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WATER SCIENCE AND TECHNOLOGY BOARD
ANNUAL REPORT 1986

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

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WATER SCIENCE AND TECHNOLOGY BOARD OVERVIEW

This fourth annual report of the Water Science and Technology Board summarizes the Board's accomplishments during 1986, its current activities, and its plans for the future. The report also includes information on Board and study group memberships, program organization, and reports produced.

The Water Science and Technology Board is a unit of the National Research Council, the operating arm of the National Academy of Sciences that exists by virtue of an 1863 act of Congress, 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 resources available to it afford a unique and effective forum for addressing cohesively various important 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 1986, several hundred individuals participated in Board activities in various capacities.

The Board's principal products are its reports (see Appendix C). They 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, the reports have had and are having important effects, and the Board's credibility and visibility have increased with each successive project during its four-year history.

The Water Science and Technology Board was established in 1982 as the focal point for activities within the National Research Council related to water resources. The Board was created out of recognition of the importance of water resources to our nation and the expectation that a standing Research Council unit could be a prominent resource in addressing issues on the national water agenda. This has proven to be correct: the Board's program cuts across numerous issues, and on many occasions it has resulted in the resolution of conflict and improvements in water programs. The Board's scope covers the traditional scientific and engineering aspects of water resources and

economic, institutional, legal, educational, and social aspects as well. Because of its 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 general program is shared equally by the two commissions, specific technical projects and administrative activities are most often 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 their related needs for equipment and facilities.

The Water Science and Technology Board meets three times each year. At meetings, issues and research needs are considered, new initiatives are developed, and ongoing projects are monitored. Meetings of the Board serve as a mechanism of communication within 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 sometimes meet as a group to discuss board-related and other activities, and through the bimonthly "WSTB Newsletter," produced by the Board's staff, and the Annual Report of the Board. During 1986, on several occasions, Board members met informally with federal agency representatives to discuss program needs and plan appropriate activities.

In 1985, the Board initiated a new colloquium series on emerging issues in water science and technology. As of early 1987 three general topics had been addressed in the colloquium style: drought management, national water quality monitoring and assessment, and water quality

issues associated with hazardous waste management. Initially intended as a means of educating members and liaison representatives on emerging issues, colloquia have proven to be considerably more--they have in fact become an effective mechanism for airing and evaluating issues from a variety of perspectives. The colloquia are designed and managed by the Board members themselves and supported principally with available "core" funds.

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 Board members often are established to conduct activities such as issue evaluation, project development, committee nominations, and report reviews.

In 1986, 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, U.S. Environmental Protection Agency, National Science Foundation, U.S. Army Corps of Engineers, U.S. Nuclear Regulatory Commission, The State of California, and the William H. Donner Foundation, Inc. The Board's budget for general activities and special studies during 1986 totaled about $800,000.

In fulfilling its goals, the Board is supported by a small staff, which is critical to the effective and timely performance of every Board work group. The staff helps to ensure that work group tasks are clearly understood and carefully formulated in accordance with NRC policies, 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.

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.

ACTIVITIES COMPLETED IN 1986

Ground Water Quality Protection: State and Local Strategies

This study was initiated in 1984, in response to a request from the U.S. Environmental Protection Agency (EPA) that the Board assemble a group of experts (see Appendix A) to review several state and local ground water protection programs, focusing on prevention of ground water contamination. The review considered programs with respect to their scientific bases, performance over time, administrative requirements, and their legal and economic frameworks. The WSTB Committee on Ground Water Quality Protection released its report to EPA in April 1986. This report is viewed as a valuable reference for those concerned with implementation or improvement of program activities aimed at protecting ground water resources from pollution.

In essence, the report summarizes a review of ground water protection strategies in selected areas and identifies those significant technical and institutional features that show progress and promise in providing protection of ground water quality. The state and local areas reviewed were: Arizona, California, Massachusetts and Cape Cod, Colorado, Connecticut, Florida and Dade County, Kansas, New York, Long Island, New Jersey, and Wisconsin. Findings of the report are based on the expert knowledge of the committee members and on information received from representatives of state and local health and environmental departments or ground water protection offices.

The committee classified ground water protection program approaches into five major categories: (1) information collection and management systems; (2) classification systems; (3) ground water quality standards; (4) control of contamination sources; and, (5) implementation of ground water protection programs.

Emphasis is placed on the need for elimination and reduction of the sources of ground water contamination, and the committee recommends ways to help eliminate or reduce both hazardous and nonhazardous waste. One program highlighted in the report is New Jersey's Environmental Cleanup Responsibility Act, which places responsibility for cleanup on industry before sale of property to a new owner. The committee found that this type of legislation can provide an effective prevention incentive as well as a remedial pollution control program, and they recommended that other states adopt a similar program.

Several recommendations also focus on prevention of pesticide contamination and the purposeful application of agricultural chemicals to land.

Classification of ground water using a system like that seen in Connecticut is also highlighted as an effective tool for optimizing ground water protection efforts. The system is recommended in conjunction with a mapping program that specifically identifies critical areas and resources for special protection. As regards standard-setting, the report recommends that states consider a multitiered standards-setting approach, such as Wisconsin's two-tiered set of standards designed to limit degradation of ground water and require action by polluters. Another key recommendation is that land use controls be considered an essential part of a ground water protection program and implemented at early stages for vulnerable, undeveloped areas.

The report also recommends that the federal government provide financial support for development and implementation of state- or basin-level programs; that states consider a variety of funding mechanisms including user and disposal fees as well as general revenues for program support; that states play a key role in expanding the number of well-trained hydrogeologists by providing more support of hydrogeologic programs in universities; and that the federal government provide technical support to state and local governments through research on health and environmental effects of ground water contamination, fate and transport of pollutants, and technologies and strategies for ground water protection.

The report also touches on political mobilization and public participation and support of ground water protection programs. A key recommendation is that attention be directed to the need to attract and develop high level political leadership to shepherd ground water protection legislation and ensure commitment to continued funding and implementation of ground water programs.

