Anne Wagner
JH 710

DOE/ER/60161--T4

DOE/ER/60161--T4

DE90 007436

WATER SCIENCE AND TECHNOLOGY BOARD
ANNUAL REPORT 1985

DISCLAIMER

Water Science and Technology Board
Commission on Engineering and
Technical Systems
Commission on Physical Sciences,
Mathematics, and Resources
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1986

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.

MAILING ADDRESS:

Water Science and Technology Board
National Research Council
2101 Constitution Avenue, NW
Washington, D.C. 20418

OFFICE LOCATION:

2100 Pennsylvania Avenue, NW
Joseph Henry Building, Room 421

TELEPHONE:

(202) 334-3422

CONTENTS

CHAPTER 1

INTRODUCTION

This is the third annual report of the Water Science and Technology Board. The report summarizes the Board's activities during 1985, ongoing activities, and plans for the future. Included also is information on Board and study group memberships, program organization, issues of concern, and reports produced.

The Water Science and Technology Board is a unit of the National Research Council (NRC), part of the National Academy of Sciences that exists by virtue of an act of Congress in 1863 instructing it to provide scientific and technological assistance to the federal government. The Board is independent of the federal government, and participants in Board activities serve without compensation. The expertise and resources available to the Board extend across many disciplines and types of organizations concerned with water and related resources. The Board's independence and the availability of resources to it afford a unique and effective forum to address cohesively the variety of issues on the national water resources agenda. The volunteers who serve the Water Science and Technology Board and the Board's federal agency liaison representatives are the constituency on which it depends for the quality of its work in response to those who seek its advice. In 1985, several hundred individuals participated in Board activities in various capacities.

In 1985, Board activities continued to increase in number and took a variety of forms. Several special committees were appointed by the Board, to study ground-water protection strategies, the Great Lakes Water Quality Agreement, irrigation-induced water-quality problems, recycling and reuse technologies, flood estimating techniques, and water resources research. A new colloquium series was initiated, focusing attention on emerging issues in water science, technology, and policy. The first colloquium, carried out in September, concerned drought management and public water supplies. In addition two ad hoc "work groups" made up of Board members were convened to review planned federal programs--the proposed National Water Quality Assessment Program of the U.S. Geological Survey and a U.S. Department of Energy research plan concerning transport of energy-related organic compounds and mixtures in subsurface environments.

The Board's principal products are its reports (see Appendix C). These reports range from letter reports, generally read by a limited

number of federal officials, to major publications that are distributed by the thousands. In all cases, these reports have had and are having important effects, and the Board's credibility and visibility have increased with each successive project.

The Board and its Committee on Water Resources Research share a continuing watch of research issues. Among the more critical of research issues is the rather sad state of funding available for water resources research. Many agencies and entities have programs of research in water resources, however most of this effort is done in house and is essentially applied in nature. Inadequate funds are available for basic research at universities. At the same time, many scientific, technological, and policy issues are begging to be explored. The Board hopes that sight of the importance of water resources and exploratory research thereof will not be lost in 1986 as pressures mount to reduce the federal deficit. In fact, the Board believes that those few extramural water resources research programs managed by the U.S. Geological Survey, National Science Foundation, and others need to be expanded.

To fulfill its goals, the Water Science and Technology Board is supported by a small, but qualified and dedicated, staff. The staff is critical to the effective and timely performance of every Board work group. For example, the role of the staff is to help ensure that work group tasks are carefully formulated in accordance with NRC policies and clearly understood, that the appropriate professional communities are adequately surveyed in the selection of work group members, and that expert staff or consultant assistance is available during studies and preparation of reports. The Water Science and Technology Board commends its staff, which in June 1985 was awarded the NRC Staff Recognition Award for outstanding performance and service.

This report should provide the reader with a basic understanding of the Board's interests, achievements, and capabilities. The Board welcomes inquiries and suggestions concerning its activities and will provide more detailed information on any aspect of its 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 (NRC) related to water resources. Its 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, generally technical projects and administrative activities are assigned 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 NRC;
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.

The Board chairman and four additional members compose the Board's five-member 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. Ad hoc work groups of the Board often are established to conduct program-level activities such as issue evaluation, project development, and report reviews.

The Board meets three times each year. At meetings, issues and research needs are considered, new initiatives are developed, and ongoing projects are monitored. In 1985, the Board initiated an important new colloquium series on emerging issues in water science and technology; it is planned to continue this series with colloquia on various topics in conjunction with every other Board meeting.

Meetings of the Board serve as a mechanism of communication among the water resources community. Most federal agencies with water resources responsibilities have active liaison representatives to the Board. Additional communication is effected among the liaison members, who periodically meet as a group to discuss Board-related activities, and through the bimonthly "WSTB Newsletter" prepared by the Board's staff and the Annual Report of the Board. During 1985, on several occasions, Board members met informally with federal agency representatives to discuss program needs and plan appropriate activities.

In 1985, 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, U.S. Nuclear Regulatory Commission, and the William H. Donner Foundation, Inc. The Board's budget for general activities and special studies during 1985 totaled approximately $700,000.

CHAPTER 3

PROJECT ACTIVITIES

Review of the Great Lakes Water Quality Agreement

A review of the 1978 Great Lakes Water Quality Agreement between the United States and Canada was undertaken at the request of the Donner Canadian Foundation and the William H. Donner Foundation, Inc. beginning in 1984 and ending with the issuance of the final report from a binational committee of the Royal Society of Canada and the U.S. National Research Council in December 1985.

A major opportunity to review the Agreement comes in 1986 after the International Joint Commission (IJC) issues its third biennial report. The objective of the committee's study was to review the progress under the Agreement since 1978 from a scientific and scholarly perspective. Many of the experts on the committee were also familiar with research conducted in the Great Lakes and with the joint institutions governing implementation of the Agreement.

The committee found that "major progress" has been achieved in reducing levels of phosphates and several pollutants in the Great Lakes. However, it also reports that there remains an "urgency to achieve a reduction of toxic pollutants in the Great Lakes and thereby reduce the risks to the human population using the resources of the basin." In fact, the committee concluded that people living in the Great Lakes region are exposed to "appreciably more" toxic chemicals through contaminated drinking water and food products than similar populations in North America.

Both the 1972 and 1978 Great Lakes Water Quality Agreements are widely recognized as among the world's pioneering international instruments designed to foster intergovernmental cooperation to correct pollution in a large river basin. The committee recommends that the two governments should continue and strengthen the 1978 Agreement. To improve accountability in carrying out the Agreement, the committee suggested that the U.S. and Canadian governments publish a report every two years on the progress achieved and that bilateral meetings be held regularly between senior officials to discuss any problems. Additionally, the committee believes that there needs to be a clearer delineation of the responsibilities of the various institutions in managing Great Lakes water quality. The committee also desires to see Great Lakes water quality managed more from an ecosystem approach. This means that Great Lakes water quality related programs and policies, and the institutions that implement them,

should be guided by the two basic ecosystem goals set forth in the 1978 Agreement to "restore and maintain the integrity of the waters of the Great Lakes basin ecosystem."

The committee is listed in Appendix A, and a report abstract and information on how to obtain a copy of the report is included in Appendix C.

Programs for Ground-Water Quality Protection in the United States

A committee (see Appendix A) was established in 1984 at the request of the U.S. Environmental Protection Agency to review several selected ground-water protection programs (state or local) with respect to their scientific bases, performance over time, administrative requirements, and institutional, legal, and economic frameworks.

The resulting report, to be issued in the spring of 1986, will summarize the committee's review of developing or ongoing ground-water protection programs in Kansas; Arizona; California; Dade County, Florida; the state of Florida; Cape Cod, Massachusetts; the state of Massachusetts; Colorado; New York State; Long Island, New York; Connecticut; Wisconsin; and New Jersey. It will contain a number of useful examples that can aid federal, state, and local officials, elected representatives, and citizens in improving ground-water protection programs. The state and regional programs selected for review emphasize the planning and regulatory aspects such as information gathering, classification systems, direct and indirect land-use controls, and enforcement systems that are preventative, as opposed to corrective, in nature. Technical and institutional features will also be identified that may have application to other areas of the country.

