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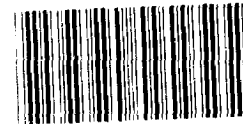
BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Congressional Action Needed To Provide A Better Focus On Water- Related Research Activities

The Nation faces droughts and increasing problems in meeting water demands. Developing and implementing technologies that conserve or augment water supplies could help alleviate these problems. Also, these efforts and other water-related research and development activities are fragmented among 28 Federal organizations that plan to spend about \$380 million during fiscal year 1981. More effective use of these funds is needed. The Congress should amend the Water Research and Development Act to:



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- Require that conservation and augmentation technologies be comparatively assessed to assure that those with the most potential receive the highest level of Federal funding.
- Require that formal plans be prepared to guide research efforts to improve the likelihood of successful technology development and implementation.
- Assign responsibility for coordinating water research to the Water Resources Council provided the Congress believes it desirable to have an independent Council chairperson and resolves the issue of the Council's continued existence. Otherwise, the Congress should establish a water resources research committee under the direction of the Office of Science and Technology Policy.

CED-81-87
JUNE 5, 1981

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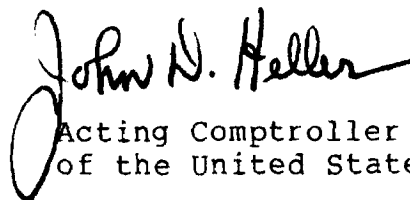
To the President of the Senate and the
Speaker of the House of Representatives

This report discusses Federal agencies' involvement in developing technologies that could contribute toward solving water shortages and the need for legislative changes to enhance the likelihood of successful technology development and implementation.

We made our review to determine whether there is a need to (1) make a comparative assessment of water conservation and augmentation technologies, (2) develop formal plans based upon the results of a comparative assessment, and (3) assign an organization responsibility for implementing on a continuing basis the coordination provision of the Water Research and Development Act of 1978.

We believe the report is particularly relevant to current discussions by the Congress and the executive branch concerning the Water Resources Council. The report points out that assigning the Council responsibility for coordinating water-related research would be a logical extension of some of its current responsibilities.

We are sending copies to appropriate House and Senate committees and the heads of departments and agencies concerned with water resources research. We will also make copies available to interested organizations as appropriate and to others upon request.

Handwritten signature of John N. Heller in cursive script.

Acting Comptroller General
of the United States

D I G E S T

Although the Nation has an abundant water supply, its geographical distribution and availability often do not match demand. Consequently, the Nation faces serious water problems in the West and certain other areas of the country. Developing and implementing technologies that conserve or augment water supplies could help alleviate these problems. Also, these efforts and other water-related research and development activities are fragmented among 28 Federal organizations that plan to spend about \$380 million during fiscal year 1981. Congressional action is needed to better focus use of these funds.

TECHNOLOGIES NEED TO BE
COMPARATIVELY ASSESSED

A comparative assessment of conservation and augmentation technologies is needed to establish water research priorities and allocate the research funds. GAO found considerable disagreement as to which technologies have the most potential for solving water supply and quality problems. Some appear to have considerable potential, whereas the potential of others is not known or appears minimal. Also, there appears to be no correlation between the potential of some technologies, after considering the adverse impact of obstacles, and their relative level of Federal funding. (See p. 5.)

For example, cloud seeding has been researched extensively, but its potential for augmenting water supplies is not certain. Some researchers believe its potential may be significant, whereas others believe it has little or no potential. (See p. 5.)

By contrast, Federal funding of evaporation reduction was only a few thousand dollars during fiscal year 1980 and has never been high in relation to certain other technologies. Yet, a recent study, which comparatively assessed 13 alternative water sources for meeting future water demand in Tucson, Arizona, ranked an evaporation reduction technique as having more potential than the other alternatives, including cloud seeding. (See p. 6.)

Before assessing the various technologies, regional and local water problems and potential alternative solutions should be identified. Potential solutions could include developing and implementing one or more conservation and augmentation technologies; constructing more dams, reservoirs, and conveyance systems; transferring water from one basin to another; and/or curtailing demand. (See p. 7.)

The comparative assessment should also identify and evaluate the impact of technical, environmental, legal, and social obstacles on each technology's potential. For instance, irrigation scheduling, a systematic determination of when to irrigate and how much water to apply, could make more efficient use of water supplies than current irrigation practices. However, farmers are often reluctant to implement the technology because it deviates from familiar irrigation practices. In assessing the potential benefits of irrigation scheduling, or any other technology, an important consideration is the likelihood of whether additional research, development, and/or technology implementation efforts will overcome the obstacles. (See pp. 7 to 9.)

FORMAL PLANS SHOULD BE DEVELOPED
BASED ON THE RESULTS OF THE
COMPARATIVE ASSESSMENT

Much applied research on water conservation and augmentation technologies is not part of a meaningful plan to increase usable water supplies. Formal plans need to be prepared for these technologies to guide research efforts and increase the likelihood of implementation. (See p. 14.)

Although adequate planning cannot guarantee the eventual success of technology development, improved Federal planning can increase the likelihood of success. Otherwise, technical, environmental, legal, and social obstacles may not be adequately considered; a technology development effort may continue indefinitely without a decision being made as to whether additional research is warranted; or research results may sit idle. For instance, in 1974 a university researcher developed a model showing how reservoir water mixing could reduce evaporation. However, no Federal organization has assessed the research results to determine what additional research, if any, is warranted. (See pp. 15, 16, 21, and 22.)

GAO reviewed the research planning activities of several Federal agencies and found that some agencies had not prepared formal plans, whereas others had prepared plans that lacked many of the elements needed to enhance technology development and increase the likelihood of user acceptance. The plans did not provide for periodic independent evaluations. Also, many plans lacked specific, measurable objectives and estimated completion dates. One plan, for example, was basically a compilation of projects of interest to laboratory researchers. (See pp. 16 to 21.)