Following completion of the report, in May 1986, committee members presented testimony on Capitol Hill concerning conclusions and recommendations of the report. They also commented on two proposed pieces of legislation concerning ground water quality protection.

In summary, the central theme of this report is that the essence of prevention is anticipation, planning, assessment, and preventive action. The preventive efforts anticipate adverse effects from chemical and land use practices and the disposal of waste and provide the necessary protection of ground water with emphasis on prevention of pollutants at the source. A report abstract and information on how to obtain a copy is included in Appendix C.

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

This study, completed at the end of 1986, evaluated the program of the U.S. Army Construction Engineering Research Laboratory (CERL) on

recycling and reuse of field laundry and shower wastewater with respect to its technical and scientific merit and recommended additional research needs to achieve the goals of the recycling/reuse program.

In general, the study committee (Appendix A) found that efforts funded to date by CERL and other branches or agencies within the Department of Defense on recycle/reuse of laundry and shower wastewaters in military field operations provide only a limited data base for evaluating the overall technical feasibility of recycle/reuse options, with respect to assessing any potential health risks.

The technical feasibility of the treatment systems was found to have received the greatest attention in the studies reviewed, with only limited attention given to water-quality constituents of health concern. While the committee reports that both recycling options are achievable with existing treatment technology, additional pilot and field tests were recommended to evaluate the success of the treatment system in reliably providing a safe supply for both water uses. The committee felt that there was a clear need to expand the testing of recycle systems in the area of health effects considerations if shower recycle is pursued.

A major part of the committee's report concentrates on health effects considerations of recycling laundry and shower wastewater. Two main routes of exposure need to be considered: inhalation and topical contact. In addition, two levels of exposure should be recognized: that of the operators who work in the facility and those who use the facility (e.g., shower) or its product (e.g., laundry). Because of the importance of the inhalation route of exposure, the committee recommended that some modeling work be considered for any chemical that appears to be present at sufficient concentrations in the recycled wastewater. An issue that the committee felt had clearly received too little attention is the level of chlorine that is used for disinfection, the nature of the by-products that are potentially irritating to the skin and mucous membranes, and the extent to which some of these by-products might accumulate in the recycled water. High levels of chlorine have been associated with depressed immune function when administered in drinking water. The extent to which this might be produced by other routes of administration, particularly inhalation, is not clear.

The establishment of standards often depends on experimental work in animals, in the case of chemicals, or derives from past experience in which water of a given quality has been safely used by a consuming population, in the case of microorganisms. The committee reported that further development of health criteria for shower and laundry wastewater recycling must first determine (a) acceptable and unacceptable health effects and (b) the probability within stated degrees of confidence that an adverse health effect may occur. Clear policy statements in these two areas will simplify the development of standards from available literature and provide a clear focus for any experimental work that is deemed necessary.

To date the only condition placed on potable water used by the Army is that no performance degradation should result from its use. Recycled waters should not impair the health of exposed personnel, and

no increased risk should be placed on personnel by water reuse/recycle. Such general, qualitative statements ignore the realities of water use and reuse. An evaluation of the likely health effects from each type of product water will have to consider: volume of water ingested; volume of water inhaled; estimation of the dose of volatilized and aerosolized constituents inhaled; effective dose to the skin; the combined systemic dose derived from each of these routes; and local and systemic toxic effects of chemical constituents.

The committee recommended that the ongoing process of criteria review and standards development for potable water be extended to nonconsumptive water as soon as possible. Judicious consideration should be given to the various routes of exposure described above for both troops and operations personnel, recognizing that individuals in the latter group have the greater exposure.

The committee reports that the available data are encouraging for the field Army laundry wastewater recycle and that the data required to ensure the safety of laundry recycle are achievable with minimal additional studies. However, since shower wastewater recycling will involve direct human exposure through inhalation and dermal contact, the committee recommended more detailed studies to provide the data necessary to ensure safe shower recycle. Additional pilot studies should be performed to better characterize the quality of water associated with the shower recycle system. The tests should be designed to ensure that an adequate number of recycles are included to achieve operational steady state. The data made available to the committee indicate that steady state was either not achieved or just minimally reached in previous testing.

The committee concluded that the CERL program should focus on characterizing the wastewater with respect to chemical and microbiological quality. The committee also recommended that a quality assurance program be part of the development of the data base necessary to conclude this program.

The report finally emphasizes that proof of the success of the treatment process can only be established through additional interdisciplinary studies. Engineers, chemists, and microbiologists must identify the contaminants to be added to the water by its previous use and determine the extent to which the treatment processes alter the composition of the wastewater. This type of information is needed before toxicological and microbiological data that establish dose-response relationships can be used to develop health criteria appropriate to the specific use. See Appendix C for a report abstract and information on how to obtain the report.

Colloquium on Drought Management and Its Impact on Public Water Systems

In order to focus attention and debate on issues in water science, technology, and policy, the Board introduced a colloquium series in 1985. These colloquia are held once a year following a scheduled Board meeting and are designed to provide public forums for discussion and

debate, to stimulate research, and to provide an opportunity for Board members and liaison representatives to interact with the scientific and engineering community. The first colloquium, "Drought Management and Its Impact on Public Water Systems," addressed the need for water conservation and planning for future water needs.

Drought preparedness has suffered from neglect. Historically, research efforts have focused on problems associated with the over abundance of water rather than its scarcity. Droughts may be infrequent, or of short duration, but they have serious and long-lasting effects on communities. Information from previous droughts is not effectively communicated to the public, nor is it perhaps always fully understood by water professionals. There is a great need to educate the public about the advantages and disadvantages of proposed alternative courses of action.