Since, by definition, preventative programs are long range, few explicit results will be demonstrated. Most of the programs analyzed by the committee are new, and experience is limited. However, a chapter is to be included that will provide examples of many different strategies being used by these state and local regions that the committee believes comprise a reasonably complete summary of alternative ground-water protection program designs.

Water Resources Research

In response to a request from the U.S. Geological Survey, a standing Committee on 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 the Water Resources Research Act of 1984 (Public Law 98-242) authorizing the Secretary of the Interior to make grants for (1) support of one water resources research institute in each state and (2) water-resources-related research by the state institutes and

Irrigation contam

others. The committee assists in evaluating institute effectiveness, setting research priorities, and providing advice to the Department of the Interior relevant to this legislation. This committee also assists the Geological Survey and the Board with other water resources research-related activities, as appropriate. During 1985, the committee met three times, mainly to assess water resources research priorities and other matters, such as "coordination" of research. In November, the committee issued a report of recommendations on research grants program focus, which is featured in Chapter 6 of this report.

Irrigation-Induced Water-Quality Problems

Water-quality degradation associated with irrigated agriculture has been recognized as a significant regional problem in California for decades. In 1983, abnormal numbers of waterfowl mortalities and deformities discovered at Kesterson National Wildlife Refuge (NWR) were attributed to toxic levels of selenium in agricultural drain water originating from the Westlands Water District near Fresno. This clear environmental crisis with implications for the future of agriculture in the Central Valley became a topic of the national news (including a 60 Minutes segment in March of 1985). The problems at Kesterson NWR resulted in the initiation of a joint federal/state study to determine the sources of the contaminants that have an impact on the aquatic environment and how the irrigation drainage problems could best be mitigated.

In response to a request from the Secretary for Resources of the California Resources Agency and the Assistant Secretary of the Interior for Water and Science, the WSTB established a Committee on Irrigation-Induced Water Quality Problems in April 1985. The committee (see Appendix A) was created to advise and assist the San Joaquin Valley Drainage Program (a consortium of federal Interior agencies and California water and wildlife agencies) in a $40 million to $50 million, 3-4-year research program to improve understanding of drainage problems and identify remedial actions/solutions. The charge to the committee is to (1) review and provide advice with regard to the overall research strategy, (2) review the research program in progress, and (3) assist in identifying conceptual alternatives available to deal with irrigation drainage problems.

The full committee met three times during 1985 with all the meetings occurring in Sacramento. The first meeting was held in May to familiarize the committee with water-quality issues in the San Joaquin Valley. The members were briefed by numerous representatives of federal and state agencies, environmental groups, and farm organizations. An informative air and ground tour of the Central Valley was arranged by the Bureau of Reclamation for the benefit of the committee.

The second meeting occurred in early August. One purpose of the meeting was to receive in-depth briefings from the three federal agencies--the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the U.S. Bureau of Reclamation--who are engaged in the

bulk of the research that constitutes the San Joaquin Valley Drainage Program. The committee also prepared a letter report of comments on the overall plan of study/plan of work in October 1985 for the program, which is summarized in Appendix C.

A third meeting of the full committee occurred in December. This meeting was focused on the research related to irrigation and drainage under way in the University of California system and how it might be integrated into the overall research program. Also, briefings were presented by an expert in public participation programs and an agricultural economist who has studied deliveries of federally subsidized water for irrigation in the Central Valley.

At the end of the year the committee was busy establishing four subcommittees in areas identified as being of critical importance at this time; these include public health, quality assurance/quality control, systems analysis, and treatment technologies. Also, discussion was begun related to broadening the committee's scope to consider additional areas in the western United States where irrigation practices appear to have an adverse impact on water quality.

Study of Techniques for Estimating Probabilities of Rare Floods

In response to a request from the U.S. Nuclear Regulatory Commission, and as a follow-up to previous Board studies, in late 1985 the Board undertook a study of techniques for estimating probabilities of extreme floods. Reasonable estimates of the magnitudes and associated probabilities of extreme floods are required for a variety of planning and design purposes. However, in the United States, streamflow records of greater than 100 years are meager and most records are shorter. Consequently, statistical analyses of historical data do not often produce credible flood estimates for much greater than the 100-year (0.01 percent chance) flood. A variety of other approaches are applied (modeling of physical processes, paleohydrology, etc.), but none is widely accepted, and decisions involving large floods are often debated. This effort is being undertaken by a study committee, listed in Appendix A, and the charge (designed to improve this situation) is summarized as follows. The committee will (1) review and critique various approaches to estimation of extreme flood probabilities, (2) identify and assess a preferred approach, and (3) identify specific research to be accomplished that may be required to further develop and implement such approaches. The need for this study was articulated in previous Annual Reports of the Board and the 1985 report of its Committee on Safety Criteria for Dams (see Appendix C). The committee's work is scheduled to be completed in early 1987, with the publication of a report that may help to improve the science of rare-flood hydrology.

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), a study committee of the Board (see Appendix A) is 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. An initial review of these concepts as presented in several relevant reports provided by CERL has just begun. This review is focusing on the engineering concepts and technologies, and especially the health requirements as regards the recycling of shower and laundry water for military units operating in harsh (i.e., desert) environs. The committee's review will also provide useful information on recycling and reuse of water in general for other areas that may experience shortages of acceptable quality water.

CHAPTER 4

THE WATER SCIENCE AND TECHNOLOGY BOARD COLLOQUIUM SERIES

In September 1985, the Board initiated a colloquium series, "Emerging Issues in Water Science and Technology," designed to focus attention and debate on issues in water science, technology, and policy. These colloquia, to be held regularly in conjunction with approximately every other Board meeting, will provide limited public forums for discussions of issues identified by the Board and opportunities for the Board and liaison representatives to interact with the community of scientists and engineers specializing in various aspects of water resources. Each colloquium is to be organized and hosted by Board members, will focus on carefully constructed invited papers, and will result in a published monograph on the subject of inquiry. The first topic addressed (September 5, 1985, in Boulder, Colorado) was "Drought Management and Its Impact on Public Water Systems," and its principal authors are listed in Appendix A. The overview and conclusions of this colloquium are included on the following pages; the full monograph is published separately. A second colloquium on "National Water Quality Monitoring and Assessment" is being planned for May 1986; the steering committee is listed in Appendix A.

DROUGHT MANAGEMENT AND ITS IMPACT ON PUBLIC WATER SYSTEMS

Overview and Conclusions

Humankind is in a continuous struggle with a vast range of natural hazards. Many of these hazards (e.g., floods, earthquakes, tornadoes, and hurricanes) are encountered as short-duration, high-intensity, and relatively localized events. In this country, most research and formal emergency planning procedures are directed toward damage mitigation and rehabilitation needs associated with such events. Drought is different in that it seldom has a spectacular or sudden onslaught. Damage inflicted by drought usually occurs rather subtly over a span of months to years instead of minutes to days. Truly serious drought is usually a regionalized--as contrasted to localized--trauma, with the attendant need to broaden preplanning and mitigation efforts.

A precise definition of drought is difficult, because the meaningful threshold of significant moisture deficiency is a function of the water use being impacted. For the purpose of the colloquium, drought was considered to represent a period of time when streamflows, reservoir storage, and shallow ground-water levels are abnormally low as a result of climatically induced moisture deficiency. Drought severity as it relates to public water systems is necessarily a function of human actions and/or inactions as well as the magnitude and duration of the individual hydrologic event.

There is need to direct both research and pragmatic mitigation efforts toward the neglected problems of water management during drought episodes. The Board's colloquium was limited to the subject of drought as it affects the management of public water systems. The observations and recommendations summarized herein reflect that constraint. No attempt has been made to capture individual views. Instead, emphasis has been placed on those points for which a general consensus was identified in the floor discussion.