WHO SHOULD COORDINATE
WATER RESOURCES RESEARCH?

The Water Research and Development Act of 1978 stipulates that the President should clarify agency responsibilities for water research and make arrangements for implementing interagency coordination. Although Federal agencies are currently attempting on an ad hoc basis to address the act's coordination requirements, no single organization coordinates water research on a continuing basis. (See pp. 24 and 26.)

GAO examined the advantages and disadvantages of various organizations having responsibility for coordinating water research. Among the possibilities, GAO preferred two of the alternatives. (See pp. 29 to 33.)

Of these, GAO believes the Water Resources Council, a Federal entity responsible for assessing the adequacy of the Nation's water supplies, should be assigned this responsibility provided the problems discussed below are overcome. It currently is responsible for assessing the Nation's water supply situation and identifying regional and local water problems. Water research coordination would be a logical extension of this responsibility, because regional and local water problems must be known before the potential of various technologies can be adequately determined. Nevertheless, agency officials and researchers expressed the following concerns which they believed would impede effective coordination by the Council.

--The Council does not have the independence or authority needed to be effective.

--The Council's continued existence has been questioned. This has hampered the Council's ability to recruit and retain an effective work force. (See pp. 29 to 31.)

If these problems are not resolved, GAO believes that establishing a water resources research committee with representatives from the major agencies involved in water research could be an effective alternative, provided that

--the committee reports directly to the Office of Science and Technology Policy and

--the Office of Science and Technology Policy has the ability to redirect research funding to reflect priorities established by the committee. (See pp. 26 to 29, 31, and 32.)

RECOMMENDATIONS TO THE CONGRESS

GAO recommends that the Congress amend section 406 of the Water Research and Development Act of 1978 to require the Water Resources Council to coordinate water resources research provided the Congress believes it desirable to have an independent full-time Council chairperson and resolves the issue of the Council's continued existence. Otherwise, GAO recommends that the Congress amend section 406 to establish a water resources research committee reporting directly to the Office of Science and Technology Policy. This committee should be composed of representatives from the major Federal organizations involved in water resources research.

GAO also recommends that the Congress amend section 406 to require the coordinating organization to (1) establish priorities for conservation and augmentation technologies based upon the results of overall comparative assessments of the technologies, (2) provide leadership and guidance to other agencies in developing formal plans for the technologies, (3) make recommendations annually to the Congress concerning the adequacy of water research funding, and (4) consider the data developed pursuant to another section of the act, which calls for Interior to develop a 5-year research program, in coordinating research and establishing research priorities. (See pp. 35 and 36.)

AGENCY COMMENTS AND
GAO's EVALUATION

The Water Resources Council generally agrees that water-related research could be handled more effectively if a single entity had responsibility for coordinating such research. However, it did not believe it would be able to serve as the research coordinating entity because the administration proposes not to fund the Council beyond fiscal year 1981. (See app. IV.)

The Office of Science and Technology Policy also agrees with GAO's concern about coordinating water-related research, but did not feel it was in a position to discuss who should have the responsibility until a new director for that organization is chosen and additional evaluation is completed. (See app. V.)

The Department of Agriculture believes GAO's alternative to the Council--an interagency committee reporting to the Office of Science and Technology Policy--would be a more workable solution than the Council. GAO believes the Water Resources Council would be in a better position to coordinate water-related research than such an interagency committee provided it is given an independent chairperson and the issue of its continued existence is resolved. It currently is responsible for assessing the Nation's water supply situation and identifying regional and local problems. (See app. VI.)

The Department of the Interior does not believe the Water Resources Council should have responsibility for coordinating water-related research and proposes a Department of the Interior water policy office that would (1) provide policy development in conjunction with State Governors and (2) coordinate water programs within the executive branch. GAO questions whether such an organization could effectively coordinate research because it would not have the clout needed to influence other agencies to change their research priorities. (See app. VIII.)

The National Science Foundation did not comment on the conclusions and recommendations. The Department of the Army stated each agency should establish its own priorities. The Environmental Protection Agency generally agreed with the draft report. (See apps. VII, IX, and X.)

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ABBREVIATIONS

BLM	Bureau of Land Management
BOM	Bureau of Mines
COWRR	Committee on Water Resources Research
CRS	Congressional Research Service
EDA	Economic Development Administration
EPA	Environmental Protection Agency
GAO	General Accounting Office
NAS	National Academy of Sciences
OMB	Office of Management and Budget

ABBREVIATIONS

OSM	Office of Surface Mining Reclamation and Enforcement
OSTP	Office of Science and Technology Policy
OWRT	Office of Water Research and Technology
SEA-AR	Science and Education Administration - Agricultural Research
USDA	Department of Agriculture
WPRS	Water and Power Resources Service
WRC	Water Resources Council

CHAPTER 1

INTRODUCTION

The United States has an abundant water supply, but its geographical distribution and availability often do not match demand. This condition, magnified by the Nation's increasing population, industrial development, and agricultural production, has led to water shortages and increased competition for the available supply. Therefore, developing and implementing water conservation and augmentation technologies may be essential if the Nation is going to assure adequate water supplies for meeting these competing demands. Otherwise, demand may have to be curtailed at the disadvantage of Western States and other regions of the Nation.

SIGNIFICANCE OF THE PROBLEM

Federal agencies involved in water resources warn that large areas of the United States, especially in the West, face the prospect of water shortages. Some authorities predict that if corrective action is not taken, water shortages will cause serious problems in vast areas of the Nation.

