed. This concurrently increases the impact on society of extreme hydrologic events that may destroy or totally exhaust the normally dependable resource. A flood on an undeveloped river may cause damage, but failure of a flood control structure upstream of an urbanized area could cause a catastrophe. Likewise, drought will cause crop damage, but extreme drought in an irrigated area supplying most of a country's foodstuffs could lead to widespread famine.

It is precisely because extreme events are rare that it is difficult to quantify their probabilities. At the same time it is more and more important to recognize the risk of and plan for catastrophic failure of water resource developments. The Board believes that development of credible techniques for quantifying probabilities of extreme hydrologic events can and should be developed.

Oceanic Branch of Hydrologic Cycle

We have little direct knowledge of the various components of the hydrologic cycle of the oceans in spite of their central importance to global climate. The numbers that appear on diagrams of the global

hydrologic cycle are obtained as closure for the cycle, given observation-supported estimates of the continental phase. What is the continental ground-water runoff to the oceans? What are the magnitudes and spatial distribution of the precipitation and evaporation on the ocean? These quantities are important not only to complete our understanding of the global cycle but also because their distribution is a major factor in climate. Formation of dense bottom water in the North Atlantic Ocean is a result of the predominance there of evaporation over precipitation. This southward flowing bottom water leads to a return surface flow of warmer water, which is responsible for Northern Europe's moderate climate. It will first be necessary to learn how to make these measurements.

Precipitation Mechanisms

Improvement in short-range flood forecasting, in rain-augmented irrigation management, and in other rainfall-runoff problems requires a better knowledge of the characteristics of storm precipitation to be expected from given atmospheric conditions in different geographical locations. In probabilistic terms, what are the likely precipitation intensities, durations, and areal extents? This research will require observations of spatial distributions of precipitation in addition to the usual station observations.

Snow and Ice Mass

In spite of considerable activity during the International Geophysical Year, the mass of water stored in ice caps, glaciers, and snowpack is still not well known, and we speculate over the possible causes of apparent sea level rise. How much of this water is coming from ice melt?

Scale in Hydrology

When observing or analyzing physical processes, we need to know their size. But what are the horizontal dimensions of the hydrologic cycle? Where does local precipitation come from? How much of it was evaporated locally? Where does local evaporation next appear as precipitation? These questions are all important to issues of environmental impact.

Another question of scale arises when trying to represent the dynamic hydrologic behavior of a large area. How must we spatially average the inputs and the system parameters in order to have the large system obey the same physical laws we would ascribe to an elemental volume? This is much the same question as faced in ground-water flow, which led to defining the representative elementary volume. What are the basic scaling relationships for the hydrologic cycle?

Experimental Confirmation of Hydrologic Theory on Large Scales

The availability of large computers has made possible substantial advances in hydrologic theory in the past decade. Computationally enormous simulations of watershed and even climatic behavior are now possible. However, often the data necessary to confirm the validity of the new theories are inadequate, generally because of the relatively high cost of data collection. The Board believes that the collection of data to validate models experimentally is crucial to the further advancement of hydrologic science and encourages a program of coordinated atmospheric-hydrologic observations at the mesoscale.

Ground-Water Quality

The increasing public requirements for potable water have begun to be heavily impacted by the entry of contaminating chemicals into available ground-water supplies. Other societal activities, e.g., the land application of agricultural fertilizers, conditioners, and insecticides, and the disposal of toxic industrial and energy wastes, are contributing to water supply degradation at accelerating rates. Although these problems now receive a high national priority, there has been no mobilization of scientific research with the potential for providing appropriate long-term solutions.

An assessment of the status of the research required to resolve water quality problems might be divided into a description of research needs and research opportunities.

With regard to research needs, there is minimal quantitative understanding of interactive physical, chemical, and biological processes that affect the behavior and fate of various contaminants in ground water. This lack makes it difficult to evaluate long-term impacts and trends of existing or potential contamination problems and to propose mitigative actions. There are also insufficient data available to make even crude assessments of the extents, trends, and causes of ground-water contamination on regional or national scales. Proper management of hazardous waste or mitigation of problems in ground water already contaminated by hazardous substances is strongly dependent on the properties of the specific aquifer, the types of contaminants, and the hydrochemical, microbiological, and mineralogic conditions of the subsurface environment. Practical solutions require that principles of hydraulics, microbiology, hydrogeology, and geochemistry be integrated to study successfully the complex, multicomponent, and multiphase systems found in nature.

With regard to research opportunities, a number of questions might be pursued: How significant is pollutant transfer via volatile phases? What roles do various microbiological processes play both in upgrading and degrading water supplies? What are the physiological consequences of long-term exposure to various types of degraded water supplies? What natural mitigative processes remove contaminants? On what time scales? What controlled mitigative processes can be

developed? What laboratory capabilities are necessary to monitor and improve the quality of ground water, and do they exist at present?