Research Concerns

There are numerous areas of inquiry where research can be expected to be productive. Categories of primary interest include cause and effect aspects of the drought mechanism, the probability distribution of drought events, measurement of the consequences of system failure, and the legal aspects of drought management.

Our lack of ability to provide a firm rationale and explanation of the drought mechanism impedes efforts to develop reliable alert systems. The development of such systems would represent a crucial step toward implementation of effective and efficient drought contingency plans. Our present capability to predict drought appears to be confined to empirical equations relating such factors as sunspot numbers to streamflow and various physical anomalies, such as sea surface temperature and the positioning of land-based high-pressure centers, and to projected precipitation patterns. Though such correlations have been well documented, why or when these relations trigger the occurrence of significant drought is not understood.

Analysis of drought frequency relationships has lagged appreciably behind the companion efforts related to flood discharge. There are several reasons for this, not the least of which relates to difficulties associated with the definition of drought. Annual peak discharges are a meaningful measure of flood size and are easily identified for purposes of flood frequency analysis. Neither minimum instantaneous flows nor lowest daily ground-water levels provide a meaningful measure of the magnitude of drought. Both the duration and the magnitude of flow deficiency and/or moisture availability must be known in order to characterize a drought. Clearly, design of water supply system components based on drought of record begs the issue. Tree ring analyses have suggested the possible occurrence of historic droughts more severe than those readily documented by available flow records in this country. Nonetheless, we need to develop our

knowledge of drought occurrence, for such knowledge is a prerequisite for effective analysis of drought management alternatives.

Equally key to the analysis of drought management alternatives are valid assessments of the costs associated with different types and durations of system failure. Several difficulties are encountered in attempting to develop generalized and transferable relationships. First, certain costs can be very site specific. Second, acquisition of firm data is difficult until a drought is encountered. Third, the average time span between significant droughts for a given system may be so long that the local economic and social patterns, and thereby the potential consequences of different types of system failure, may have changed appreciably. These obstacles should not be allowed to deter continued inquiry. Though they may work against the quantification of well-defined cost bench marks, they do not lessen the need to develop methodological concepts to allow for an orderly process of analysis of alternative management strategies.

Proper institutional arrangements can facilitate effective management of water supplies during drought periods. Conversely, inadequate or unwieldy institutional frameworks can effectively destroy the most industrious of management efforts. Since the management of public water systems is primarily a local responsibility, research is needed on the powers local authorities require to implement effective drought management programs. In addition, legislation at other than the local level can either expedite or constrain effective management choices. Little research has been directed at the effectiveness or influence exerted by different state laws and/or subregional, state, and interstate organizational structures during droughts.

Management Concerns

A wide range of decision issues was touched upon during the formal presentations and subsequent floor discussion. They generally can be categorized as follows: appraisal of risk, choosing between relying on supplemental supplies or relying on the management of demand, social aspects of demand management, water transfers from other uses, and other regional solutions.

There was consensus that a uniform level of hydrologic risk should not be advocated as a design or decision parameter for a variety of reasons. The use of this approach in floodplain management has discouraged rational evaluation of floodplain productivity. In addition, the risk of system failure could be as sensitive to the quality of system maintenance as to variations in hydrologic events. Consideration of scale also influences this decision. That is, a small system can, from solely a logistic consideration, accept a higher risk of having to resort to emergency supplies than can a large system. Finally, site-specific considerations must be taken into account. A system with little access to alternative or emergency supplies must seek a more risk-free environment than one not so constrained. Despite lack of unanimity as to what constitutes an

acceptable risk, there was general support for the need to integrate risk analysis into system planning as opposed to basing evaluations solely on the drought of record.

Without risk appraisal, quantitative comparison of trade-offs between investments in supplemental emergency sources and demand management techniques could be meaningless. Application of demand management techniques should increase as the relative risk of system failure, especially the hydrologic portions thereof, decreases. This concept is supported by the recent trend in legal liability decisions that suggest the designer or planner could well be required to keep the risk of hydrologic system failure low. There was general agreement that system planning for drought management should capitalize on the decades of evolution in trade-off analysis that has taken place in the overall field of water resources planning. A primary prerequisite is development of an orderly and systematic matrix for analysis, and a current constraint is the lack of reliable data for quantifying the consequences of system failure.

Several major considerations surfaced in the comments related to implementation of demand management techniques. First, there is little evidence these techniques will produce a continued reduction in water demand in postemergency conditions. The public obviously feels that such reductions do, indeed, adversely affect the quality of life and finds them unacceptable in the long term. Second, public cooperation in implementing demand management techniques has been shown to be excellent provided there is clear evidence of need. Third, the successful implementation of demand management techniques requires an adequate legal foundation. These factors must be understood by managers developing drought contingency plans.

demand

Appreciable attention was directed toward the possible diversion of water from other uses, primarily agriculture, as a means of mitigating public system drought issues. The legal concept is well established via the route of condemnation, but implementation can lead to much acrimony and is often costly and time consuming. Two alternative approaches, responsive to different physical situations, were examined and found attractive.

In the case of large, rapidly growing urbanized regions, the projected transfers may be so large as to have an impact on the associated agribusiness industry. In this case, urban investment in conservation facilities for agriculture in return for the water saved has been found attractive to all three parties (i.e., the public system, the irrigator, and the related agribusiness interests). For many systems, the problem is quite different: existing sources are adequate for most years. The agricultural transfer is not needed on a permanent basis. In such cases, negotiated lease transfers wherein the irrigator is provided an initial signing bonus and then compensated for each subsequent year his water is used have proven successful.

Legal Concerns

Several legal concerns surfaced during the presentations, some of which have already been noted. Matters of primary concern to public systems confronted with drought management issues relate to questions of authority, water transfer, and constraints imposed by state or federal actions.

Several participants in the colloquium emphasized the need for public systems to have their legal house in order before the onset of drought. The point was made that, in some instances, this might require a regional approach. Of main concern is the system's ability to initiate demand management techniques involving voluntary or mandatory conservation, revised rate schedules, or imposition of penalties. For publicly operated systems, this can be handled by the pre-enactment of a drought contingency ordinance that spells out the authority granted and the actions permitted. Privately operated systems, in the absence of supporting ordinances from local government, can establish the necessary authority via contractual arrangements with individual customers.

The need for system managers to be aware of the status of their water rights, and the related state administrative and judicial procedures, was stressed. In this light, system managers should explore ways of increasing system yield within the confines of existing rights and seek administrative or legislative relief if unnecessary and ill-advised constraints are encountered. For example, conjunctive use of ground and surface waters is not widely practiced, although the practical advantage of conjunctive management is quite clear. Often its successful implementation would require a higher maximum rate of withdrawal from the ground water during the drought, although the overall demand on the ground water through the combined wet and dry cycle would be reduced. In such cases, existing administrative and legislative policies may prohibit implementation of a conjunctive use pattern. Public system managers need to move to lessen such constraints.

There is every reason to believe that an increasing number of water supply problems will be resolved via water transfers. Again, the point was made that these solutions may need to be appraised in a regional context. The phrase "water transfer" may relate to change of use or to change of location or both. Public system managers need to know about the legal controls relating to such transfers. Where the need for transfer is of limited duration, the use of leases as described above deserves exploration. The competition for water has prompted the enactment of various state statutes concerning both intrastate and interstate transfer of waters. Judicial interpretation of these statutes is undergoing rather rapid evolution. Similarly, recent decisions citing the public trust doctrine may have an impact on water allocation issues. These several matters deserve continued examination.

Conclusions

1. There is substantial need for continued research on drought and its impact on the management of public water systems. Key research topics include (a) cause of drought, (b) development of effective drought alert mechanisms, (c) probability analysis of drought, (d) quantification of the consequences of system failure during drought, and (e) identification of the institutional environment necessary for successful implementation of drought management plans. Federal agencies, universities, the water supply industry, and private foundations should all support research in these areas.