The Water Resources Council (WRC), a Federal entity responsible for assessing the adequacy of the Nation's water supplies (see p. 29), has estimated that most of the eastern third of the Nation has a relatively good water supply outlook to the year 2000. In the remaining two-thirds of the Nation, however, significant water supply problems exist or are expected in southern California, the Great Basin, the Lower Colorado, the Rio Grande, the south central portion of the Missouri Basin, and the High Plains of Texas. In the High Plains, for example, groundwater depletion of the Ogallala Formation 1/ is so severe that the Texas Water Plan of November 1968 predicted that if by 1985

"* * * a supplemental surface supply of water has not reached the High Plains, this vast area will have begun an area-wide retrogression to dryland farming which will have profound economic consequences throughout the State."

Water quality problems are also becoming increasingly serious in surface waters throughout the Western States. According to an

1/The Ogallala Formation is an interstate aquifer system underlying virtually all of the northern High Plains in Texas and about 22,000 of the 25,000 square miles of Texas' southern High Plains. The aquifer extends into New Mexico, Colorado, Oklahoma, Kansas, and Nebraska.

April 1975 report 1/ by the Department of the Interior, most major river systems in the West are facing high levels of salinity.

ALTERNATIVES FOR IMPROVING WATER SUPPLY OUTLOOK

As water demand continues to increase, the Nation will have little choice but to research, develop, and implement conservation and augmentation technologies, 2/ such as irrigation improvements, evaporation reduction, reuse of wastewater, cloud seeding, and desalting sea and brackish water; construct more dams, reservoirs, and conveyance systems; transfer water from one basin to another; and/or curtail demand.

Traditional structural solutions, such as dams and reservoirs, may continue to play an important role for some time in Western States, but their importance is diminishing because the best sites have already been developed. Also, the time required from approval to completion can take up to 30 years, which increases the initial high cost. Furthermore, environmental concerns have reduced the probability of using the traditional structural solutions.

Consequently, the research, development, and use of conservation and augmentation technologies, some of which hold considerable promise, is of increasing importance. Developing and implementing such technologies, along with the existing means of increasing usable water supplies, could help solve many of the water shortage problems facing the Nation.

Chapter 2 of this report discusses the need for comparatively assessing these technologies to assure that those with the most potential receive the most attention. Chapter 3 discusses the need for developing formal plans based upon the results of the comparative assessment to enhance the likelihood of successful technology development and implementation.

FEDERAL APPROACH TO WATER PROBLEM SOLVING

During fiscal year 1981, 28 Federal organizations plan to spend about \$380 million 3/ conducting water-related research,

1/"Critical Water Problems Facing the Eleven Western States," Department of the Interior, April 1975.

2/Conservation generally involves making more efficient use of existing water supplies, whereas augmentation generally pertains to those technologies, such as desalting, that actually increase the amount of water available for agricultural, municipal, and industrial use.

3/Estimate provided by the Federal agencies involved in water resources research. Appendix II shows the amounts each Federal organization plans to spend during fiscal year 1981.

development, and technology transfer activities that may affect water quantity and quality through such means as augmentation and better management and conservation. Many of these organizations have attempted to coordinate their fragmented efforts to minimize unnecessary overlap and duplication and to establish priorities to ensure that the most important research and development activities receive the most attention.

In 1963 the Committee on Water Resources Research (COWRR) was established as a mechanism to overcome the inherent problems with the fragmented approach. COWRR, which was assigned responsibility for coordinating water resources research, continued to operate until the fall of 1977 when it was abolished. (See p. 25.) The Congress also recognized the inherent problems with the fragmented approach when it enacted the Water Research and Development Act of 1978 (Public Law 95-467, sec. 406). The Congress directed the President to clarify agency responsibilities for water resources research and make arrangements for implementing interagency coordination of such research.

Chapter 4 discusses past and current Federal efforts at coordinating water-related research and the need for an organization to be specifically assigned this responsibility. Also discussed are the advantages and disadvantages of certain Federal organizations being responsible for carrying out this function on a continuing basis.

OBJECTIVES, SCOPE, AND METHODOLOGY

We wanted to determine whether there was a need to (1) make a comparative assessment of water conservation and augmentation technologies, (2) develop formal plans based upon the results of a comparative assessment of technologies, and (3) assign an organization responsibility for implementing on a continuing basis the coordination provision of the Water Research and Development Act of 1978. The term "research" as used in this report refers to all aspects of the technology development and implementation process, including identification of obstacles and how they will be overcome. Chapter 3, which calls for the development of formal plans, involves only those technologies that are determined to be technically feasible and in the applied research stage.

This report is based in part on discussions with Federal and State officials, research institute directors, researchers, contractors, and other organizations and individuals knowledgeable about water resources. We also relied on reports and other documents, which are identified throughout this report, pertaining to water resources research and research planning that have been published over the past 20 years. In addition, we relied on reports issued by the Congressional Research Service (CRS) and on our own reports, which are identified throughout this report.

The results of these discussions and our evaluation of water-related reports and other documents were combined in what we judge to be an accurate analysis of the situation. Appendix III shows the organizations we contacted.

Our selection of the individuals to interview was based on discussions with Federal and State officials involved in water resources research and a computer-assisted literature search that identified organizations and individuals involved in water resources research. We also expanded our coverage by asking those we interviewed if they knew others knowledgeable about the subject areas covered in this report.

CHAPTER 2

COMPARATIVE ASSESSMENT OF WATER

TECHNOLOGIES IS NEEDED

Some water conservation and augmentation technologies have been studied in depth while others have received little attention. Also, there appears to be no correlation between the realistic potential 1/ of some technologies and their relative level of Federal funding. A comparative assessment of all technologies is needed to determine which have the most potential for solving water supply and quality problems at the lowest cost and least risk. The assessment should evaluate the obstacles--technical, environmental, legal, and social--which could inhibit success.

A brief description of the conservation and augmentation technologies we reviewed and views concerning their realistic potential is included in appendix I.