The institutional and socioeconomic aspects of ground-water contamination also need increased attention. A number of federal laws govern the disposal of wastes, clean-up activities, and drinking water quality, which variously affect ground water. The conflicts and gaps in these laws need to be analyzed, along with an evaluation of the accomplishments of existing laws in protecting ground-water quality. An EPA report on ground-water strategy was released in 1984 (Ground-Water Protection Strategy, U.S. EPA, August 1984). The adequacy of this strategy needs to be assessed on the basis of a thorough understanding of existing laws, institutions, and practices. Much of the control over ground water resides at state and local levels. State laws and governmental arrangements affecting ground water vary enormously, and studies are needed of the relative success of different arrangements and overall state capabilities. Numerous communities have experienced outbursts of public concern over ground-water pollution events. Community reaction has varied according to the role of the media, interest groups, and local officials. Comparative case studies of community handling of ground-water pollution would be very instructive for future planning.

WATER SUPPLY

Water Reuse

Although reuse of domestic wastewater as a water resource is not a new concept, its deliberate integration into a water resource system is a more recent development. In the past, reuse has generally been a matter of expediency or necessity, and typically it has been unplanned and unacknowledged. For example, unplanned reuse occurs on many major rivers around the world where one city's wastewater becomes a portion of the water supply for the downstream city. Unplanned reuse will continue as available water resources are strained by population increases, improvements are achieved in waste treatment technology, and new uses for water are implemented.

Planned water reuse for nonpotable purposes has, in the past, occurred primarily in arid and semiarid areas. Land application of municipal or industrial effluent in these areas, which does not present conflicts with downstream water rights, provides both a disposal alternative for wastewater and a water supply for agricultural purposes. Also, industrial reuse of municipal water may permit the location of water-consuming industries in areas that otherwise would not be able to support such activities. Planned reuse for nonpotable purposes can provide many benefits, even in humid regions. Municipal reuse for urban irrigation (e.g., lawns, golf courses, and parks) may reserve higher quality water for potable purposes, water pollution problems may be lessened, and the cost of waste treatment may be reduced.

Instances of direct potable reuse are extremely rare compared to agricultural and industrial reuse. This is because adequate quantities of high-quality water have generally been available, and reuse has been driven by necessity. The cases of necessity have been brought about by severe drought (e.g., Chanute, Kansas, in 1957) or lack of sufficient supplies in arid regions (e.g., Windhoek, Namibia). Direct potable reuse must be carefully planned with its implementation reflecting careful consideration for potential health effects and economic feasibility. A number of research and demonstration programs have been carried out (e.g., Denver Water Department, Water Factory 21, and El Paso) and will improve our knowledge of the ability to reuse water.

Water conservation via recycling will be one means to augment conventional sources. Municipal wastewater reclamation and reuse for beneficial community purposes may be a viable planning alternative, but it is not a panacea. Water reuse, like all supply options, is characterized by a number of barriers and institutional problems. In this regard, a few of the water research needs associated with increased water reclamation include (1) development of improved monitoring techniques and more sensitive analytical procedures, (2) development of improved treatment processes for contaminant removal, (3) research to facilitate removal of legal, regulatory, and institutional barriers to provide access to reuse options, where appropriate, and (4) health effects research directed toward reuse to enable the designer to have an objective toward which he may aim.

Water quality standards must be established for all water uses and for water sources of all types. Standards that ignore the fact that many of our water sources have been contaminated by human activity are meaningless for many water supply activities. Standards for each problem contaminant should be developed for each type of water use. For example, standards will be needed that specify volatile chlorinated organics may not exceed a certain level for unrestricted direct potable reuse, while other levels may be acceptable for waters having other uses. Existing data can be used to establish reasonable criteria, with standards designed with flexibility to update the criteria as new health effects data become available.

Drought Preparedness

Critical water quantity problems are usually associated with the occurrence of extreme events, i.e., natural conditions of too much or too little water. By and large, governmental mitigation and research efforts have focused far more on the problems of water excess than those of water deficiency. Why this is so is not easily explained but may relate to the fact that floods have a sudden traumatic impact, whereas drought slips into place rather quietly and exacts its penalty slowly but surely.

In any event it is quite clear that drought planning, whether considered as a subject of intellectual inquiry or as a problem for pragmatic implementation, suffers from neglect. In fact, there is

little agreement on how to define or estimate the probability of droughts or make risk assessments. Few communities have appraised the probability of failure in their water systems. Often such appraisals as have been made are limited to the drought of record with no accounting of the relative severity of the drought, the intervening growth in demand, and the impact induced by the action of others. Similarly, most emergency planning is oriented toward violent disasters (e.g., floods, earthquakes, and tornadoes) with emphasis on near-term restoration of facilities and services. The fact is, however, that the logistics of providing emergency services for the multimonth and multiyear drought periods present a far different problem.

Our experience has been limited, but a rare drought could, in the absence of adequate preparation, tax the fragility of a modern urban community. The nature of inquiry desired is, indeed, broad. It ranges from the need to know more of cause and effect, thereby improving the opportunity for reliable forecasting, to the legal procedures required to implement various management options. The foregoing focuses on the municipal aspects of drought. Suffice it to say that the agricultural dimensions of the problem, both in this country and abroad, pose still other needs.