The findings of this first colloquium were published in April of 1986 in a National Academy Press monograph (see Appendix C for information on ordering). Presentations of principal authors (Appendix A) provided much of the substance of this report which points out that there is substantial need for continued research on drought and its impact on management of public water systems. Key research topics should include: cause of drought; development of effective drought alert mechanisms; probability analysis of drought; quantification of the consequences of system failure during drought; and identification of the institutional environment necessary for successful implementation of drought management plans. The research should be supported by federal agencies, universities, the water supply industry, and private foundations. 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. Predrought preparation, i.e., good system maintenance program, periodic assessment of system capacity, identification and appraisal of the reliability of emergency or supplemental sources of supply, and development of the framework of public information programs needed to implement drought management measures, holds the key to adequate drought management of public water systems.

Colloquium on National Water Quality Monitoring and Assessment

The second WSTB colloquium, "National Water Quality Monitoring and Assessment", was held in May 1986. The report, published in February 1987, comprises two major sections--an overview and a set of background papers by individual authors. A steering committee of Board members prepared the overview based on a review of the background papers and consideration of presentations and workshop discussions during the colloquium.

In general, the report focuses on the question: Could a coordinated national effort toward water quality monitoring and assessment produce the needed results? Beginning with definitions of the terms

"monitoring" and "assessment" which--with respect to water quality considerations are not synonymous--the participants moved toward the conclusion that a national water quality monitoring and assessment program, in some form and at some level of effort, is warranted in order to improve comprehensiveness and reliability of information for decisionmaking. Among their reasons were the need to improve:

- characterization of the general quality of the nation's water resources;
- understanding of water quality trends, specifically changes showing improvement or worsening in conditions;
- understanding of the extent, nature, and causes of water pollution so as to suggest ways of protecting human health and the environment;
- setting of standards and assurance of compliance with regulations;
- development of water quality control technology;
- quality assurance/quality control efforts to ensure greater consistency, compatibility, and reliability of data collection;
- data base management and information exchange;
- understanding of aquatic phenomena; and
- predictive capability.

While historically there has been a lack of understanding among decisionmakers concerning the importance of water quality monitoring and assessment, there are some hopeful signs of a gradual increase in the realization that a well planned, reliable water quality monitoring and assessment program needs to be an integral part of an acceptable water resources management strategy.

This 108-page report (see Appendix C), "National Water Quality Monitoring and Assessment," is available in limited supply, free of charge, from the WSTB office. Information concerning the steering committee and principal authors may be found in Appendix A.

Continued Attention to the Great Lakes Water Quality Agreement

Seldom does National Research Council involvement in an activity end with the expiration of its enabling contract or the discharge of a study committee. Often Congressional testimony, additional studies, intensive report distribution efforts, or presentations by committee members or staff occur in the first year or so following study completion. Usually such activities are ad hoc, but in some cases they are deliberate and planned. A good example of the latter were efforts by the Board's Committee to Review the Great Lakes Water Quality Agreement which completed its report (The Great Lakes Water Quality Agreement: An Evolving Instrument for Ecosystem Management) in late 1985. This report was prepared as a resource document to be considered as the U.S. and Canadian governments evaluated the existing Agreement in 1986. The Committee maintained a formal presence in deliberations and discussions. Some of these activities are summarized as follows.

The U.S. co-chairman gave invited seminars in Duluth and Indianapolis on the report and its findings. He also gave a paper at the meetings of the International Association for Great Lakes Research in Toronto, Ontario. The most substantial discussion of the report took place at the Second World Large Lakes Conference held in May at Mackinac Island, Michigan. Several speakers commented on the report: they cited it for its comprehensive assessment and recommended its findings to the two governments as they consider proposals for a renewal of the Agreement. The co-chairmen gave a joint presentation at the conference titled, "A Global Strategy for the Prevention of Toxic Contamination of Large Ecosystems: International Agreements and Institutions." Additionally, the committee's report served as the primary reference for a program developed by Great Lakes United titled, "Citizens Hearings on Great Lakes Water Pollution." On July 30, the House Public Works Subcommittee held hearings to review the Canadian-U.S. Agreement where the co-chairmen presented testimony.

3

CURRENT PROGRAM

Water Resources Research

In response to a request from the U.S. Geological Survey, a standing multidisciplinary Committee on Water Resources Research was established in January 1985. Initially, the committee's principal purpose was 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 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 is also charged with assisting the Geological Survey and the Board with other water resources research-related activities, as appropriate.

While in 1985 most of the committee's attention focused on Public Law 98-242, in 1986 its attention shifted to other programs of the Geological Survey's Water Resources Division. Most notably, the committee was exposed to the National Research Program and the proposed National Water Quality Assessment Program (NAWQA). The full committee met twice to consider these topics, and also during the year representatives of the committee hosted a workshop to define priorities for research of an "institutional" nature to be funded under the P.L. 98-242 program in fiscal year 1987. At its later meeting, concerned that biological aspects of water quality be considered appropriately in NAWQA, the committee began to organize for a special workshop on this topic to be held in March 1987.

In January 1987, the terms of appointment for many of the charter members of the committee expired and several new members were appointed. Appendix A lists both retired members and the roster as it stands following reorganization in January.

Irrigation-Induced Water Quality Problems

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 water originating from Westlands Water District near Fresno. The problems at Kesterson NWR resulted in the initiation of a joint federal/state study to determine the sources of the contaminants having an impact on the aquatic environment and how the irrigation drainage problems could best be mitigated.

Responding to a request from the State of California and the U.S. Department of Interior (USDI), the WSTB established a Committee on Irrigation-Induced Water Quality Problems in April 1985 (Appendix A). The committee was created initially to advise the San Joaquin Valley Drainage Program (SJVDP) with a charge 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 for dealing with irrigation drainage problems. The committee met three times during 1986.

The first meeting of the committee in 1986 was held in March when the committee heard from representatives of the USDI who requested assistance on additional areas of concern related to irrigation-induced water quality problems in the western United States. Approximately twenty sites in seven western states have been identified by an Interior task group on irrigation drainage that potentially may present significant environmental problems. The committee expressed interest in expanding its purview beyond the San Joaquin Valley and welcomed the request from Interior that the committee broaden the scope of its work.

In May 1986 Dr. Jan van Schilfgaarde assumed the chairmanship of the committee for a one-year term. Dr. van Schilfgaarde succeeded Dr. William H. Allaway, who remains an active member of the committee.