CORRELATION BETWEEN POTENTIAL AND FUNDING IS NEEDED

Development and implementation of conservation and augmentation technologies could help solve many of the water supply problems facing the Nation. However, the potential of these technologies varies considerably. Some appear to have considerable potential for increasing usable water supplies, whereas the potential of others is not known or appears to be minimal. Also, there appears to be no correlation between the realistic potential of some technologies and their relative level of Federal funding. Some technologies appear to have high potential but low funding, whereas others appear to have low potential but relatively high funding.

For example, cloud seeding is one of the more extensively researched technologies, but its potential for augmenting water supplies is not certain. Some researchers believe the technology may significantly augment water supplies, but others believe the technology has no potential. The evidence is not overwhelming either way. Federal agencies spent about \$14.3 million on cloud seeding activities during fiscal year 1980.

In another example of an extensively researched technology, the Federal funding level for desalting sea and brackish water may be high in relation to its potential for augmenting water supplies. Although years of research and development and the expenditure of

1/Realistic potential, as used in this report, refers to the likelihood of a technology solving water supply and quality problems after considering the obstacles that may inhibit success, such as technical (including cost), environmental, legal, and social obstacles.

about \$318 million since 1952 have resulted in proof that desalting is technically feasible, large quantities of water cannot be produced at the relatively low cost originally envisioned. Continuing increases in energy costs compound the problem of achieving low cost water because all known desalting processes use a lot of energy. Federal agencies spent about \$11.5 million on desalting during fiscal year 1980. The Acting Assistant Director for Technology Development of the Office of Water Research and Technology (OWRT), Department of the Interior, said private industry probably spent from \$2 million to \$5 million. Also, a recent National Academy of Sciences (NAS) study 1/ indicated that the desalting funding level should be reduced because of private industry involvement.

By contrast, evaporation reduction received only a few thousand dollars during fiscal year 1980. One evaporation reduction technique, destratification, 2/ received no Federal funding during fiscal year 1980 and has never received more than a few thousand dollars. Yet, a recent study 3/ by the University of Arizona's Water Resources Research Center ranked destratification as having more potential for meeting Tucson, Arizona's future water demand than other alternatives, including cloud seeding and desalting. (See p. 11.)

FACTORS TO CONSIDER IN A COMPARATIVE ASSESSMENT OF WATER TECHNOLOGIES

A comparative assessment of water technologies should enable the Federal Government to more effectively establish priorities and allocate the limited research funds. A comparative assessment should

- identify regional and local water supply and quality problems and the potential alternative solutions and
- assess the impact technical, environmental, legal, and social obstacles may have on a technology's realistic potential.

1/"Water Resources Research Priorities for the FY 1982 Budget," Water Resources Research Review Committee, September 15, 1980.

2/Destratification involves using electrical pumps to mix cooler, lower level reservoir water with warmer, upper level water, thereby reducing evaporation losses.

3/"The Feasibility of Utilizing Remote Sources of Water to Augment the Natural Supply of the Tucson Area, Pima County, Arizona," The Water Resources Research Center, College of Earth Sciences, University of Arizona, April 1980.

Although no organization has conducted a comparative assessment of water technologies for the purpose of establishing funding priorities, we identified a regional assessment that is currently being done and a local assessment that was completed in April 1980. (See p. 9.)

Identify the problems and potential solutions

Before assessing the various technologies, regional and local water supply and quality problems and the potential solutions should be identified. Potential solutions could include developing and implementing one or more conservation and augmentation technologies; constructing more dams, reservoirs, and conveyance systems; transferring water from one basin to another; and/or curtailing demand.

In many cases, several potential solutions may be feasible. For example, the Water Resources Research Center identified 13 alternatives for meeting Tucson's future water demand, including several interbasin transfers and various conservation and augmentation technologies. (See p. 11.)

In other cases, the number of potential solutions may be minimal. For example, a December 1978 report ^{1/} prepared for OWRT on locations where desalting could help alleviate water problems indicated that desalting may be the only practical alternative for solving the water problems of Virginia Beach, Virginia. According to data provided to OWRT by the city, the potential for developing significant surface water sources in the area does not exist; only limited quantities of potable groundwater are available, and it would be extremely difficult to obtain approval for a major water impoundment.

Assess impact of obstacles

Technical, environmental, legal, and social obstacles may adversely affect the extent to which each technology can contribute toward solving a water supply or quality problem. A comparative assessment should determine the impact these obstacles may have on a technology's potential. In doing this, an important consideration is the likelihood of whether additional research, development, and/or technology transfer will overcome the obstacles.

^{1/}"Evaluation of Potential Sites for Desalting Demonstration Plants," Boyle Engineering Corporation, San Diego, California, December 1978.

Technical obstacles

Technical problems range from a lack of knowledge concerning the scientific feasibility of some technologies to the need for major technological breakthroughs to reduce the cost of developed technologies. For instance, inadequate data exists concerning the scientific feasibility of some technologies, such as cloud seeding. Other technologies, such as various evaporation reduction techniques, have been proven to work, but their effectiveness is questioned. Also, some technologies, such as desalting, are very costly, and the likelihood of major scientific breakthroughs to reduce costs appears remote.

Environmental obstacles

Implementing some technologies could have adverse environmental consequences. In some instances, additional research and development may overcome the obstacles, such as the environmental questions associated with cloud seeding, iceberg towing, and recycle and reuse of wastewater. However, additional research and development is not likely to overcome the environmental problems associated with certain other technologies, such as reducing transpiration by phreatophyte 1/ eradication. Although eradicating phreatophytes should increase usable water supplies in the Western States, such action could also cause soil erosion and eliminate or reduce wildlife habitats. Consequently, the realistic potential of increasing water supplies by eradicating phreatophytes may be low.