National Drinking Water Inventory

From the standpoints of both the public and decision makers nationwide, it is essential to develop a national inventory of drinking water quality by community, including the cost and other related information regarding treatment sources of supply and problem areas. A plan for research should be developed that would provide the following.

1. A list of representative water supplies in the United States with emphasis on major community water supplies and an appropriate list of water quality parameters for comparison;
2. A list of other important data that could be made available; and
3. A study of who should conduct the inventory, its costs, and the form in which it could be published.

At present there is no central source of information to compare water supplies among communities or to identify the characteristics of water supplies; the only source of information is individual contacts with individual utilities. With the advent of the Safe Drinking Water Act and the reporting requirements thereof, it would be increasingly possible for the public, researchers, and planners to obtain good information on the nation's water supplies.

Alternative Individual Water Treatment and Suppliers

Because of reports in the news media questioning the quality of drinking water, some people have turned to the use of bottled water or end-of-pipe devices commonly sold in hardware and department stores so as to be assured of having a safe water supply. The efficacy of the use of bottled water or such devices, their total costs, and public acceptance have not been determined. The public has apparently, in many areas, a greater degree of confidence in individual action, whether or not it solves the problem and regardless of the total cost.

The U.S. Environmental Protection Agency has done some research on devices, but no one has analyzed the national character of this development. It would be desirable to undertake a study of the frequency of the use of these solutions to water supply problems, including the rationale of the purchase of bottled water or devices, the experience of individual users, the willingness of these users to expend funds for alternative permanent solutions to water quality problems, the problems that can be encountered with these devices, and the regulatory control on quality now being exercised over these devices.

Water Supply Improvement Analysis

An increasingly important reason for obtaining a new water supply or improving an existing water supply is to obtain better quality from either surface water or ground water. In the past the decision to select a new supply to improve quality has been largely subjective. Where there are clear and present health dangers or a severe aesthetic problem, decision making is relatively simple. But frequently the capital requirements for a new supply are high and the quality needs ill-defined. It would be desirable to develop a sound basis for comparing existing and alternative supplies with emphasis not just on cost and feasibility but on the benefits or detriments of various water qualities, given the changing state of public attitudes regarding aesthetics and of science regarding health risks.

Research could focus on several real situations in different circumstances, e.g., Southwest surface-water contamination, requiring blending or an alternative supply, and Midwest agricultural drainage contamination, requiring an alternative supply. The objective would be to develop a standard way of displaying and analyzing health, aesthetic, and economic values in selection of water supplies or new treatment facilities.

Special consideration should be given to the following factors.

- Valuation of local or regional issues and values, the quality available from each source, and the analysis that should be given to each water source;
- The effect of institutional factors, i.e., water rights, supply ownership, and history of using the same supply that may affect the attitude of agencies or customers; and

- The cost and demand characteristics for each source and whether the water quality improvement is needed on a short-term or long-term basis.

The specific objective of this study should be to provide a method by which water system managers and the public can decide how much it is worth to obtain a given water quality improvement and what level of improvement should be achieved for each dollar spent.

FLOOD MANAGEMENT

Floods pose a serious natural hazard nationally in terms of damage to property and the environment, disruption of commerce, loss of life, and human health problems. For several decades, federal government programs emphasized structural means of flood control until about 20 years ago when flood mitigation by nonstructural means (i.e. flood insurance, land use regulation, and building practices) took root. Despite these efforts, flood losses continue to increase. Currently, there are a number of federal, state, and local programs for structural flood control, flood insurance, floodplain land use management, building construction regulation, and related environmental programs. However, there is no consensus approach for selecting and implementing combinations of structural and nonstructural flood mitigation measures, and research in a variety of areas is needed to assemble facts and develop methods. First, research is needed to enable more accurate and reliable definition of flood risk. Studies during 1984 by the Board's Committee on Safety Criteria for Dams found general need for improved precision both in statistical hydrology and accounting for watershed and stream characteristics in hydrologic and hydraulic modeling. There are also considerable needs to understand better flood risks in urban areas, alluvial floodplains, and areas vulnerable to coastal flooding. A second general area of needed research is improved quantification of flood losses, including the economic, environmental, and social dimensions. A sound theoretical basis is needed for measuring flood losses for planning applications. A third general area of research is to develop socially efficient methods for choosing (i.e. decision-making) among combinations of available flood mitigation measures to reduce flood losses.

RISK ANALYSIS/RISK MANAGEMENT

Role of Risk Analysis in Water Resources Related to Public Decision Making

With recent scientific advances in hydrology and environmental science, we have become increasingly aware of the risks associated with development and use of water resources. Our ability to quantify risk has substantially increased. However, the art and science of

incorporating this new knowledge in the public decision-making process are in their infancy. It is believed that risk analysis can make a significant contribution to our use of water resources if the means for using the information it provides are substantially improved. For example, in order to implement such methods, better bases are needed for establishing acceptable levels of risk.