The committee reconvened in July in Boulder, Colorado, to discuss, among other items, a proposed interim report on the general issues surrounding irrigation-induced water quality problems and the establishment of a subcommittee to address the economic, institutional, and legal elements of the drainage issue. The committee met with principals from the SJVDP and from Interior's National Irrigation Drainage Program (NIDP). It was formally agreed during this meeting that the committee would broaden its purview to include the NIDP and, initially, to assist Interior teams reviewing the progress made on reconnaissance-level studies initiated at nine priority sites in seven western states. The committee agreed to establish a Subcommittee on Economics and Policy that would advise both the SJVDP and the USDI. The committee also prepared a letter report commenting that they believed there was merit to a proposal by the Lawrence Berkeley Laboratory (LBL), University of California, to keep the evaporation ponds at Kesterson Reservoir flooded with water of low selenium concentrations (Appendix C). The letter report, transmitted September 5, recommends that the Bureau assess the LBL hypothesis at Kesterson Reservoir as a first step in their cleanup program.

The committee convened for its third meeting of 1986 in October in Sacramento, California. The primary objective of this meeting was to hear updatings from researchers involved with the SJVDP on the current understanding of the drainage problem. It was agreed that the committee's next meeting would be coordinated with Interior representatives so that the committee could be briefed on the reconnaissance-level field studies initiated by Interior. (This meeting was held March 4-6, 1987 in Tucson, Arizona.) The committee agreed to move ahead with developing a first draft of an interim report on irrigation-induced water quality problems. A fourth letter report of program assessment was drafted following this meeting.

As the parent committee chose to broaden the purview of its activities to advise Interior on the NIDP, it also decided to become more intimately involved with the SJVDP through the establishment of subcommittees to address areas identified as critically important. Thus far, subcommittees have been established to address the areas of data management, economics and policy, public health, quality assurance/quality control (QA/QC), systems analysis, and treatment technologies (Appendix A). The Subcommittees on Public Health, QA/QC, and Treatment Technologies were active during 1986 and produced two letter reports commenting on needs of the SJVDP in the areas of public health and QA/QC (Appendix C). It is expected that most, if not all, of the subcommittees will be active during 1987.

Study of Techniques for Estimating Probabilities of Extreme Floods

In late 1985 in response to a request from the U.S. Nuclear Regulatory Commission, and as a follow-up to previous Board studies, the Board undertook a study of techniques for estimating probabilities of extreme floods. 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 more 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 (i.e., an event of that magnitude or larger that has a 1/100 probability of occurring in each year) 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 is (1) reviewing and critiquing various approaches to estimation of extreme flood probabilities, (2) identifying and assessing a preferred approach, and (3) identifying specific research 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 met on four occasions in 1986 to deliberate on issues and to work on its report. This project should be completed in the summer

of 1987, and it is expected that the published report of findings and recommendations will help to improve the science of rare-flood hydrology.

Glen Canyon Environmental Studies Review

In the summer of 1986, a committee was appointed (See Appendix A) in response to a request from the Bureau of Reclamation for assistance in the evaluation and interpretation of 42 studies being done by the Department of the Interior concerning the lower Colorado River and operations of the Glen Canyon Dam. The Glen Canyon Environmental Studies (GCES) intend to evaluate relationships between dam operations and the natural resources of the Grand Canyon. The committee's purposes are: to review and advise on studies in progress, including a general assessment of how well these activities are achieving their intended goals; to advise on interpretation of information for impact analysis from the technical data that are being developed; to provide advice on the process of identifying the environmental elements for ranking operational alternatives for Glen Canyon Dam; and to extrapolate from this "case study" recommendations to others who may pursue similar environmental studies at other sites in the future.

While the committee will render advice on the GCES, the ultimate decisions affecting actions will be made by government officials. The main thrust of the committee's effort has been to evaluate and critique the impact analysis procedures used throughout the GCES.

The study area extends from the dam to the backwater of Lake Mead, approximately 250 miles. Interior's studies fall into four main categories: biology, recreation, hydrology and sediment transport, and operations. Based on the conclusions drawn from these studies and the advice from the NRC committee, modified reservoir operating policies may be considered.

Committee members have received all draft reports in their area of expertise or interest from the GCES researchers and are in the process of critiquing each study. The committee met twice in 1986, providing advice to the research investigators and the GCES project staff. A final committee report is expected in December 1987.

Colloquium on Hazardous Waste Site Management: Water Quality Issues

Following about six months of preparation, the third in a series of Board colloquia took place in Washington, D.C., on February 19-20, 1987. Each colloquium, organized by a steering committee comprising Board members and WSTB staff, provides opportunities for the Board and its liaison representatives to interact with the community of scientists and engineers specializing in various aspects of water resources.

The topic chosen by the Board for the third colloquium was "Hazardous Waste Site Management: Water Quality Issues." One of the primary objectives of the current nationwide efforts to clean up

hazardous waste sites is the protection of the nation's ground water from contamination. In overseeing these efforts, the nation's regulatory agencies are faced with the difficult task of defining target cleanup levels for contaminated soil or ground water. This task has major impacts on the cost of remediation at the diverse sites currently undergoing assessment of the nature and extent of contamination. Consequently, the setting of these target levels is quite controversial.

The steering committee (see Appendix A) organized the program and obtained various views representing government, industry, public interest groups, water utilities, private consultants, and academia. Attendees also participated in four workshops on hydrogeology, engineering, risk assessment/toxicology, and regulatory strategies. A monograph to be published by the National Academy Press in late summer 1987 will include an overview written by the chairman of the colloquium and the presented papers. This third colloquium was sponsored by The Ford Foundation which supplemented the Board's "core" funds from government agencies.