2. Sizing of the physical facilities of a system should not be based solely on full-service requirements during the drought of record, nor should such facilities be sized by the arbitrary specification of hydrologic risk. The reasons are many and range from the inadequacy of existing records to individual system characteristics. Instead, the measure of facility adequacy should be established by orderly comparison of incremental facility requirements versus the use of demand management techniques over the range of probability conditions. As the risk of system inadequacy decreases, the relative advantage of demand management techniques can be expected to increase.

facility size relative to demand

3. The key to adequate drought management of public water systems lies in predrought preparation. This consists of a variety of actions best typified as drought contingency planning, including (a) a good system maintenance program, (b) periodic assessment of system capacity and the relative balance among all system components (source, transmission, treatment, and distribution), (c) identification and appraisal of the reliability of emergency or supplemental sources of supply, (d) analysis of the probable effectiveness of demand management techniques and determination of criteria for implementation, (e) development of the framework of public information programs needed to implement drought management measures, and (f) establishment of the legal foundation necessary to implement emergency source plans and projected demand management techniques.

CHAPTER 5

PLANNED PROJECTS

Education of Environmental Engineers for Developing Countries

At one time, universities in the United States played an important role in training water supply and wastewater disposal professionals from developing countries. However, this preeminence has diminished. Over the past four decades, U.S. graduate education in these subjects has evolved from an empirically based applied science to a curriculum that prepares students for careers in sophisticated, highly industrialized societies. Yet, there continues to be a demand for graduates who are capable of dealing with environmental issues at a more basic level. Adequate facilities for water supply, excreta disposal, and sanitation in developing countries are sadly lacking and are, in fact, major issues currently facing these countries. Lack of appropriate training is largely responsible for this situation.

At the request of the Pan American Health Organization (PAHO), in March 1984, Professor Abel Wolman (NAS, NAE), The Johns Hopkins University, convened a small group of concerned environmental engineering educators, including Professor Walter R. Lynn, then WSTB Chairman. Those discussions focused on the options and roles of U.S. universities in providing Latin American students with the skills required to meet environmental engineering needs in their countries. Subsequently, at the June 1984 WSTB meeting, Lynn reported on that session and the concerns and interests of those present, and the WSTB concluded that an appropriate activity should be further developed under the auspices of the NRC. Since then, WSTB members and staff have engaged periodically in dialogue with Agency for International Development and PAHO engineers who agreed in principle that a WSTB study would be of great value.

However, much effort remains to be put into program development, owing to the complexity of the problem, the number of agencies and other organizations with interests in this subject, and the international character of the issues. As a result, in November 1985, the WSTB requested and obtained a small amount of money from the National Research Council's Program Initiation Fund for this purpose. It is hoped that with these program initiation funds a planning session can be convened to discuss the possibility of a NRC study. Several suggested study topics are characterization of public health needs as they pertain to environmental engineering needs of selected Latin American countries; appropriateness of educational curriculum

and facilities; options for education; and design of cooperative programs.

Review of Glen Canyon Environmental Studies

In response to a request in late 1985 from the Bureau of Reclamation, the Board is considering development of an activity that will involve assessment and assistance in interpretation of environmental studies of alternative operation schemes for the Glen Canyon Dam on the lower Colorado River, Arizona. Glen Canyon Dam is one of several high-head, multipurpose storage projects in the Colorado River system. Since completion of construction in 1964, a number of issues have been raised concerning the impacts of its operation, including concerns for shoreline erosion, impacts on recreation, degradation of water quality, and negative impacts on fish and wildlife. These concerns are underscored by the project's location upstream of the Grand Canyon, a special national resource, and by the significance of the project as an electric power resource.

The Glen Canyon Environmental Studies were initiated by the Department of the Interior in December 1982 to study the effects of the project's operations on the natural resources of the Grand Canyon. The study area extends from the dam to the backwater of Lake Mead, approximately 250 miles. Interior's studies fall into four general categories: biology, recreation, hydrology and sediment transport, and operations. A total of 42 individual studies are now in progress, and in late summer 1986 a unique report integration and review process will be required. Based on this prototype, modified reservoir operating policies will begin to be considered in the spring of 1987. Never before has the Bureau of Reclamation conducted this type of review of an existing project.

These studies are evaluating the relationships between dam operations and the natural resources of the Grand Canyon. In order to maximize the effort and help to ensure a logical decision-making process, the WSTB has been asked to provide a review role and assist in the process of making decisions concerning alternative operation schemes. It is planned that a study committee will assist in the evaluation and interpretation of the studies, which will soon be nearing completion; the committee also will provide assistance in the decision-making process that is so critical to drawing conclusions from the overall research program.

Assessment of Models for Analyses of Ground-Water Flow and Contaminant Transport

During the past few years, considerable attention has been focused on problems of contamination of ground water. Contaminants principally originate from agricultural, industrial/chemical waste, military, and energy-production related activities. Several well-known, distressing incidents have prompted much activity and a

general raising of the interest level in the science and research aimed at understanding, mitigating, or preventing ground-water pollution incidents. The underpinnings of our capacity to deal with such problems are the scientific techniques applied in understanding contaminant transport and the natural processes (i.e., reactions with air, water, and minerals) that alter the chemical and biological characteristics within ground-water flow systems. New, advanced large computers provide opportunities to improve on analytical techniques, but ground-water quality modeling itself is a young field in need of further development to be regarded as reliable--principally because of the complexity and diversity of hydrogeological problems. Hundreds of models exist, but few have been verified or documented to any extent. Nonetheless, model results enjoy credibility that sometimes is not merited; sight may be lost that models are mathematical approximations of complex phenomena where data for verification are meager. But, given the considerable expense of establishing monitoring programs and performing sample analyses, it is inevitable that the need for reliable models will increase in the future. Human judgment and knowledge of the applicability of the various ground-water models are key to appropriate utilization. The use of models and the results that they generate are being increasingly scrutinized by the regulatory community and in the courtroom. Clearly, if responsibility for costly cleanup efforts are being assessed using modeling techniques, the adequacy and worth of those models will be of great interest to the parties implicated. The Board believes that a review of the state of the art of models, review of the analytical techniques available for problem assessment, assessment of the applicability of models for various hydrologic conditions, and assessment of research needs will be useful to the numerous managers and researchers working toward related goals. Thus, the Board has begun to plan for an assessment of ground-water flow and contaminant transport models.

CHAPTER 6

RESEARCH NEEDS IN WATER SCIENCE AND TECHNOLOGY

Background

Water problems persist worldwide. The problems generally are well known and include matters of too much or too little water available at appropriate quality and cost for a variety of sometimes competing purposes. In the United States, over the past 100 years or so, large networks of federal and nonfederal governmental agencies and institutions have evolved, each of which has been designed to carry out specific programs such as development, resource regulation, management or protection, information development, and/or advancement of science.

Water resources is not a new or neglected field. But the contexts in which issues arise are constantly changing as demographic and physical changes occur, society dictates new priorities, and new information is developed. Furthermore, water issues generally are inherently complex, involving both technical questions and often difficult institutional or social questions. Water resources research programs necessary to address these issues intelligently are supported by numerous federal agencies and other organizations. These programs are predominantly designed to support operational decisions and thus most research is "applied" in nature with only a small percentage "basic" or "anticipatory" in nature.

The Water Science and Technology Board considers an important part of its mandate to look ahead in anticipation of problems and research needs (thus, the colloquium series). Also, routinely the Board tries to organize its activities so as to have generic applicability when possible. At other times it has tried to call attention to emerging issues or encourage research on issues that may not be on the agenda of an operating agency. For example, in its annual reports for 1983 and 1984 the Board identified numerous research opportunities that covered a wide range of needs. These are not repeated here but are not necessarily less pressing now. In 1985, the Board's Committee on U.S.G.S. Water Resources Research examined the status of water resources research and, in accordance with its charge to help identify priority topics to be funded under the section 105 grants program of the Water Resources Research Act of 1984, pointed to two particular areas meriting attention: (1) the science and technology of water quality management and (2) water resource institutional issues. These are obviously not the only areas of water resources deserving

attention, but the Board does believe that they present significant opportunities and that the potential exists for making creative, worthwhile advances in better scientific understanding and in resolving major water problems. Also, while the recommendations are aimed specifically at the section 105 grants program, the funding for that program is currently quite modest, and the Board hopes that other agencies will support research in the areas identified.