Risk-Based Engineering Design

Advances in electronic detection devices are expanding our capability to collect data, organize the information into useful forms, and interpret the results. Simultaneous advances in simulation capability provide new resources for estimating the risks (including uncertainties in the estimates) associated with various designs and operating procedures. These resources should be used to convert water resources design and operation from deterministic to stochastic bases. The stochastic information can be expressed as probability distributions of risk of failure or as distributions of economic impacts or as incidences of effects. The change from a deterministic to a risk-based approach to engineering design and operation would appear to offer an opportunity to increase system benefits. Such benefits could be realized earlier and more efficiently if a formal research agenda were adopted, alternative methodologies were screened, and worthwhile innovations were institutionally adopted.

Support for Better Drinking Water Health Risk Assessment

The Board strongly encourages efforts to define and evaluate health risks of toxics and cost factors associated with risk reduction. There needs to be a much clearer national understanding of the risks of various toxic substances that may occur in the water supply, including the following.

1. Synthetic organic compounds (pesticides and herbicides) that may enter water systems through drainage, and purposeful and accidental contamination;
2. Halogenated organic compounds that are formed as a result of treatment or naturally occurring substances that have been dealt with in part in the recent EPA regulations on trihalomethanes;
3. Metals, such as lead, chromium, zinc, and aluminum; and
4. Other substances that have uncertain health significance.

There should be a national guide listing the specific compounds, concentrations, duration of exposure, and remedial measures. The body of knowledge in this area is growing, and it needs to be codified in a usable way.

Improved Structural and Facility Performance

The nation has already controlled in a physical way a sizable portion of its developable waters. Future water policy must put increasing emphasis on improved performance from existing structures and facilities as opposed to the development of new projects. Fortunately, new technologies are available for accomplishing this objective. For example, electronic sensing and modern computer techniques provide the opportunity for real-time data collection and real-time decision making. Applied research that illustrates the use of such techniques and serves to quantify the improvement in the performance of existing facilities and research directed toward real-time monitoring of structural safety is encouraged.

Through the use of systems analysis as a tool, several major opportunities exist for upgrading reservoir system management. They include refining the rules for operation during flood and drought emergencies, adjusting operating policy as demands for project output change over time, integrating water quality considerations into operating policy, and integrating real-time data into the operating procedures. However, pursuit of these larger changes should not occur at the neglect of the opportunities to increase project net benefits through more effective operation in normal situations. The Board has been instrumental in initiating a study of these opportunities by the Bureau of Reclamation that is currently underway. The Board commends the Bureau for its leadership in this area and believes that such a study will be useful in demonstrating opportunities for improved water management and possibly in developing a standard approach.

WATER LAW

The Need to Redefine State Water Planning

The rights and interests of states in the water resources occurring within their borders are being redefined by the U.S. Supreme Court and Congress. The stubborn notion that states "own" the water over which they have jurisdiction has been called a "fiction" by the U.S. Supreme Court. Water is now legally a commodity that can be transported in interstate commerce over the objections of the state in which the water originates. This diminution in the power of states to control water ironically comes at a time when the federal government is contracting its role in water policy making, planning, development, and management, as illustrated by the effective demise of the Water Resources Council, regional river basin commissions, and "new starts."

As states lose their control to limit export and yet gain greater responsibility over water management, a serious question arises: What is the purpose and prospect of state water planning? Answers are evolving on a state-by-state basis, but some guidelines and parameters for the upcoming era of state water management planning would be helpful to all levels of water governance, local, state, and federal. The undertaking calls for creative contributions from many disciplines.

The Need to Redefine the Concept of Beneficial Consumptive Use

Traditionally, Western water law has limited the right to consume water to "beneficial use." The doctrine of beneficial use, while it varies from state-to-state, prescribes the types of water use for which a right can be held (e.g., domestic, irrigation) and the manner by which it can be used (e.g., nonwastefully). The doctrine has been liberal in the types of use it allowed. It has also tolerated wasteful and inefficient practices. Courts and legislatures frequently have looked to local custom for standards of beneficial use, with the result that the lowest common denominator of practice becomes the standard for lawful behavior.

In some states a statutory maximum water duty has been set for irrigation, irrespective of variations in crop water demand. In other states, water duties are set by state engineers, using discretion and varying criteria. Some states have no uniform water duty standards, relying on courts to reach judgments on a case-by-case basis when and if disputes reach the level of litigation. Where advanced standards of irrigation efficiency are being urged to put teeth in the beneficial use concept, some inequities are feared. Marginal farming operations can be put out of business if costly equipment or procedures are required. In the case of Indian reservations, where people have waited for years to irrigate, suggestions that their water rights be reduced to reflect water savings now possible from costly advanced technology are greatly resented. Such reactions raise the issue whether there ought to be graduated implementation, forms of subsidy, or even double standards.