4

FUTURE PLANS

Study of Modeling Approaches to Simulate Contaminant Transport and Environmental Fate in Ground Water and Their Application in Regulatory Decision Making

For nearly a year the Board has been preparing to conduct a study of methodologies available for simulating the transport and environmental fate of contaminants in ground water. Understanding the transport and fate of contaminants in the sub-surface environment is often perplexing; yet, the regulatory arena increasingly demands credible and documented hydrologic analyses. To this end, the use of modeling technology has become common, as has the scrutinizing of modeling efforts by the regulatory community, industry, and the courts. Clearly, if responsibilities for costly clean up efforts are being assessed using information produced by modeling techniques, awareness of the adequacy and limitations of models will benefit all parties involved. Thus, the Board believes that the proposed critical assessment will be of considerable value.

The Board's study will examine the current state of knowledge and scientific bases upon which existing contaminant transport models are founded. It will also critique the philosophy and approach routinely used in the application of these models to regulatory and legal decision making. The study will be conducted by a committee of experts who will prepare a report on their findings. The report is expected to be a constructive contribution to the literature, one that would provide a blueprint for development of future modeling applications. Some topics to be addressed explicitly include: ground water flow contaminant transport parameters, chemical and biochemical reactions, and opportunities to improve the usefulness of models in regulatory situations.

It is expected that this effort will be supported by several agencies and the Electric Power Research Institute. After discussions at each of the three Board meetings in 1986 and a one-day planning session to design the study's terms of reference, it should begin in the spring of 1987 and be completed by the fall of 1988.

Assessment of the Science of Hydrology

In late 1986, the Board began to plan for an assessment of the state of hydrologic science. The initiative results from increasing recognition among hydrologists of the need for fundamental advances in hydrologic science to support the emerging complex problems of water technology--problems of forecasting at ever larger spatial scales and lead times, and problems of anthropogenic change. Historically, hydrologic science has been largely reactive and driven by needs to solve problems of water supply and hazard reduction. Improved understanding and new directions are needed if hydrology is to play its appropriate role in addressing regional and global-scale environmental problems where the atmosphere and surface must be treated as interactive.

A planning group of ten scientists, led by former WSTB member Peter S. Eagleson (M.I.T.), is in the process of defining detailed objectives and the scope of work. In general, the focus will be on our understanding of the natural reservoirs and fluxes comprising the hydrologic cycle (oceanic as well as atmospheric and terrestrial) over the range of space (micro-scale to global-scale) and time scales critical to biogeochemical cycles and to issues of global change. With this approach it is believed that the scientific needs of the various subfields (e.g., meso-scale hydrology and meteorology, hydrogeology, geochemistry, soil physics, geomorphology) of hydrology (including education and research aspects) can be identified without diversion to areas of application.

The study will be important to further advancement of the science of hydrology and to progress in other earth sciences where the water cycle plays an important role. It is hoped that pre-project planning can be completed and funding obtained in time to appoint a study committee by the summer of 1987.

The Role of Markets in Allocating Irrigation Water Supplies

The Board on Agriculture and the WSTB have initiated a joint project for exploring the potential of a program in the area of water markets/transfer of irrigation water from agricultural use to municipal and industrial needs. A high percentage (80 to 90 percent) of the total water used in the western United States is devoted to agriculture. Because surface water resources are now almost fully developed in the West and because increased municipal and industrial water demands are anticipated, the transfer of water from agriculture has increased appeal to water managers cognizant of reduced federal funding for water development projects and to farmers seeking revenue sources in a depressed agricultural economy. A planning session was held January 15-16, 1987, in Denver with approximately twenty experts in the area of water markets to discuss the issues, opportunities, and problems associated with water marketing. There was a consensus that the NRC could play a vital role in clarifying the legal, institutional, and environmental roadblocks currently limiting the development of

water markets, and that it would, at the same time, complement the work of others in moving the concept toward broader acceptance.

APPENDIX A

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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 multi-disciplinary 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 appointment 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 National Research Council for a period not to exceed three years.

The Board nominates individuals for its own continuing membership.

When appropriate, the Board may invite federal agencies and organizations to nominate individuals to serve as non-voting 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 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 an annual plan of its proposed program of activities and projects for submission to the two Commissions, accompanied by a request for authorization to receive outside funds for the support of these activities. The Board prepares reports on its activities as may be requested or required by the Commissions or the Governing Board of the National Research Council.

The Board Chairman and staff Director present the Board's 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 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 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 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 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 (1982-1986)

National Water Quality Monitoring and Assessment

1987, 108 pp. (W87-1)

The second WSTB colloquium, held on May 20, 1986 in Reston, Virginia, provided a forum to discuss the pros and cons of a national water quality monitoring and assessment program for the United States. Although they were far from unanimous, the participants concluded that a national water quality monitoring and assessment program, in some form and at some level of effort, is warranted in order to improve comprehensiveness and reliability of information for decisionmaking.

Among the reasons cited for having a national program were the need to improve:

- characterization of the general quality of the nation's water resources;
- understanding of water quality trends, specifically changes showing improvement or worsening in conditions;
- understanding of the extent, nature, and causes of water pollution so as to suggest ways of protecting human health and the environment;
- setting of standards and assurance of compliance with regulations;
- development of water quality control technology;
- quality assurance/quality control efforts to ensure greater consistency, compatibility, and reliability of data collection;
- data base management and information exchange;
- understanding of aquatic phenomena; and,
- predictive capability.

The monograph reveals signs of a gradual increase in the realization that a well planned, reliable water quality monitoring and assessment program needs to be an integral part of any acceptable water resource management strategy. The colloquium chairman was Richard S. Engelbrecht of the University of Illinois at Urbana. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 free of charge in

limited supply. This report is also listed with tha National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession Number: PB 87 157467. Cost: $18.95.

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

1986, 104 pp. (W86-8)

The overall objective of this study was to evaluate the program of the U.S. Army's Construction Engineering Research Laboratory (CERL) on recycling and reuse of field laundry and shower wastewater with respect to its technical and scientific merit, and to recommend additional research needs for achieving the goals of the program.