Implementing some technologies may cause both beneficial and adverse environmental consequences. For instance, the Water Resources Research Center's 1980 report on alternatives for meeting Tucson's future water demand stated that evaporation reduction by destratification could reduce a reservoir's algae growth, increase the dissolved oxygen level, and improve the water's taste and odor. The report also stated, however, that the resulting temperature change of the water could disrupt wildlife habitats in the lake.

Legal obstacles

Western water law generally follows the appropriation doctrine which states in principle that an earlier acquired water right has priority over later acquired water rights. The appropriation doctrine with its "use it or lose it" emphasis

1/Phreatophytes are deep-rooted plants that are abundant in the Western States, covering over 16 million acres and discharging from 20 to 25 million acre-feet of water into the atmosphere annually.

may encourage wasteful use of water and acts as a disincentive to implementing some conservation and augmentation technologies since the right to water not used may be lost to a subsequent appropriator. For example, the Department of the Interior's Water and Power Resources Service (WPRS) has had difficulty convincing farmers to adopt irrigation scheduling 1/ because it could, among other things, result in farmers losing a portion of their water rights. Farmers are concerned because the appropriation doctrine does not recognize any part of a water right in excess of the water reasonably needed or actually used.

Social obstacles

Social attitudes and customs may adversely affect some technologies' potential because they reduce the likelihood of implementation or transfer to users. For example, in addition to the legal problems, farmers are often reluctant to implement irrigation scheduling because it deviates from familiar irrigation practices. Also, public and user perceptions about the health problems associated with recycle and reuse of wastewater may prevent widescale implementation of the technology.

EXAMPLES OF REGIONAL AND LOCAL COMPARATIVE ASSESSMENTS

Currently, the Department of Commerce's Economic Development Administration (EDA) is comparatively assessing various alternatives, including conservation and augmentation technologies, for assuring adequate water supplies in the High Plains region. Also, the Water Resources Research Center recently issued a report comparatively assessing various alternative water sources for meeting Tucson's future water demand. The approach used for these studies illustrates the importance of identifying specific regional and local water problems and comparing the alternatives to determine the best solution or solutions to the problem. Such regional and local assessments are necessary for the successful development of an overall comparative assessment.

Study of the High Plains region

Groundwater depletion of the Ogallala Formation is so severe that the Congress has directed the Secretary of Commerce to examine the feasibility of various alternatives to assure adequate water supplies for continued economic growth in the High Plains region. (Public Law 94-587, sec. 193.) Six million dollars was authorized for the study.

1/Irrigation scheduling is a systematic determination of when to irrigate and how much water to apply.

On January 15, 1979, the general contractor conducting the study issued an interim report 1/ to EDA addressing the alternative strategies the contractor planned to examine. The contractor listed the following strategies.

1. Baseline--no new public action or deliberate change; continue current trends in water and agricultural management in public and private sectors.
2. Voluntary water demand management--provide incentives for technological change and improve water and agricultural management practices at the farm level.
3. Strategy number 2 plus mandatory water demand management--involves institutional/regulatory change requiring water conservation, improved water and agricultural management practices at the farm level, and/or restrictions on new irrigated agricultural developments.
4. Strategy number 3 plus local water supply management--involves water supply augmentation (such as snowpack, vegetation, land use, evaporation suppression, precipitation management, and artificial recharge).
5. Strategy number 4 plus minor subregional importation supply management--generally involves intrastate if long-term surpluses exist in certain intrastate regions.
6. Strategy number 5 plus major importation supply management--involves major water importation schemes.

Strategy number 4 will involve identifying some potential technologies and establishing research priorities. The consulting firm also plans to identify and assess various methods, such as tax incentives, for accelerating implementation of technologies by farmers. An EDA official said the study will essentially identify and comparatively assess each alternative's potential for solving the the High Plains regional water shortage problem. The study is currently scheduled for completion in May 1982.

1/Interim Report, Six-State High Plains-Ogallala Aquifer Area Study, High Plains Associates, January 15, 1979.

Study of alternatives for meeting
Tucson's future water demand

In April 1980 the University of Arizona's Water Resources Research Center issued a report comparatively assessing various alternative water sources for meeting Tucson's future water demand. The report compared 13 alternatives listed below. The Center concluded that based on the technical, economical, environmental, and legal aspects of each alternative, evaporation suppression by destratification may be the best alternative for meeting Tucson's future water needs.

<u>Alternative</u>	<u>Ranking</u>	<u>Remarks</u>
Evaporation suppression	1	Especially considering destratification.
Alter Valley (interbasin transfer)	2	Close proximity but involves legal and political questions.
San Pedro Valley (interbasin transfer)	3	Close proximity but involves legal, political, and environmental questions.
Soil-conditioned catchments	4	Provides restricted quantities of water.
Cloud seeding	5	Has large potential at low cost but involves environmental questions.
Iceberg harvesting	6	Technical and environmental feasibility has not been demonstrated. Also involves institutional questions.
Desalinization	7	High cost and involves legal and environmental questions.
Vegetation management	8	Involves technical, economic, and environmental questions. Also, institutional agreements would be needed.
Salt-Verde-Gila Rivers (interbasin transfer exclusive of the Salt River Project)	9	Involves technical, legal, and political questions.

<u>Alternative</u>	<u>Ranking</u>	<u>Remarks</u>
Salt River Project (interbasin transfer)	10	High cost and involves legal and institutional questions.
Columbia River (interbasin transfer)	11	Involves legal, institutional, and environmental questions.
Upper Colorado River (interbasin transfer exclusive of the Central Arizona Project)	12	Involves legal and institutional questions.
Other long-distance surface water transfers	13	Involves legal, institutional, economic, and environmental questions. Would also require long time for implementation.

The Center concluded that the cost of destratifying Lakes Mead and Powell would be about \$2 per acre-foot of water saved and that the hydropower produced from the additional water saved would generate three times as much power as would be used to initially destratify the reservoir.