FINANCIAL MANAGEMENT

Techniques for Appraising the Value of Water Resources Projects

The value of benefits from water resources projects is generally computed using present-value analysis, a technique borrowed from business and financial analysts. Unfortunately, the time scale for private investments is substantially shorter than the time scale for public investments in water resources projects, which often have useful lives of five to ten decades. The Board is concerned that the technique of present-value analysis, as currently used, may be inappropriate for evaluating such long-term projects, especially where project benefits include low probability (but catastrophic) events such as floods. Research concerning the social value of past and present projects may lead to a better understanding of how such investments should be viewed and how benefits should be measured.

Financing Arrangements for Identification, Containment, or Cleanup of Existing and Future Contamination of Ground Water and Surface Water

The difficult problem of financing water pollution control activities is not new. A variety of incentives, grants, and cost-sharing strategies is available, which often affect our choices regarding overall clean-up and water management strategies. There is need for research addressing sources of funds, economic consequences, and redistributional effects of alternate financing arrangements for identification, containment, and cleanup of contaminated ground water and surface water. Study of several specific case studies could help elucidate the effectiveness and impacts of the Superfund. However, concern has been expressed that exclusive emphasis on Superfund cases may detract from the need for research on effective prevention of future ground-water problems.

UNIVERSITY EDUCATION AND RESEARCH

There is concern about trends in university research, the institutional framework for university research, and training of water resources scientists, engineers, and professional practicioners. A study might be undertaken that would provide answers to questions such as the following: Has there been a reduction in training and a diversion away from water research? Can any changes in research and training be related to changes in the structure and funding level of university research in water fields? What changes can be expected in the future? To what extent in water resources science and engineering degree programs should the political, legal, and social aspects be emphasized as compared with the more traditional science and engineering aspects?

The importance of a solid, cooperative federal, state, and university water research program seems to be recognized. But, it has been argued that progress in water resources research has been impeded by a lack of critical mass in terms of jurisdiction, expertise, laboratory equipment, analytical facilities, etc. Is there evidence to support this claim? Would different types of institutions remedy this situation?

It has been claimed that, although many of the most important water resources issues are institutional and political, the existing research framework has responded inadequately by underfunding institutional research and avoiding significant but sensitive issues. What has been the pattern of research funding for policy and institutional studies? What might be the effect upon institutional research of changing the framework to a national center or some alternative?

APPENDIX A

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COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND RESOURCES

APPENDIX B

TERMS OF REFERENCE
WATER SCIENCE AND TECHNOLOGY BOARD
(Adopted November 29, 1982)

Introduction and Purposes

The Water Science and Technology Board has been established in the National Research Council in order to provide a single 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 the traditional scientific and engineering aspects of water resources and the economic, institutional, legal, educational, and social aspects, as well.

Areas of Interest

In pursuing its purposes, the Board is concerned with:

- Basic hydrologic and related sciences and their applications in water resource systems, including analyses of ground-water movement and 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, levees, renovation-retrofit technologies, and treatment processes.
- 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:

1. Responding to specific requests by government agencies and others;
2. Reviewing and evaluating water-related research and scientific, engineering, and technological developments;
3. Initiating investigations of issues considered to be appropriate by the Board, its parent Commissions, and the Governing Board of the National Research Council;
4. Reviewing research and the state of the art in science, engineering, and technology related to the development and management of water and related resources, especially in relation to national objectives and priorities;
5. Projecting future needs for and capabilities of multidisciplinary water-related research and education in the sciences, engineering, and technology;
6. 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;
7. Fostering communication among members of the professional community in the United States on national and international water resources issues; and
8. Articulating water-related educational issues, including undergraduate, postgraduate, continuing education, and public-education programs and the related needs for equipment and facilities.

Organization and Management

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 Physical Sciences, Mathematics, and Resources (CPSMR). CETS is primarily concerned with the development and application of engineering disciplines to technological systems and their relationship to societal problems, while CPSMR is primarily concerned with basic sciences and their relation 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 CPSMR.

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

The Board may recommend to the Chairman 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 need for expertise, the Board consists of not fewer than 15 and not more than 18 members in addition to its Chairman. Members are chosen for their background 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.

Terms of appointments are normally for three years. Members are not eligible for more than two consecutive three-year terms. The Board Chairman is appointed by the Chairman of the NRC 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.

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 Board exercises its oversight responsibility for ongoing studies by receiving reports from the chairpersons or staff of its units or meeting with them as it deems appropriate.

The Board originates or reviews and approves nominations for membership of its units and transmits its recommendations to the Chairman of the appropriate Commission.

The Board Chairman, with the approval of the Chairman of the appropriate Commission and the Chairman of the National Research Council, appoints chairmen and members of units of the Board.

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

Report Review

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.

Board Meetings

The Board normally meets three times each year, twice at the NRC headquarters in Washington, D.C., and once elsewhere in the United States. 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

The Board, with the aid of its staff, prepares a bi-annual plan of its proposed program of activities and projects for submission to the two Commissions, accompanied by a request for authorization to receive outside funds for the support of these activities. The Board prepares reports on its activities as may be requested or required by the Commissions or the Governing Board of the National Research Council.