In general, the committee found that the greatest attention in the studies reviewed had been paid to the technical feasibility of the treatment systems, with only limited attention to the water-quality constituents of health concern. The committee has recommended that CERL go forward with its program on laundry/laundry recycling and reuse with some additional testing. However, the committee recommended that more research and studies should be carried out as regards shower wastewater recycling and reuse before CERL proceeds with this program. Specifically, two major routes of exposure are of concern: inhalation and topical contact. Because of the importance of the inhalation route, the committee recommended additional modeling work for any chemical that appears to be present at sufficient concentrations in the recycled wastewater. The committee also recommended that explicit consideration is necessary of the concentration of chlorine and its by-products in air that is present in the laundry room or shower.

The chairman of the committee was Richard S. Engelbrecht, University of Illinois at Urbana-Champaign, Illinois. The report is available in limited quantity from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 free of charge. The report will also be listed with the National Technical Information Service.

Letter Report of the Committee on Irrigation-Induced Water Quality Problems (September 5, 1986)

1986, 2 pp. (W86-7)

This is the third letter report issued by the Committee on Irrigation-Induced Water Quality Problems reviewing research and related programs addressing the agricultural drainage problems in the San Joaquin Valley, California. The "letter report" recommends that the US Bureau of Reclamation assess a proposal for the cleanup of Kesterson Reservoir made by the Lawrence Berkeley Laboratory (LBL) of the University of California. The LBL proposal hypothesizes that

maintaining flooded conditions at Kesterson Reservoir using low-selenium water will create an anaerobic environment in the pond sediments. It is believed that an anaerobic environment would create conditions where selenium is immobilized in a reduced form and, thus, unavailable to biologically cycle in the environment. The committee recommends that basic studies of the biological cycling of selenium in saline, alkaline aquatic ecosystems be given high priority. They recommend that a thorough monitoring system be established to assess the impacts of this management approach on plants, animals, sediments, and water. The study committee chairman is Jan van Schilfgaarde, USDA-ARS, Fort Collins, Colorado. 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 Irrigation-Induced Water Quality Problems (July 8, 1986)

1986, 6 pp. (W86-6)

This is the first letter report issued by the Subcommittee on Quality Assurance and Quality Control reviewing a draft quality assurance plan for the San Joaquin Valley Drainage Program (SJVDP). The "letter report" is critical of the plan as it exists and provides many suggestions on ways to improve the document. Among the areas highlighted by the subcommittee are: (1) quality assurance policy and management; (2) data quality objectives and sampling procedures; (3) analytical procedures; (4) data reduction, validation, and reporting; and, (5) performance and system audits. The subcommittee states that a well designed QA plan can be effective in accomplishing a coordinated program that ensures the overall objectives of the SJVDP while preserving the independence and flexibility that the individual participating agencies require. The study committee chairman is Jan van Schilfgaarde, USDA-ARS; the subcommittee chairman was Robert R. Meglen, University of Colorado. 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 Irrigation-Induced Water Quality Problems (June 12, 1986)

1986, 4 pp. (W86-5)

This is the first letter report issued by the Subcommittee on Public Health of the Committee on Irrigation-Induced Water Quality Problems reviewing the research proposed by the Ad Hoc Committee on Public Health of the San Joaquin Valley Drainage Program (SJVDP). Generally the subcommittee was impressed with the breadth and quality of the proposed studies, but some needs and deficiencies were identified. The subcommittees' comments fall into five categories concerning (1) the

need for a more coherent conceptual approach; (2) identification of hazards; (3) exposure assessment; (4) integration of public health delivery services; and (5) the establishment of a public health subcommittee within the SJVDP. The study committee chairman is Jan van Schilfgaarde of the Agricultural Research Service; the subcommittee chairman was Edwin H. Clark of The Conservation Foundation. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Ground Water Quality Protection: State and Local Strategies

1986, 309 pp. (W86-4)

This report reviews ground water protection strategies in ten states and three local areas of the United States. A study committee initiated its effort in November 1984 after the U.S. Environmental Protection Agency requested a review of state and local ground water programs, focusing on prevention of ground water contamination. The review considered these programs with respect to their scientific bases, performance over time, administrative requirements, and their legal and economic frameworks. The states and local areas reviewed were: Arizona, California, Massachusetts and Cape Cod, Colorado, Connecticut, Florida and Dade County, Kansas, New York, Long Island, New Jersey, and Wisconsin.

The committee found that no program had all the elements of a comprehensive ground water protection program: (1) clearly defined goals, objectives, scope and priorities; (2) an adequate information base to allow proper definition of the resource and the problems; (3) a sound technical basis; (4) elimination or reduction of the sources of ground water contamination; (5) intergovernmental and interagency linkages; (6) effective implementation and adequate funding; (7) studies on the economic, social, political and environmental impacts of ground water protection; and (8) public support and responsiveness.

The report emphasizes the need for elimination and reduction of the sources of ground water contamination and recommends ways to help eliminate or reduce both hazardous and nonhazardous waste. Other recommendations focus on prevention of pesticide contamination; the need for state and local programs to obtain hydrogeological information; the use of a classification system to identify critical areas and resources for special protection; water quality standards and EPA's proposed RMCL's and MCL's for all inorganic and organic chemical compounds commonly found in ground water; land use controls; adequate legal authority and funding for ground water protection programs; and political mobilization, public participation and support of ground water protection programs.

In summary, the report states that the essence of prevention is anticipation, planning, assessing, and preventive action. These preventive efforts anticipate adverse effects from chemical and land use practices and the disposal of waste providing the necessary

protection of ground water with emphasis on prevention of pollutants at the source. The study committee chairman was Jerome B. Gilbert, East Bay Municipal Utility District, Oakland, California. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: $24.50.

Drought Management and Its Impact on Public Water Systems

1986, 127 pp. (W86-3)

Through a series of colloquia, the Water Science and Technology Board focuses attention and debate on emerging issues in water science, technology, and policy. These colloquia provide forums for encouraging discussion and debate of certain issues which the Board believes should be addressed by the scientific and engineering communities. The first colloquium, held September 5, 1985 in Boulder, Colorado, addressed the title subject of drought management and its impact on public water systems.