VIEWS CONCERNING THE NEED FOR A COMPARATIVE ASSESSMENT OF WATER TECHNOLOGIES

We questioned agency officials and researchers concerning the need for a comparative assessment. Generally, those involved in the more extensively researched technologies did not believe a comparative assessment would be useful. Those involved in other technologies believed such an assessment would illustrate that there is no correlation between the realistic potential of some technologies and their level of funding. An exception, however, involved the Director of OWRT, who has primary responsibility for desalting. He said a comparative assessment would help agencies establish water research priorities.

Another OWRT official said an assessment would not be useful for establishing water research priorities because (1) it would be too judgmental due to the lack of absolute data, (2) site-specific water problems would have to be addressed, and (3) agencies should not terminate work on a technology just because it would benefit only a few people. A few other agency officials and researchers also mentioned that a comparative assessment of technologies would be too judgmental because absolute data is lacking.

We agree that a comparative assessment would be judgmental, that water problems in various areas would have to be addressed, and that agencies should not necessarily terminate work on a technology solely because it would benefit only a few people. Nevertheless, we believe the decisionmaking process, although judgmental, would be improved by assuring that funding levels are based on the expected contribution specific technologies would make toward solving water supply and quality problems. For example, OWRT is studying the contribution that recycle and reuse of wastewater can make toward solving water supply and quality problems. Initially, OWRT did a national study to determine the technology's gross potential. OWRT then did a few regional studies to provide a better perspective of the technology's potential. Currently, it is studying certain high water use industries to determine the technology's realistic potential. Although these studies will cost between \$1 and \$2 million, the study results should, if compared against those of other technologies, help provide a sound basis for determining the relative funding level the technology should receive.

CONCLUSIONS

Federal agencies are conducting research on many conservation and augmentation technologies. Some of these technologies appear to have considerable potential for solving water problems, but the potential of others is not known or appears minimal. Also, there appears to be no correlation between some technologies' realistic potential and the level of Federal funding. A comparative assessment of these technologies is needed to identify those with the most potential for solving water supply and quality problems and to provide a sound basis for establishing water research priorities and funding requirements. Our recommendations and agency comments are included in chapter 5.

CHAPTER 3

FORMAL PLANNING SHOULD IMPROVE

TECHNOLOGY DEVELOPMENT

Much applied research on water conservation and augmentation technologies is not part of a meaningful plan to increase usable water supplies. Formal planning could assist technology development and increase the likelihood of user acceptance. It can tie research from a variety of sources into a program to better assure the efficient and effective development of a technology. Without plans, some research results may sit idle, obstacles to technology transfer may not be overcome, and programs may be prolonged with no determination that objectives have been satisfied.

ELEMENTS OF AN EFFECTIVE PLAN

A plan for developing a particular conservation or augmentation technology should be a formal mechanism which identifies the tasks needed to develop the technology and encourage user acceptance. It should be considered a "living management tool," changeable as necessary to reflect current research results and expectations. A plan should include such elements as

- specific measurable objectives;
- identification of additional needed research and development;
- milestones, including an estimated program termination date;
- technology transfer goals, including identification of obstacles and how they will be overcome; and
- independent periodic evaluations.

An effective plan should identify all Federal and non-Federal organizations involved in developing and transferring the technology, the role of each organization, and the coordination mechanism to promote information sharing and dissemination.

The planning organization should determine what needs to be done to implement the technology. The decision should be based on both the data developed in the comparative assessment (see ch. 2) and discussions with researchers, private industry, prospective water users, and agencies involved in technology development.

The planning organization should make sure that its plan includes all identifiable tasks needed to develop and transfer the technology. Agencies which will contribute to the technology's development should provide input into this portion of the plan.

The planning organization should try to have all tasks accomplished within a given time frame or know why a milestone was not achieved.

An independent evaluation team should be established to review progress throughout the technology's development. The team should recommend needed changes in projects and examine the validity of planning process assumptions. If needed, the team should also recommend that decisionmakers change funding levels or terminate technology development.

CURRENT PLANNING PROCESS NEEDS IMPROVEMENT

Although adequate planning cannot guarantee the eventual success of technology development, improved Federal planning, in our judgment, can increase the likelihood of success. Because Federal agency plans we reviewed lack the elements of formal planning, some applied research may sit idle, overlooked obstacles may prevent implementation of some technologies, and technology development programs may continue indefinitely without the agency determining if objectives have been satisfied.

Formal planning has benefits

The benefits of using plans to guide research efforts are difficult, if not impossible, to prove. However, we believe that planning could help tie many agencies' applied research projects into meaningful programs to conserve or augment water supplies. Also, each Federal organization would have a better basis for requesting changes in funding levels because it could explain the impact its work has on the overall technology development effort.

In a November 1977 report ^{1/} discussing the importance of planning, a former OWRT Director noted that even relevant research reports and scientific articles will continue gathering dust in the archives, apparently unused or unusable, unless the research is part of an effective program plan. His report also noted:

"The difficulty is that 'trial and error' research can be an extremely expensive way to learn that a brilliant idea did not accomplish the objective or that it created more unforeseen problems than it solved. Accidental research can be painful in the physical, social and economic sense. Both are difficult to defend as cost-effective ways of gaining knowledge and understanding.

^{1/}"Problem-Based Research Needs Analysis for Research Application and State-of-the-Art Reports," Warren A. Hall, Department of Civil Engineering, Colorado State University, November 1977.

"Formal research, on the other hand has been demonstrated to be very cost-effective for this purpose, provided the formal research to be accomplished constitutes a 'necessary and sufficient' program which will produce the knowledge needed for the problem and is not diverted toward other interesting but irrelevant facts of the discipline.