The Board Chairman, together with the Executive Director of the Board, presents the Board's bi-annual program plan and budget to the Commissions. New projects, approved by the Board, that do not appear in the approved plan and authorized budget are brought to the appropriate Commission for action. The Chairman and Executive Director also report periodically to the Commissions on any issues and problems of particular concern to the Board and any issues of broader scope that may require a response of the National Research Council.

The Board formulates programs and requests funds in support of undertakings deemed to be logical, appropriate extensions of its approved program plan, subject to appropriate approvals.

The Board reviews all proposals for new activities that require the use of outside funds. Proposals must be approved by the Board or an Executive Committee before a request for authorization to receive funds is submitted to the appropriate Commission.

Proposed projects are evaluated by the Board according to the following criteria: (a) the importance of the issue to the nation relative to its water needs; (b) the availability of expert volunteers who can ensure that the Board's contribution will be appropriate, effective, and timely; (c) the relevance of the work to the Board's areas of interest and competence, and (d) the involvement of policymakers of sufficient stature to ensure that the Board's response will have a significant impact.

Staff

The senior staff officer of the Board is its Executive Director who is responsible to the Chairman for the general management of the Board's program and to the Executive Directors of CETS and CPSMR. The Executive Director has the authority to hire additional staff necessary to assist in the overall management of the Board's program, subject to the constraints and approvals of National Research Council policies and the administrative budget of the Board.

Expenses

Expenses of the Board (and any study groups), including support of its staff and meetings, are ordinarily financed by grants or contract funds.

APPENDIX C

PUBLICATIONS OF THE WATER SCIENCE AND TECHNOLOGY BOARD (1982-1984)

SAFETY OF DAMS: FLOOD AND EARTHQUAKE CRITERIA

1985, 321 pp.

This report was prepared during the period May through December 1984 at the request of the Assistant Secretary of Interior for Water and Science and the Assistant Secretary of the Army for Civil Works. The report concerns the levels of safety to be provided at new and existing dams to withstand extreme floods and earthquakes. The report includes a thorough inventory of safety criteria for dams in use in the United States and internationally relative to levels of design for floods and earthquakes. The report provides assessments and critiques of the variety of present practices and recommends alternative safety criteria. Also included are chapters on risk assessment, legal aspects of dam safety, and recommendations for continuing development of hydrologic and earthquake engineering technologies. The findings and recommendations of the study committee are condensed in an executive summary. Technical appendixes provide discussions on probable maximum precipitation estimates, statistical hydrology, and risk assessment. A glossary of technical terms is included. The report emphasizes that a principal objective in dam safety evaluations should be to strike a balance among such considerations as project benefits, construction costs, social costs, and public safety, including the possible consequences of dam failure due to major earthquakes and floods. Available from National Academy Press, 2101 Constitution Avenue, NW, Washington, D.C. 20418. Cost: $17.50 (estimate).

REVIEW OF THE GREAT LAKES WATER QUALITY AGREEMENT WORKING PAPERS AND DISCUSSION

1984, 174 pp.

The William H. Donner Foundation, Inc., in consultation with the staff of the International Joint Commission (IJC), asked the Water Science and Technology Board to study the Great Lakes Water Quality Agreement

in two phases. The first phase, which is the subject of these proceedings, consisted of a conference to define the details of a major review study. Conference participants were asked to identify those scientific, technical, and institutional issues upon which an in-depth study, in its second phase, should focus in order to be most effective. In general, this report contains five formal papers and the discussion that followed each presentation along with a final summary chapter prepared by the Conference Advisory Panel. These working papers and discussion are being used as background information for the phase II effort. Available from Water Science and Technology Board (Limited Supply), 2101 Constitution Avenue, NW, Washington, D.C. 20418 and National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 85-110807. Cost: $17.50.

WATER SCIENCE AND TECHNOLOGY BOARD ANNUAL REPORT 1983

1984, 39 pp.

This is the first annual report published by the Board since its creation in 1982. The report includes an introduction describing in general the types of issues handled by the Board and its committees; a description of the Board's structure in relation to other units within the NRC; project activities completed in 1983; description of current and planned projects; and a list of research needs in water science and technology envisioned by Board members. Also included as appendixes are lists of program participants, the Board's Terms of Reference, and brief descriptions of the published reports issued by the Board. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 84-216571. Cost: $8.50.

WATER FOR THE FUTURE OF THE NATION'S CAPITAL AREA - 1984

1984, 71 pp.

This report is the culmination of a continuing review by the National Research Council of the U.S. Army Corps of Engineers Metropolitan Washington Area Water Supply Study, which was initiated in 1977 and completed in 1983.

The committee was charged with reviewing the Corps methods for their investigations of the future water resources needs of the metropolitan Washington area and to comment by written report upon the scientific bases for the conclusions reached. The committee issued five letter reports, one interim report, and one final report to the Corps within a seven-year period.