The report concludes that there is substantial need for continued research on drought and its impacts. Key research topics include cause of drought, development of effective drought alert mechanisms, probability analysis of drought, quantification of the consequences of system failure during drought, and identification of the institutional environment necessary for successful implementation of drought management plans. 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 key to adequate drought management of public water systems lies in predrought preparation. The colloquium chairman was Robert L. Smith of the University of Kansas. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: $7.50.

Water Science and Technology Board Annual Report 1985

1986, 54 pp. (W86-2)

This is the third annual report published by the Board since its creation in 1982. The report contains an overview of the Board's activities, including the introduction of a new colloquium series on emerging issues in water science, technology, and policy; descriptions of project activities; the overview of and conclusions from the Board's first colloquium on Drought Management and Its Impact on Public Water Systems; and planned projects. Highlighted are research needs in water science and technology. Also included in appendixes are lists of program participants, the Board's Terms of Reference, abstracts of reports published by the Board since 1982, and a list of meetings held by the Board and its committees during 1985. The board chairman is John J. Boland of The Johns Hopkins University. 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 Irrigation-Induced Water Quality Problems (April 2, 1986)

1986, 3 pp. (W86-1)

This is the second report of the Committee on Irrigation-Induced Water Quality Problems, which responded to briefings provided by the University of California research program initiated to address irrigation drainage problems in the San Joaquin Valley. The "letter report" notes that a number of recommendations made in the committee's first letter report of October 10, 1985 have been acted upon by the San Joaquin Valley Drainage Program (SJVDP), but it urges that other recommendations previously made (such as development of a strong public participation program; full consideration of economic, institutional, and legal factors; investigation of public health concerns; and development of a quality assurance/quality control program and a data management program) be implemented as soon as possible.

The committee praises the research under way addressing on-farm water and salinity management, transport processes, and trace element chemistry. However, it also indicates that the University of California researchers should be more fully integrated into the overall research program stating that more formal interaction with researchers at the university will benefit the SJVDP significantly. Specific areas of research mentioned by the committee include public health concerns, economic evaluations of potential alternative solutions, which include social and private impacts, and long-term influence on ecosystems. The committee emphasizes that the environmental consequences of various technological alternatives are not being adequately addressed and suggests that the resources available through the university be exploited to achieve that end. The study committee chairman was William H. Allaway of Ithaca, New York. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

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 came 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 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 the challenge. The study committee co-chairmen were Orie Loucks of the Holcomb Research Institute, and Henry Regier of the 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. The committee chairman was James J. Morgan of the California Institute of Technology. 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 Irrigation-Induced Water Quality Problems (October 10, 1985)

1985, 11 pp. (W85-4)

This report--the first of the Committee on Irrigation-Induced Water Quality Problems--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. It was noted that a program of public participation was yet to be 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 providing timely and constructive guidance and comment on the San Joaquin Valley Drainage Program. The committee chairman was William H. Allaway of 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 written by an ad hoc work group, comprising 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 for and value of such a program and includes some specific suggestions aimed at improving design and implementation of the planned program. The workgroup chairman was Walter R. Lynn of 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 for and importance of the research, the proposed timetable, and the need for controlled field facilities prior to conducting experiments at natural field sites. The subcommittee chairman was Mary P. Anderson of the University of Wisconsin-Madison. The letter report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20481.

Water Science and Technology Board Annual Report 1984

1985, 48 pp. (W85-1)

The second annual report from the Board summarizes Board activities during 1984, ongoing activities, and future plans. Information is also included on Board and Committee memberships, program organization, issues of concern, and reports published. The year was highlighted by the introduction of several new studies of such topics as groundwater protection; a bi-national review of the Great Lakes Water Quality Agreement; and a water resources research committee which assists the U.S.G.S. and the Board with water research-related matters. The board chairman was John J. Boland of The Johns Hopkins University. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession Number: PB 85 204485/AS. Cost: $10.00.

Safety of Dams: Flood and Earthquake Criteria

1985, 321 pp. (W84-5)

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

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

1984, 174 pp. (W84-4)

The William H. Donner Foundation, in consultation with the staff of the International Joint Commission (IJC), asked the Water Science and Technology Board to study the Great Lakes Water Quality Agreement in two phases. The first phase, which is the subject of these proceedings, consisted of a conference to define the details of a major review study. Conference participants were asked to identify those scientific, technical, and institutional issues upon which an in-depth study, in its second phase, should focus in order to be most effective. In general, this report contains five formal papers and the discussion that followed each presentation along with a final summary chapter prepared by the Conference Advisory Panel. These working papers and discussion are being used as background information for the phase II effort. The conference chairman was Orie Loucks of the Holcomb Research Institute. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession Number: PB 85-110807. Cost: $17.50.

Water Science and Technology Board Annual Report 1983

1984, 39 pp. (W84-3)

This was the first annual report published by the Board since its creation in 1982. The report includes an introduction describing in general the types of issues handled by the Board and its committees; a description of the Board's structure in relation to other units within the NRC; project activities completed in 1983; description of current and planned projects; and a list of research needs in water science and technology envisioned by Board members. Also included as appendixes are: lists of program participants, the Board's Terms of Reference, and brief descriptions of the published reports issued by the Board. The board chairman was Walter R. Lynn of Cornell University. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. 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 is the culmination of a continuing review by the National Research Council of the U.S. Army Corps of Engineers Metropolitan Washington Area Water Supply Study, which was initiated in 1977 and completed in 1983.

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

In its final report, the committee acknowledges and commends the Corps for certain achievements, such as (1) development of systems management (nonstructural) solutions to problems relative to the metropolitan Washington area future water supply needs, (2) determination and assessment of future water demands by the use of improved modeling, (3) development of a wide range of alternative methods of meeting future water resources needs of the metropolitan Washington area, (4) involvement and use of the citizens of the metropolitan Washington area in developing design criteria and recommendations for future actions, and (5) the collection and collation of current and historical data used in the analysis of the metropolitan Washington area study.