Recommended Research

The committee identified two general areas of research calling for special attention. These include the science and technology of water-quality management and water resource institutional issues. Within the first of these research areas, particular emphasis was placed on the issue of toxic substances and their behavior in surface waters and ground waters, the exploration of new control technologies (e.g., biotechnology and genetic engineering), and the engineering of water-quality protection and improvement schemes incorporating physical, chemical, and biological information. Under institutional issues, special attention is devoted to needs for research in water allocation and in regional approaches to water-quality and water-quantity problems. The topics discussed include water rights, mechanisms for water transfer, methods for regional water-systems design, and economic incentives. It is noted that very little research is currently being conducted in these areas, while institutional hurdles are significant in resolving most water problems.

Science and Technology of Water-Quality Management

There is a clear need for research that will improve the scientific understanding of water quality in all natural water systems serving as water resources. There is an especially great need for original research on the chemistry, biology, and engineering of ground-water protection and decontamination. Emphasis is on the scientific basis for water-quality management. Such research will require the participation of scientists and engineers in research embracing water resources and source protection. A major goal is the protection and improvement of the quality of water resources, both ground waters and surface waters. Water quality in many ground-water and surface-water resources is now experiencing significant deterioration because of the presence of toxic or hazardous substances. The problem is national in scope. Degradation of water resources quality can lead to a significant decrease in the quantity of water available for human consumption. Adverse changes in quality also have a broad impact on aquatic life and on human populations, to a degree not yet understood. Chemical, biological, and physical research efforts will need to be integrated to solve water-quality problems.

It is believed that there is need for focused research in the water-quality area that will generate results contributing to our

basic knowledge and enhancing our power to solve water resources problems. Among the opportunities for focused research in this area are development of comprehensive, fundamentally based models for predicting the fate of hazardous materials in surface waters, soils, and ground waters and new technologies (e.g., biotechnology and genetic engineering) to degrade or immobilize hazardous chemicals.

Scientific Understanding of Hazardous Substances in Water There are a number of research problems that appear to deserve high priority here: (i) Interaction of synthetic organic compounds with naturally occurring organics (e.g., humic substances) in waters and sediments. The chemical and biological activity of point-hazardous organic compounds (e.g., chlorinated phenols and polychlorinated biphenyls) is expected to be affected by such chemical interactions. (ii) Interactions of inorganic, organic, and combined toxic materials with organisms. Of particular interest here is the subject of metal or metalloid chemical speciation in water and the differing biological effects of the principal species. One example of current interest is the role of selenium speciation in the transport, fate, and toxicity of selenium in surface waters and ground waters. (iii) Chemistry of binding inorganic and organic species to particle surfaces in waters and sediments. There is a need for quantitative studies in the laboratory and in the field that evaluate the applicability of available physical-chemical models of pollutant adsorption into particles. (iv) Improved understanding of microbiological alteration of organic compounds in water with emphasis on the intermediate degradation products and end products and their biological activity (e.g., determining whether they are more or less toxic than the parent compounds). (v) The physics and fluid mechanics describing rates and mechanisms of transfer of reactants (e.g., oxygen, pollutants, nutrients) in natural systems, such as in ground waters and hypolimnetic lake waters.

Applications of Biotechnology to Water Resources Under this topic there are opportunities for innovative research in four areas: (i) The development of novel approaches to detect and measure specific pollutants in water resource systems using DNA probes. (ii) Genetic research on natural microbial communities as a basis for engineering (through cloning, for example) microorganisms for application to water quality management. This area includes research on microbial physiology and ecology as well. (iii) Research on microbial genetics as it affects toxic chemical degradation in surface water and ground-water environments. (iv) Understanding the microbial genetics associated with resistance and resilience phenomena in order to harness both genetically engineered and natural microbial populations for detoxification of hazardous compounds.

Engineering and Technology of Chemical and Biological Applications for Water Resources Systems The application of physical, chemical,

and biological principles to large-scale systems requires engineering research in a number of areas. Some of the more important examples are (i) engineering of biocatalysts to accelerate in situ degradation processes of hazardous organic compounds; (ii) bioreactor research and biochemical process engineering for decontamination of natural waters; (iii) bioengineering of in situ processes for water-quality control with the objective of optimizing operations under the conditions of natural systems.

Water Resources Institutional Issues

Water Allocation Given the relatively full appropriation of existing water supplies and the limited number of high-quality sources available for development, future water management decision making will emphasize the process of reallocation of water among competing uses and preservation of sources for development. Existing institutional arrangements, i.e., existing decision-making and incentive systems for allocating resources and costs and benefits to individuals and society, may require modification to facilitate reallocations. The modifications should provide more efficient transfer mechanisms while ensuring equitable treatment for all interested parties and consideration of all societal values. These challenges to existing institutional arrangements are particularly severe in the West owing to quantification of Indian water rights, regional shortages, Supreme Court decisions with respect to the definition of water rights, and water-quality problems. Similar challenges may be expected in the East under conditions of regional shortages and severe water-quality problems. It is therefore imperative that research be undertaken concerning institutions for reallocation in the variable contexts in which it must occur, i.e., varying hydrologic, legal, economic, and geographical circumstances. The research should examine the conditions under which such institutions would be workable: the incentives for change, the political viability of change, and the distribution of costs and benefits to particular parties and the various interests of society. The following are priority research topics in the general field:

1. Definition of water rights: the extent to which water rights may be susceptible to redefinition to facilitate the reallocation process. Such issues are the reserved water rights for Indian and federal lands, the definitions of beneficial use under the doctrine of prior appropriation, definitions of rights to in-stream uses, and the relationship of water rights to legal requirements to maintain water quality.
2. Market and administrative mechanisms for achieving efficient and equitable transfers of water: the combination of legal, administrative, and economic incentive arrangements (with due consideration for the hydrologic dimensions) for making such transfers. The reallocation process may be facilitated by appropriate legal definitions of water rights that facilitate reallocation, the

REALLOCATION VS WATER RIGHTS

creation of administrative mechanisms for negotiations among interested parties, and removal of barriers that impede the economic exchanges necessary for reallocation of water.

3. Centralized and decentralized mechanisms for reallocation: appropriate mixes of federal, regional, state, and substate decision-making and administrative institutions for reallocation. The geographic distribution, the nature of flow of the water resources, and the requirements of the constitutional system inevitably lead to decision-making systems involving many levels of government. The issues involved include the stakes of the parties involved, the protection of the general interests of society, and the capacity to develop, integrate, and use information for purposes of efficient and equitable decision making.

Design of Regional Water Systems and Design of Incentives for Regional Cooperation Research and experience have shown that regional approaches to water problems, of both quality and quantity, often produce major gains in both the economy and efficiency with which water problems are addressed. Still, major obstacles have limited the extent to which such approaches have been implemented. The situation calls for improved methods for determining under what conditions regional systems should be advocated and, especially, for a better understanding of incentives that can help or hinder the creation of regional institutions for water management. The following two areas of research are recommended:

1. Methods for the design of regional water systems. The creation of optimization methodologies (heuristic or exact) for the analysis of regional water systems has been identified as an important area for research. The methodologies would be directed toward the design of regional water management systems, including both water supply and wastewater management. A regional authority may oversee such systems, mandating standards and allocating costs.

Regional water supply systems generally promise lower costs to society because of the efficiencies inherent in joint enterprises that permit management of water on a larger scale than is possible where each local authority is obliged to make decisions on its own within the constraints of its political boundaries. Joint management makes more feasible the provision of joint physical facilities that can provide significant economies of scale. The Pareto Principle, a basic tenet of welfare economics, applies here in that, if all parties share the cost, the benefits are optimized and not denied to or decreased for any individual party. Another benefit may result owing to increased feasibility of reusing wastewater for nonpotable purposes in areas where water resources are being depleted.