In its final report, the committee acknowledges and commends the Corps for certain achievements, such as (1) development of systems management (nonstructural) solutions to problems relative to the

metropolitan Washington area future water supply needs, (2) determination and assessment of future water demands by the use of improved modeling, (3) development of a wide range of alternative methods of meeting future water resources needs of the metropolitan Washington area, (4) involvement and use of the citizens of the metropolitan Washington area in developing design criteria and recommendations for future actions, and (5) the collection and collation of current and historical data used in the analysis of the metropolitan Washington area study.

However, the committee also points out several flaws in the Corps study which detract from the above acknowledgements. These flaws concern (1) the uncertain reliability of institutional arrangements, (2) the nonpreservation of reservoir sites, and (3) the lack of scientific attention in assessing the drinking water quality available to the metropolitan Washington area. Available from Water Science and Technology Board (Limited Supply), 2101 Constitution Avenue, NW, Washington, D.C. 20418 and National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 84-195585. Cost: $11.50.

THE POTOMAC ESTUARY EXPERIMENTAL WATER TREATMENT PLANT

1984, 135 pp.

This report is the culmination of an eight-year review by the National Research Council (NRC) of the U.S. Army Corps of Engineers study to determine the feasibility of using the Potomac estuary waters as a source of water supply to the metropolitan Washington area. In this connection, a two-year pilot plant project was authorized involving the construction, operation, and evaluation of a small water treatment plant. The NRC committee was requested to provide a review and written report commenting upon the scientific bases for the conclusions reached by the Corps from this study. The NRC committee had been reviewing the Corps study since 1976 and issued four letter reports, a panel report, and a final report to the Corps within an eight-year period.

In its final report the committee commends the Corps study for certain outstanding features, including (1) detailed comparative evaluation of the quality of treated estuary water with that of three major treated water supplies for the metropolitan Washington area, (2) development of a detailed inorganic and organic chemical characterization of treated estuary water and of local water supplies, (3) development of a data base on microbiological contaminants and toxicological indications, and (4) the demonstrated reliability of advanced treatment processes to provide treated water with relatively consistent quality.

However, the committee also felt that there were important limitations to this study and to the conclusions reached, as follows: (1) insufficient scientific evidence was provided to adequately evaluate the safety to humans from consumption of treated estuary

water, (2) potential changes in the quality of estuary water that might result from biological growth during drought conditions were not adequately addressed, (3) failure to detect viruses in the experimental estuary water treatment plant finished waters cannot be accepted as an indication that they are absent, and (4) the economic evaluation of a Potomac estuary water treatment plant was inadequate, as it did not provide a comparative cost with other alternatives. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 84-195643. Cost: $16.00.

THE LAKE ERIE-NIAGARA RIVER ICE BOOM: OPERATIONS AND IMPACTS

1983, 74 pp.

This report is the result of a request from the International Joint Commission--United States and Canada (IJC) to the NRC to assist in resolving issues associated with the ice boom located at the entrance to the Niagara River, New York and Ontario. The panel's mission was to address whether the ice boom has a climatic effect in the Buffalo/Fort Erie region and, if so, to determine the magnitude of that effect and what alternative ice control strategy could be used that would have less of a climatic effect.

The panel findings are as follows:

1. There is no cooling to local climates if the boom is removed when there are 250 mi^2 of ice on Lake Erie;
2. No monitoring program is required;
3. No benefit of the boom to the region after the beginning of April has been demonstrated;
4. No negative impacts of the ice boom on navigation, erosion, and fisheries could be demonstrated with available data; and
5. No feasible alternative exists that would produce effectiveness comparable to that of the present ice boom.

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 84-129709. Cost: $11.50.

SAFETY OF EXISTING DAMS: EVALUATION AND IMPROVEMENT

1983, 384 pp.

The goal of this report is the enhancement of dam safety. A major objective is to provide guidance for achieving improvements in the safety of existing dams within financial constraints. Many dam owners are faced with safety problems of such a nature and extent that they are unable to finance remedial measures. To these owners, as well as to regulatory agencies and others concerned with the engineering and

surveillance of dams, the report presents suggestions and guidance for assessing and improving the safety of existing dams. The contents of the report are intended to be informational and not to advocate rigid criteria or standards. The report also contains a suggested glossary for terms used relating to dam safety and an index. Available from National Academy Press, 2101 Constitution Avenue, NW, Washington, D.C. 20418. Cost: $18.95.

LETTER REPORT: MAY 31, 1983, TO U.S. DEPARTMENT OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, AND OFFICE OF WATER POLICY

1983, 5 pp.

This letter report responds to agency requests for comments on an outline for the proposed National Water Summary 1983--Hydrologic Setting of Water-Related Issues. The review was provided in accordance with the Board's contract with agencies to provide advice and short reports on selected issues. The letter report comments on the need for, expectations, and content of the proposed document as suggested by the outline reviewed. The Board endorses the concept of the national water summary as an interim, prototype data base until the needs and contents of a national assessment program are more thoroughly reviewed. Available from Water Science and Technology Board, 2101 Constitution Avenue, NW, Washington, D.C. 20418.