"Unfortunately, very little of the formal research directed towards the broad social problems of today appears to meet the requirements of the previous paragraph. Most of it is indeed relevant to the problems faced, and on this basis would appear to be fully justifiable as studies to be accomplished. However, such a collection of relevant studies seldom constitutes a necessary and sufficient research program. Relevance is not a sufficient criteria. A relevant set of studies may still be grossly insufficient to allow the development of any new or improved solution strategies."

* * * * *

"What is needed is an objective, defensible, procedure [or plan] by means of which specific problems can be analyzed and the critical and serious knowledge deficiencies defined in context with that specific problem. The procedure must involve participation of those who are responsible for resolving the problems as well as those who know the states of knowledge in various disciplines."

Many essential elements excluded from plans

Many Federal agencies fund or develop technologies that could conserve or augment water supplies. However, some agencies' research and development efforts are not included in formal plans. Other research is part of plans, but the plans lack elements that are needed to enhance efficient development and user acceptance. Many plans, for example, lack specific objectives and estimated completion dates. As a result, the programs could continue indefinitely even after intended objectives have been satisfied. Following are our observations on the planning activities of the Federal agencies we reviewed in the water research area.

Office of Water Research and Technology

OWRT supports research and development at colleges and universities through matching grants. However, it screens grant proposals on individual merit, rather than fitting the separate research projects into meaningful technology program plans.

Consequently, it cannot assure that anyone will use completed water research projects to develop a water conservation or augmentation technology.

In 1979 OWRT initiated action to alleviate this problem by establishing a technology assessment program. The program includes a series of state-of-the-art assessments on research subject areas with high national priority. The assessments' purpose is to examine past and present research in order to evaluate its usefulness in solving identified problems, to identify further research and development needs, to determine the need for demonstrations to gain acceptance of research products, and to identify research which warrants dissemination to users.

Although OWRT identified a vital planning need, it did not have enough funding for the technology assessment program to accomplish its purpose. OWRT's Director plans to request increased funding to implement the program properly.

OWRT also funds technology development for desalting sea and brackish water. Although OWRT has developed a plan for this technology, the plan has no provision for an independent evaluation to guide the program or to justify its continuance. OWRT--or its predecessor, the Office of Saline Water--has operated the program since 1952. The program could conceivably operate indefinitely in the absence of an evaluation of whether its objectives have been satisfied. OWRT's former Assistant Director for Technology Development, who was in charge of the desalting program, said that he recognizes the value of adequate planning but that erratic funding and program discontinuity have made proper planning very difficult. However, a former Director of OWRT said that the lack of planning may have caused erratic funding and program discontinuity.

Science and Education Administration- Agricultural Research

In 1976 a predecessor to the Department of Agriculture's (USDA's) Science and Education Administration-Agricultural Research (SEA-AR) prepared a series of national research program plans. It established the plans to identify national research objectives, to describe methods for achieving them, and to provide a program accounting and reporting system.

One typical plan's objective was to conserve and manage agricultural water resources. The plan included sections on improving watershed and river basin management, conserving and augmenting surface and ground water supplies, and developing structures for water control and measurement. It discussed tasks to be performed, identified laboratories to accomplish the tasks, and specified funding levels to complete the research.

However, the plan was basically a compilation of research approaches that were judged by agency scientists to merit further

attention within projected manpower and funding constraints. It lacked many essential elements of an effective plan. For example, the plan's objective was not specific; the plan stated only that it would "provide essential support to three other [plans] covering sedimentation, water pollution, and strip mining reclamation." Also, it included many projects that were already completed or underway when the plan was issued. It listed other projects because laboratories had indicated an interest in their development. For example, SEA-AR's Water Conservation Laboratory in Phoenix, Arizona, completed work on floating covers for evaporation suppression in 1975, but the research effort was listed as a task to be accomplished in a plan dated October 1976. The plan also listed a study of physical and chemical treatments for reducing evaporation from soils. Nevertheless, the laboratory director said that his laboratory had not performed the study and he did not know if the research would be performed.

The USDA researchers defended their approach to planning. The researchers said they needed flexibility to select their projects without headquarters direction and that formal planning might hinder innovative research. We disagree. Our view is supported by an independent review at one USDA laboratory which identified benefits of formal planning. The review was attended by university faculty and officials from State and Federal agencies with water-related expertise. They noted that

- the laboratory's headquarters should help determine whether the right problems are being pursued,
- a policy for selecting research projects would help avoid duplicating studies already completed,
- too much emphasis is placed on selecting research projects based on researchers' qualifications,
- research should have a broader application, and
- more emphasis should be given to technology transfer.

An SEA-AR headquarters official told us that its national research program plan for water conservation was inadequate as a tool for coordinating and guiding research. However, it was useful in helping management and others understand the types of research activities conducted by the agency. The official agreed that proper research planning would be an asset, but stressed the benefits of unplanned basic research.

U.S. Forest Service

Another USDA agency, the Forest Service, also does research that could increase usable water supplies. A Forest Service laboratory in Laramie, Wyoming, performed work on the use of snow fences to keep snow from blowing onto highways. The technology

could also save water because the fences keep snow from blowing and evaporating. A researcher told us that the technology could be economically used to augment water supplies. The Forest Service established a program on managing blowing snow and anticipates developing a plan to research, demonstrate, and transfer technologies such as snow fences for water augmentation. The program will be cooperatively operated with a university and will recognize research conducted by Federal, State, and private organizations.

Although the Forest Service plan might include many essential elements of proper planning, it will list only research to be completed during the program's first 5 years. It will not identify long-term research for projects requiring more than 5 years to develop and it will not include estimated completion dates. Such a plan creates an open-ended technology development process and increases the likelihood of agencies continuing research when objectives have been met or the effort has become ineffective. A Forest Service official told us that even though the technology may take longer than 5 years to develop, a formal program evaluation and substantial shifts in objectives may occur after the first 5 years.