The design components of regional systems include, but are not limited to, spatial siting of the plant and the placement and sizing of the pipeline connections between the plant or plants and the communities. In the case of the regional water supply system, the operation of reservoirs or the conjunctive use of surface water and

ground water may be important factors in the overall design of the regional system. In the case of the regional wastewater treatment system, protection of the quality of the receiving water may be an important element in the methodologies developed.

Methods are sought to determine environmentally sound designs that will minimize total costs to society. The availability of solution methods for minicomputers or microcomputers and the provision of user-friendly programs are two steps that could increase the likelihood of application of the methodologies and hence make the research more relevant to needs.

2. Cost allocation incentives. Regional water systems will not come into being automatically, even when the most efficient designs are identified. To overcome the desire for sovereignty on the part of many communities the costs allocated to participants must be carefully determined by a regional authority. The allocated costs must not only provide incentives to join the regional system, they must also appear equitable to the communities involved so as not to reinforce preferences for sovereignty. Thus cost allocation is seen as a means to provide incentives to spur regional cooperation. One case where regional institutions seem indicated is in the protection of ground water from hazardous materials by the careful siting of disposal facilities. This is a problem that has multiobjectives. On the one hand, cost minimization is clearly a goal. On the other hand, ground-water protection is an equally relevant objective. Possible applications of methodologies such as collective choice analysis and game theory to this problem should be explored.

APPENDIX A

WATER SCIENCE AND TECHNOLOGY BOARD PROGRAM PARTICIPANTS

BOARD MEMBERS

John J. Boland, Chairman
Johns Hopkins University

Walter R. Lynn, Past Chairman
Cornell University

Mary P. Anderson
University of Wisconsin-Madison

Stephen Burges
University of Washington

Paul Busch
Malcolm Pirnie Engineers
White Plains, New York

John Cairns (thru 10/85)
Virginia Polytechnic Institute and State University

James M. Davidson
University of Florida

Peter S. Eagleson (thru 10/85)
Massachusetts Institute of Technology

Leo Eisel
Wright Water Engineers
Denver, Colorado

Richard S. Engelbrecht
University of Illinois

Jerome B. Gilbert
East Bay Municipal Utility District
Oakland, California

Harry L. Hamilton, Jr.
State University of New York at Albany

Helen Ingram (thru 10/85)
University of Arizona

Michael Kavanaugh
James M. Montgomery Consulting Engineers
Oakland, California

Lester B. Lave
Carnegie-Mellon University

Orie Loucks (thru 10/85)
Holcomb Research Institute

George R. Marzolf
Kansas State University

David W. Miller
Geraghty & Miller, Inc.
Syosset, New York

Jerome W. Milliman (thru 10/85)
University of Florida

Robert L. Smith
University of Kansas

Gary Weatherford
Watershed West
Berkeley, California

Edith Brown Weiss
Georgetown University Law Center

WSTB Executive Committee

John J. Boland, Chairman
Walter R. Lynn
Leo M. Eisel
Jerome B. Gilbert
Robert L. Smith

STAFF

Professional

Stephen D. Parker, Director
Sheila D. David, Staff Officer
Patrick W. Holden, Staff Officer
Carole B. Carstater, Staff Assistant

Secretarial

Jeanne Aquilino, Administrative Secretary
Renee Hawkins, Senior Secretary
Lizette McCreary, Secretary

FEDERAL AGENCY LIAISON REPRESENTATIVES

William S. Bivins (Alternate)
Federal Emergency Management Agency

Ralph Brooks (Alternate)
Tennessee Valley Authority

Bevan W. Brown
Tennessee Valley Authority

Edward Bryan
National Science Foundation

Donald L. Chery, Jr.
U.S. Nuclear Regulatory Commission

Philip Cohen
U.S. Geological Survey

Steve Cordle
U.S. Environmental Protection Agency

John Day
Economic Research Service--USDA

Jonathan P. Deason
U.S. Army

Marian Mlay
U.S. Environmental Protection Agency

Edgar H. Nelson
U.S. Department of Agriculture

Frank Osterhoudt
U.S. Department of the Interior

Brent Paul
Bureau of Reclamation

Herbert Quinn
U.S. Environmental Protection Agency

William Roper
U.S. Army Corps of Engineers

John Schaake
National Weather Service

Frank H. Thomas
Federal Emergency Management Agency

Harry E. Thomas
Federal Energy Regulatory Commission

Clive H. Walker (Alternate)
U.S. Department of Agriculture

Gerald B. Welsh (Alternate)
U.S. Department of Agriculture

Robert Wolff
U.S. Army Corps of Engineers

Frank J. Wobber
U.S. Department of Energy

COLLOQUIUM ON
DROUGHT MANAGEMENT AND ITS IMPACT ON PUBLIC WATER SYSTEMS

Principal Authors

Robert L. Smith, Chairman
University of Kansas

Edward Clyde
Clyde and Pratt
Salt Lake City, Utah

John A. Dracup
University of California, Los Angeles

Benedykt Dziegielewski
Southern Illinois University

Duane Georgeson
Los Angeles Department of Water and Power

Gilbert L. White
Institute of Behavioral Sciences
University of Colorado, Boulder

COLLOQUIUM ON
NATIONAL WATER QUALITY MONITORING AND ASSESSMENT

Steering Committee

Richard S. Engelbrecht, Chairman
University of Illinois

James M. Davidson
University of Florida

Leo M. Eisel
Wright Water Engineers
Denver, Colorado

Daniel A. Okun
University of North Carolina, Chapel Hill

COMMITTEE TO REVIEW THE GREAT LAKES WATER QUALITY AGREEMENT
(Discharged 12/31/85)

Orie Loucks, Cochairman
Holcomb Research Institute

Henry Regier, Cochairman
University of Toronto

Dale L. Bacon
3M Company
St. Paul, Minnesota

John J. Black
Roswell Park Memorial Institute
Buffalo, New York

Jennifer Ellenton
Consulting Genetic Toxicologist
Acton, Ontario

Crawford S. Holling
University of British Columbia

H.B. Noel Hynes
University of Waterloo

James Kramer
McMaster University

Andre Marsan
Andre Marsan et Associes
Montreal, Quebec

Clifford Mortimer
University of Wisconsin

Donald J. Munton
Canadian Institute of International Affairs

William Sonzogni
University of Wisconsin-Madison

John Stolzenberg
Wisconsin Legislative Council

Edith Brown Weiss
Georgetown University Law Center

COMMITTEE ON GROUND-WATER QUALITY PROTECTION

Jerome B. Gilbert, Chairman
East Bay Municipal Utility District
Oakland, California

Eula Bingham
University of Cincinnati

John J. Boland
The Johns Hopkins University

Anthony D. Cortese
Tufts University

Thomas M. Hellman
General Electric
Fairfield, Connecticut

Wiley Horne
Metropolitan Water District of Southern California

Helen Ingram
University of Arizona

Thomas M. Johnson
Illinois State Geological Survey

Sue Lofgren
The Forum
Tempe, Arizona

Paula Magnuson
Geraghty & Miller, Inc.
Syosset, New York

Perry L. McCarty
Stanford University

Dwight F. Metzler
Kansas Department of Health and Environment (Retired)

Christine Shoemaker
Cornell University

David A. Stephenson
Dames and Moore
Phoenix, Arizona

James T. B. Tripp
Environmental Defense Fund

David W. Miller (ex officio, WSTB)
Geraghty & Miller, Inc.
Syosset, New York

COMMITTEE ON U.S.G.S. WATER RESOURCES RESEARCH

James J. Morgan, Chairman
California Institute of Technology

Rita R. Colwell
University of Maryland

Jack Keller
Utah State University

Allen Kneese
Resources for the Future

Marsha L. Landolt
University of Washington

Dean Mann
University of California, Santa Barbara

Kenneth J. Miller
CH_2M-Hill Consulting Engineers
Denver, Colorado

William J. Miller
Consulting Engineer
Berkeley, California

Daniel A. Okun
University of North Carolina, Chapel Hill

Betty H. Olson
University of California, Irvine

Wayne A. Pettyjohn
Oklahoma State University

George F. Pinder
Princeton University

Charles S. Revelle
The Johns Hopkins University

Ralph R. Rumer, Jr.
State University of New York at Buffalo

Jery R. Stedinger
Cornell University

COMMITTEE ON IRRIGATION-INDUCED WATER QUALITY PROBLEMS

William H. Allaway, Chairman
Cornell University (retired)

Ernest E. Angino
University of Kansas

Margriet F. Caswell
University of California,
Santa Barbara

Edwin H. Clark II
The Conservation Foundation
Washington, D.C.