COOPERATION IN URBAN WATER MANAGEMENT, CONFERENCE PROCEEDINGS

1983, 187 pp.

The Water Science and Technology Board held a conference, "Cooperation in Urban Water Management," on October 14-15, 1982, to assess the barriers to efficient management of urban water supplies. A steering committee invited 30 participants to the conference; some presented talking papers. The conferees explored and proposed means for overcoming obstacles envisioned by water supply engineers that prevent or assign low priority to solutions to crises in municipal water supplies. The primary objective of the conference was to decide if a broader and more intense study by the NRC is warranted. A second objective was to provide guidance on the state of research needs, development, and technology transfer needs regarding municipal water supplies. The proceedings include the speakers' presentations and a summary of the general discussion. The conference was supported by the National Science Foundation, the Environmental Protection Agency, the American Water Works Association Research Foundation, and the National Academy of Sciences. Available from National Technical Information Service, 5285 Royal Road, Springfield, VA 22151. Accession number: PB 83-217992. Cost: $17.50.

A LEVEE POLICY FOR THE NATIONAL FLOOD INSURANCE PROGRAM

1982, 107 pp.

This report provides the Federal Emergency Management Agency/Federal Insurance Administration with recommendations for a comprehensive levee policy concerning minimum design criteria for levees; levee inspection and evaluation; operation, maintenance, and other local requirements in leveed areas; treatment of levees in the insurance aspects of the National Flood Insurance Program; and flood-mapping approaches in leveed areas. This activity represents significant recommendations for integrating structural and nonstructural flood mitigation. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 83-134619. Cost: $13.00.

SAFETY OF NONFEDERAL DAMS: A REVIEW OF THE FEDERAL ROLE

1982, 53 pp.

This report constituted phase I of a study conducted by the NRC at the request of the Federal Emergency Management Agency (FEMA). The scope of the committee's study and the recommendations in this report concern the enhancement of state dam safety programs. FEMA asked the NRC to identify impediments to state-run programs for dam safety, to suggest federal actions to remove or mitigate those impediments, and to define how the U.S. government could help make such nonfederal dams safer. Areas covered in this report's recommendations include state legislation and supervision, nonfederal dams initially engineered with federal assistance, dam inventory, risk classification, technical assistance, funding assistance, training assistance, insurance costs of dam failures, public safety planning and awareness, postfailure investigations, and dam terminology.

Recommendations for the second phase of this study was also made. The following technical issues were recommended for study in greater detail: methodology of risk assessment, engineering methodologies for stability and hydrologic evaluations, instrumentation and warning systems, and model guide for emergency preparedness planning. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 82-188855. Cost: $9.00.

APPENDIX D

FORMAL MEETINGS OF THE WATER SCIENCE AND TECHNOLOGY BOARD AND ITS SUBGROUPS DURING 1984

JANUARY	
11	Committee to Review the Potomac Estuary Experimental Water Treatment Plant Project, Chicago, Illinois
FEBRUARY	
7-8	Water Science and Technology Board, Washington, D.C.
24	Committee on Safety Criteria for Dams, Planning Session, Washington, D.C.
MARCH	
12	Committee to Review the Metropolitan Washington Area Water Supply Study and Committee to Review the Potomac Estuary Experimental Water Treatment Plant Project, Washington, D.C.
29	Practical Implementation of Plans for Research on Floods and Their Mitigation in the United States Planning Session, Washington, D.C.
APRIL	
26-27	Review of the Great Lakes Water Quality Agreement Conference, State University of New York, Buffalo
MAY	
15	Practical Implementation of Plans for Research on Floods and Their Mitigation in the United States Planning Session, Washington, D.C.

MAY (continued)

21	Committee on Safety Criteria for Dams, Planning Session, California Institute of Technology, Pasadena
31	Review of the Great Lakes Water Quality Agreement Planning Session, Syracuse, New York

JUNE

11-12	Water Science and Technology Board, Woods Hole, Massachusetts
25-26	Committee on Safety Criteria for Dams, Washington, D.C.

AUGUST

13-14	Committee on Safety Criteria for Dams, Washington, D.C.
20	Practical Implementation of Plans for Research on Floods and Their Mitigation in the United States Planning Session, Washington, D.C.

SEPTEMBER

20-21	Committee on Safety Criteria for Dams, Pasadena, California

OCTOBER

25-26	Committee to Review the Great Lakes Water Quality Agreement Planning Session, Buffalo, New York

NOVEMBER

10	Committee on Water Resources Research Planning Session, Washington, D.C.
26	Committee on Ground-Water Quality Protection Planning Session, Washington, D.C.
26	Water Science and Technology Board Executive Committee, Washington, D.C.

NOVEMBER (continued)

27-28	Water Science and Technology Board, Washington, D.C.

DECEMBER

3-4	Committee to Review the Great Lakes Water Quality Agreement, Washington, D.C.