However, the committee also points out several flaws in the Corps study which detract from the above 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. The study committee chairmen were Daniel A. Okun of the University of North Carolina, and Walter R. Lynn of Cornell University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, and the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession number: PB 84-195585. Cost: $11.50.

The Potomac Estuary Experimental Water Treatment Plant

1984, 135 pp. (W84-1)

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

In its final report the committee commends the Corps study for certain outstanding features, including (1) detailed comparative evaluation of the quality of treated estuary water with that of three

major treated water supplies for the metropolitan Washington area, (2) development of a detailed inorganic and organic chemical characterization of treated estuary water and of local water supplies, (3) development of a data base on microbiological contaminants and toxicological indications, and (4) the demonstrated reliability of advanced treatment processes to provide treated water with relatively consistent quality.

However, the committee also felt that there were important limitations to this study and to the conclusions reached, as follows: (1) insufficient scientific evidence was provided to adequately evaluate the safety to humans from consumption of treated estuary water, (2) potential changes in the quality of estuary water that might result from biological growth during drought conditions were not adequately addressed, (3) failure to detect viruses in the experimental estuary water treatment plant finished waters cannot be accepted as an indication that they are absent, and (4) the economic evaluation of a Potomac estuary water treatment plant was inadequate, as it did not provide a comparative cost with other alternatives. The study committee chairman was Perry L. McCarty of Stanford University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 and the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession number: PB 84-195643. Cost: $16.00.

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

1984, 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 found:

1. no cooling to local climates if the boom is removed when there is 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 have been demonstrated;
4. no negative impacts of the ice boom on navigation, erosion and fisheries could be demonstrated with available data; and
5. no feasible alternative exists that would produce effectiveness comparable to the present ice boom.

The study panel chairman was Harry L. Hamilton, Jr. of the State University of New York--Albany. The report is available from the

National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. 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 is intended to be informational and not to advocate rigid criteria or standards. The report also contains a suggested glossary for terms used in relating to dam safety and an index. The study committee chairman was Robert B. Jansen, consulting engineer. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: $18.95.

Letter Report: May 31, 1983 to U.S. Department of Interior, U.S. Geological Survey and Office of Water Policy

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. The board chairman was Walter R. Lynn of Cornell University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., 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 on October 14-15, 1982, to assess the barriers to efficient management of urban water supplies, titled "Cooperation in Urban Water Management." A steering committee invited 30 participants to the conference with some

presenting "talking papers." The conferees explored and proposed means for overcoming obstacles envisioned by water supply professionals 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 speakers' presentations and a summary of the general discussion are presented in these proceedings. The conference was supported by the National Science Foundation, the Environmental Protection Agency, the American Water Works Association Research Foundation and the National Academy of Sciences. The conference chairman was David H. Marks of the Massachusetts Institute of Technology. The report is available from the National Technical Information Service, 5285 Royal Road, Springfield, VA 22161. 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 NFIP; and flood mapping approaches in levee areas. This activity represents significant recommendations for integrating structural and nonstructural flood mitigation. The study committee chairman was L. Douglas James of Utah State University. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. 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, post-failure investigations, and dam terminology.

Recommendations for the second phase of this study are also made. The following technical issues being recommended for study in greater detail are: methodology of risk assessment; engineering methodologies for stability and hydrologic evaluations; instrumentation and warning systems; and model guide for emergency preparedness planning. The study committee chairman was Robert B. Jansen, a consulting engineer. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession number: PB 82-188855. Cost: $9.00.

APPENDIX D

MEETINGS OF THE WATER SCIENCE AND TECHNOLOGY BOARD AND ITS SUBGROUPS DURING 1986

JANUARY	
9-10	Committee on Ground Water Quality Protection, Washington, D.C.
20-21	Committee on Techniques for Estimating Probabilities of Extreme Floods, Washington, D.C.
29	Steering Committee, Colloquium II, Washington, D.C.
30-31	Water Science and Technology Board, Washington, D.C.
FEBRUARY	
6-7	Committee on Recycling, Reuse, and Conservation in Water Management for Arid Areas, Washington, D.C.
MARCH	
11-12	Committee on Techniques for Estimating Probabilities of Extreme Floods, Denver, Colorado
27-28	Committee on Irrigation-Induced Water Quality Problems, Washington, D.C.
APRIL	
4	Subcommittee on Public Health, Sacramento, California
17-18	Committee on Water Resources Research, Reston, Virginia

MAY	
2	Subcommittee on Quality Assurance/Quality Control, Sacramento, California
21	Water Science and Technology, Board, Reston, Virginia
21-22	Colloquium on National Water Quality Monitoring and Assessment, Reston, Virginia
29-30	Committee on Recycling, Reuse and Conservation in Water Management for Arid Areas, Washington, D.C.
JUNE	
2-3	Committee on Techniques for Estimating Probabilities of Extreme Floods, Washington, D.C.
JULY	
17-18	Committee on Irrigation-Induced Water Quality Problems, Boulder, Colorado
SEPTEMBER	
4	Committee on Recycling, Reuse and Conservation in Water Management for Arid Areas, Washington, D.C.
18	Planning Session for Study of Ground Water Contaminant Transport Models, Washington, D.C.
24-25	Committee on Glen Canyon Environmental Studies, Washington, D.C.
OCTOBER	
6-7	Committee on Water Resources Research, Menlo Park, California
20-21	Committee on Techniques for Estimating Probabilities of Extreme Floods, Washington, D.C.
22	Subcommittee on Quality Assurance/Quality Control, Sacramento, California

23-24	Committee on Irrigation-Induced Water Quality Problems, Sacramento, California
28-29	Subcommittee on Treatment Technologies, San Francisco, California
29	Colloquium III - Steering Committee, Denver, Colorado
30-31	Water Science and Technology Board, Denver, Colorado

NOVEMBER

20-21	Committee on Glen Canyon Environmental Studies, Grand Canyon, Arizona