Wilford R. Gardner
University of Arizona

Rolf Hartung
University of Michigan

L. Douglas James
Utah State University

Robert R. Meglen
University of Colorado,
Denver

Francois M. M. Morel
Massachusetts Institute of
Technology

Oscar E. Olson
South Dakota State University

Scott Overton
Oregon State University

Merilyn B. Reeves
Amity, Oregon

Kenneth D. Schmidt
Ground-Water Quality Consultant
Fresno, California

R. Rhodes Trussell
James M. Montgomery Consulting
Engineers
Pasadena, California

Jan van Schilfgaarde
Agricultural Research Service
Fort Collins, Colorado

Daniel Willard
Indiana University

Walter R. Lynn (ex officio, WSTB)
Cornell University

Gary Weatherford (ex officio, WSTB)
Watershed West
Berkeley, California

COMMITTEE ON TECHNIQUES FOR ESTIMATING PROBABILITIES OF EXTREME FLOODS

Jared L. Cohon, Chairman
The Johns Hopkins University

Victor R. Baker
University of Arizona

Duane C. Boes
Colorado State University

C. Allin Cornell
Stanford University

Norman Crawford
Hydrocomp
Mountain View, California

Michael D. Hudlow
National Weather Service

William Kirby
U.S. Geological Survey

Donald W. Newton
Tennessee Valley Authority

Kenneth W. Potter
University of Wisconsin-Madison

James R. Wallis
IBM T. J. Watson Research Center
Yorktown Heights, New York

Sidney J. Yakowitz
University of Arizona

Leo M. Eisel (ex officio, WSTB)
Wright Water Engineers
Denver, Colorado

COMMITTEE ON RECYCLING, REUSE, AND CONSERVATION IN WATER MANAGEMENT FOR ARID AREAS

Richard S. Engelbrecht, Chairman
University of Illinois

Richard Bull
Washington State University

William J. Cooper
Florida International University

Michael Kavanaugh
James M. Montgomery Consulting Engineers
Oakland, California

K. Daniel Lindstedt
Black and Veatch Consulting Engineers
Aurora, Colorado

Barbara E. Moore
University of Texas at Austin

COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS

Martin Goland, Chairman
Southwest Research Institute
Southwest Foundation for
Research and Education

John A. Armstrong
IBM Corporation
Yorktown Heights, New York

Seymour L. Blum
Charles River Associates, Inc.
Boston, Massachusetts

Dennis Chamot
AFL-CIO
Washington, D.C.

Floyd L. Culler, Jr.
Electric Power Research Institute
Palo Alto, California

Daniel B. DeBra
Stanford University

Joseph F. Engelberger
Westinghouse Electric Corporation
Danbury, Connecticut

Robert R. Everett
The MITRE Corporation
Bedford, Massachusetts

James L. Flanagan
AT&T Bell Laboratories
Murray Hill, New Jersey

Robert R. Fossum
Southern Methodist University

Ben C. Gerwick, Jr.
University of California, Berkeley

James F. Lardner
Deere & Company
Moline, Illinois

Peter W. Likins
Lehigh University

Hyla S. Napadensky
ITT Research Institute
Chicago, Illinois

Leslie E. Robertson
Robertson, Fowler & Associates
New York, New York

William R. Schowalter
Princeton University

Robert L. Smith*
University of Kansas

Albert R. C. Westwood
Martin Marietta Corporation
Baltimore, Maryland

David L. Bodde
Executive Director

*WSTB Liaison

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 was 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 biannual 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 biannual 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

REPORTS OF THE WATER SCIENCE AND TECHNOLOGY BOARD (1982-1985)

THE GREAT LAKES WATER QUALITY AGREEMENT: AN EVOLVING INSTRUMENT FOR ECOSYSTEM MANAGEMENT

1985, 224 pp. (W85-6)

A review of the 1978 Great Lakes Water Quality Agreement between the United States and Canada was undertaken beginning in 1984 and ending with the issuance of a final report from a binational committee of the Royal Society of Canada and the National Research Council in December 1985. A major opportunity to review the Agreement comes in 1986 after the International Joint Commission (IJC) issues its third biennial report, and the committee's report can be a valuable resource in such a review.

The report covers four major areas concerning the Lakes and the Agreement: enrichment, toxic contaminants, institutional arrangements and the ecosystem approach and sustainable development.

The committee found that "major progress" has been achieved in reducing levels of phosphates and several pollutants in the Great Lakes. However, it also states that there remains an "urgency to achieve a reduction of toxic pollutants in the Great Lakes and thereby reduce the risks to the human population using the resources of the basin." One of the major findings of the report is that people living in the Great Lakes region are exposed to "appreciably more" toxic chemicals through contaminated drinking water and food products than other similar populations in North America.

Both the 1972 and 1978 Great Lakes Water Quality Agreements are widely recognized as among the world's pioneering international instruments designed to foster intergovernmental cooperation to correct pollution in a large river basin. The committee concluded that the two governments should continue and strengthen the 1978 Agreement. The joint institutions created in the 1978 Agreement, the Water Quality Board and the Science Advisory Board, have proven to be an effective means for advancing dialogue between the parties to the Agreement (United States and Canada) and among the various states and provinces on technical questions, programs, and expenditures.

To improve accountability in carrying out the Agreement, the committee suggested that the U.S. and Canadian governments publish a report every two years on the progress achieved and that bilateral meetings be held regularly between senior officials to discuss any problems. This was recommended since neither country releases

detailed public statements of the status of the implementation of Agreement-related programs. Additionally, the committee reported that there needs to be a clearer delineation of the responsibilities of the various institutions in managing Great Lakes water quality. Such clarification would lead to improved functioning of the various institutions as well as greater accountability for their actions. The committee also desires to see Great Lakes water quality managed more from an ecosystem approach. This means that Great Lakes water quality related programs and policies, and the institutions that implement them, should be guided by the two basic ecosystem goals set forth in the 1978 Agreement to "restore and maintain the integrity of the waters of the Great Lakes basin ecosystem."

A final overall recommendation was made that the parties to the Agreement hold a binational conference on the Great Lakes and that they establish an action plan to be acted on formally at a conference to be held before the end of the present decade. In general the committee found that substantial further reforms are needed in the Great Lakes basin, far beyond the programs specified in the 1972 and 1978 Agreements and that now is an appropriate time to face that challenge.

Study committee cochairmen: Orie Loucks, Holcomb Research Institute, and Henry Regier, University of Toronto. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

LETTER REPORT OF THE COMMITTEE ON U.S.G.S. WATER RESOURCES RESEARCH (November 26, 1985)

1985, 9 pp. (W85-5)

This report principally recommends focus for the research grants program administered by the U.S. Geological Survey and authorized by section 105 of the Water Resources Research Act of 1984. The report briefly reviews the scope of water resources research and previous "prioritization" and research review efforts. The report discusses the committee's criteria and delineates two general areas of research in need of attention and deemed appropriate for the section 105 grants program: (1) science and technology of water quality management, including scientific understanding of hazardous substances in water, applications of biotechnology to water resources, and engineering and technology of chemical and biological applications for water resources systems; and (2) water resources institutional issues, including water allocation, design of regional water systems, and incentives for regional cooperation. Committee chairman: James J. Morgan, California Institute of Technology. The substantive content of this letter report is included in Chapter 6 of this Annual Report; the full report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

LETTER REPORT OF THE COMMITTEE ON IRRIGATION-INDUCED WATER QUALITY PROBLEMS (October 10, 1985)

1985, 11 pp. (W85-4)

This is the first report of the Committee on Irrigation-Induced Water Quality Problems and followed several days of briefings on and review of plans for the San Joaquin Valley Drainage Program. The "letter report" points to needs for improved coordination of research activities and overall program management of the San Joaquin Valley Drainage Program. A program of public participation was noted to be not yet developed. Other critical areas of concern included the need for data management and the ongoing interpretation of data to provide feedback on the overall research program and clarify future research needs; the importance of establishing sound quality assurance/quality control programs in providing useful and defensible data; the need to consider agricultural chemicals in the design of analytical studies; economic, legal, institutional, and financial constraints and their influence on the range and ultimate selection of alternatives have not yet been adequately addressed and must be thoroughly studied; and, on-farm management options have not yet been given appropriate consideration. Other sections of the letter report directly address the research programs proposed and under way of the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the U.S. Bureau of Reclamation. The report is the first in what is expected to be a series of such reports providing timely and constructive guidance and comment on the San Joaquin Valley Drainage Program. Committee chairman: William H. Allaway, Ithaca, New York. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

LETTER REPORT OF THE WSTB WORKING GROUP TO REVIEW PLANS FOR A NATIONAL WATER QUALITY ASSESSMENT PROGRAM (October 7, 1985)

1985, 3 pp. (W85-3)

This report was authored by an ad hoc work group, comprised of Board members and members of the Committee on U.S.G.S. Water Resources Research, following review of documents and briefings on the proposed National Water Quality Assessment Program. The report points up the need and value of such a program and includes some specific suggestions aimed at improving design and implementation of the planned program. Workgroup chairman: Walter R. Lynn, Cornell University. The letter report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

WSTB REVIEW OF U.S. DEPARTMENT OF ENERGY (DOE) REPORT "TRANSPORT OF ENERGY-RELATED ORGANIC COMPOUNDS AND MIXTURES IN SUBSURFACE ENVIRONMENTS"

1985, 6 pp. (W85-2)

In response to a request from the U.S. Department of Energy (DOE) in October 1984, an ad hoc subcommittee of the Board reviewed a DOE report titled "Transport of Energy-Related Organic Compounds and Mixtures in Subsurface Environments" (November 1984). The DOE document was characterized by its authors as a "concept paper" describing a research plan to be adopted by the department. In the form of a 6-page letter report to DOE, the WSTB subcommittee provided a scientific overview of the proposed research and suggestions for improving the scientific content of the plan. The subcommittee commented on the need and importance of the research, the proposed timetable, and the need for controlled field facilities prior to conducting experiments at natural field sites. Subcommittee chairman: Mary P. Anderson, University of Wisconsin-Madison. The letter report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

WATER SCIENCE AND TECHNOLOGY BOARD ANNUAL REPORT 1984

1985, 48 pp. (W85-1)

This is the second annual report published by the Board since its creation in 1982. The report includes an introduction describing issues of importance, a description of the Board's modus operandi and organizational setting in the National Research Council; project activities completed in 1984; descriptions of current and planned activities; and discussions of issues and research needs in water resources. Also included are listings of program participants, the Board's Terms of Reference, and abstracts of reports issued by the Board since 1982. Board chairman: Walter R. Lynn, Cornell University. The report is available in limited supply from the Water Science and Technology Board office (2101 Constitution Avenue, N.W., Washington, D.C. 20418) or National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession Number: PB85 204485/AS. Cost: $10.00.

SAFETY OF DAMS: FLOOD AND EARTHQUAKE CRITERIA

1985, 321 pp. (W84-5)

This report was prepared at the request of the Assistant Secretary of the Interior for Water and Science and the Assistant Secretary of the Army for Civil Works and 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. Study committee chairman: George W. Housner, California Institute of Technology. The report is 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. (W84-4)

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 were used as background information for the phase II effort (See W85-6). Conference chairman: Orie Loucks, Holcomb Research Institute. The report is available from Water Science and Technology Board, 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. (W84-3)

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 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. Board chairman: Walter R. Lynn, Cornell University. The report is 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. (W84-2)

This report represents 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 that detract from the above acknowledgments. 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. Study committee chairman:

Daniel A. Okun, University of North Carolina, and Walter R. Lynn, Cornell University. The report is 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. (W84-1)

This report represents 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 water treatment plant project was constructed, operated, and evaluated. The NRC committee provided a review and written report on the scientific bases for the conclusions reached by the Corps from this study.

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. Study committee chairman: Perry L. McCarty, Stanford University. The report is 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. (W83-4)

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 with that of the present ice boom.

Study panel chairman: Harry L. Hamilton, Jr., State University of New York--Albany. The report is 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. (W83-3)

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. Study committee chairman: Robert B. Jansen, consulting engineer. The report is 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. (W83-2)

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. Board chairman: Walter R. Lynn, Cornell University. The report is 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. (W83-1)

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 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. Conference chairman: David H. Marks, Massachusetts Institute of Technology. The report is 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. (W82-2)

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. Study committee chairman: L. Douglas James, Utah State University. The report is 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. (W82-1)

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. Study committee chairman: Robert B. Jansen, consulting engineer. The report is available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Accession number: PB 82-188855. Cost: $9.00.

APPENDIX D

MEETINGS OF THE WATER SCIENCE AND TECHNOLOGY BOARD AND ITS SUBGROUPS DURING 1985

JANUARY	
17-18	Committee on Ground-Water Quality Protection, Washington, D.C.
FEBRUARY	
13-15	Committee to Review the Great Lakes Water Quality Agreement, Ottawa, Canada
MARCH	
11-12	Committee on U.S.G.S. Water Resources Research, Washington, D.C.
25	Committee to Review the Great Lakes Water Quality Agreement, Washington, D.C.
APRIL	
1-2	Water Science and Technology Board, Washington, D.C.
2-3	Committee on Ground-Water Quality Protection, Washington, D.C.
15-17	Committee to Review the Great Lakes Water Quality Agreement, Washington, D.C.

MAY	
21-22	Committee on Ground-Water Quality Protection, Denver, Colorado
29-31	Committee on Irrigation-Induced Water Quality Problems, Sacramento, California
JUNE	
5-7	Committee to Review the Great Lakes Water Quality Agreement, Niagara, On-The-Lake, Canada
27-28	Committee on U.S.G.S. Water Resources Research, Washington, D.C.
JULY	
17	Water Science and Technology Board Agency Liaison Representatives, Washington, D.C.
25-27	Committee on Ground-Water Quality Protection, La Jolla, California
31 - August 2	Committee on Irrigation-Induced Water Quality Problems, Sacramento, California
AUGUST	
22	Working Group to Review Plans for a National Water Quality Assessment Program, Washington, D.C.
SEPTEMBER	
5	Colloquium on Drought Management and its Impact on Public Water Systems, Boulder, Colorado
6	Water Science and Technology Board, Boulder, Colorado

SEPTEMBER (continued)	
20	Committee on Irrigation-Induced Water Quality Problems, Sacramento, California
OCTOBER	
3-4	Committee on Ground-Water Quality Protection, San Francisco, California
29	Committee to Review the Great Lakes Water Quality Agreement (Executive Committee Meeting), Washington, D.C.
NOVEMBER	
12	National Water Quality Monitoring and Assessment Colloquium Steering Committee, Washington, D.C.
20	Committee on Ground-Water Quality Protection (Executive Committee Meeting), Washington, D.C.
DECEMBER	
12-13	Committee on Irrigation-Induced Water Quality Problems, Sacramento, California
17-18	Committee on U.S.G.S. Water Resources Research, Washington, D.C.