Water and Power Resources Service

In many cases, WPRS researchers submit research proposals, instead of formal plans, for funding purposes. An internal research review committee meets annually to recommend funding for the various proposals. WPRS officials said that formal internal research planning is not practical for a mission-oriented agency such as WPRS because they direct research to solving problems as they occur. They believe research cannot be planned because many problems cannot be anticipated. However, WPRS' research review committee stated that one water-related research program "suffers from lack of direction [and] costs cannot be estimated without a research plan." In this regard, we believe the comments 1/ on research planning by a private consulting firm--although they were not addressed to water research--are convincing.

"One area where the program management might be improved is in research planning. Apparently, such planning has not been a Service requirement in the past, but the creation of a plan is nevertheless recommended for the benefit it can provide in improving management's understanding of the program direction and priorities.

1/"An Evaluation of the Electric Power Research Program," Power Math Associates, January 1980.

"A long range research plan with specific objectives that are aligned with Service objectives assures a starting point for maximum program effectiveness. Such a plan can be used to substantiate the research contribution * * * and thus build a bridge of understanding of the benefits to be derived from research funding and research activities.

"The development of a research plan * * * has several advantages. It provides a well defined direction for the research activity. It assists higher management in their understanding and support of the program. In the sense that improved planning provides improved response, it increases the financial return or benefit of the program. Finally, the research staff and managers themselves have a better understanding as to their own activities and contribution."

The report's author said his general comments on the benefits of planning could apply to water conservation or augmentation research programs as well as to the program he reviewed.

Although much WPRS research is not part of a plan, one research program to augment water will soon become part of a nationwide plan to systematically develop weather modification techniques. In 1979 a Weather Modification Subcommittee in the Office of Science and Technology Policy (OSTP) was established to develop an interagency weather modification plan. In 1980 the subcommittee prepared a draft which included WPRS' weather modification program. The plan is designed to develop and coordinate weather modification research activities for a variety of objectives. Although the program's success cannot be guaranteed, we believe the plan will assist in a more efficient and effective technology development. However, because it is a 5-year plan, it may have the same disadvantages as the Forest Service's proposed plan.

Other agencies

The Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers do research that could be used in water conservation or augmentation technology development. Both agencies have plans, but they lack some essential elements.

EPA researches water quality and municipal and industrial wastewater problems. EPA research could be used to augment water even though increasing usable water supplies is not EPA's primary objective. For example, OWRT's wastewater program deals with many of the same problems as EPA's, but OWRT has a water augmentation objective. Although EPA plans state that interagency coordination is beneficial, they do not show how other agency research will affect the EPA program or whether EPA research could benefit other agencies. In addition, EPA plans do not provide for independent program evaluations.

The Corps has a 5-year plan for its interagency aquatic plant control program. The program could affect water supplies by reducing undesirable plant growth in water delivery systems. A Corps official said the agency is also developing a 5-year interagency program plan to refine and use conservation technologies for Corps water projects. He said the plans cover only 5 years because it is difficult to project Corps problems and research needs beyond that time.

We believe that a standard 5-year plan could allow an agency's program to continue indefinitely. If a program termination date is not estimated, an agency might not discontinue the program once objectives are met.

Research results may sit idle

Another indication of the need for formal planning is that potentially useful research is not pursued to increase the likelihood that technologies are developed and transferred to users. Without a plan, there is little assurance research results will be used because researchers may not pursue all needed aspects of a potential technology. For example, a university researcher in Fort Collins, Colorado, said that in the late 1960s he worked on designing agricultural fields to improve the efficiency of surface irrigation to conserve water. He said he developed the technology and demonstrated it to the point where it could be transferred to water users, but was then assigned to a different position which did not give him the opportunity to pursue the technology. Thus, an opportunity to transfer a water conservation technology may have been lost because a plan did not exist that would lead the technology to eventual user acceptance. He said the research and technology transfer was too dependent on one individual, whereas a plan and resources for technology transfer would have taken the development to practitioners.

In another example, a university researcher in Logan, Utah, developed a model in 1974 showing how reservoir water mixing could reduce evaporation. He recognized that additional work was needed to determine the impact on fisheries and to prove that his theory would actually reduce reservoir evaporation. He told us, however, that his work was not pursued because he did not adequately publicize his findings. Again, a formal plan did not exist that would assure that all necessary tasks were accomplished to transform research into a useful water-conserving technology or to determine if continued study of the technology was warranted. An OWRT official with expertise in evaporation suppression techniques said that some additional research would be beneficial if it were directed to identifying the true cost of using the technology.

Plans must consider obstacles

Although many methods of conserving water have been developed, and others are being researched by Federal agencies, technical,

environmental, legal, and/or social obstacles to their use exist. Unless these obstacles are eliminated, useful technologies cannot be implemented to their maximum potential.

In 1978 the U.S. Department of the Interior reported 1/ that significant amounts of water could be saved on Federal water projects if conservation practices were implemented. However, the report noted several obstacles that could discourage water conservation. For example, lining and better managing conveyance systems in the North Unit Irrigation District, Oregon, could cut water seepage losses by up to 90,000 acre-feet per year. However, such conservation practices would adversely affect wetland wildlife habitats and instream fisheries. In the El Dorado Irrigation District, California, lining a conveyance system and expanding an irrigation scheduling program could reduce water use by 16,000 acre-feet per year. However, the report expected major legal and institutional problems. Users of wells and springs benefit from existing seepage water and would be harmed if proposed conservation practices were implemented.

We have also identified obstacles to water conservation in past reports. For instance, our 1978 report 2/ noted that social and institutional factors constrained WPRS' attempts to transfer water conservation technologies. The report noted that "water banking," which might be an incentive to promoting conservation technologies such as wastewater reuse, is not allowed under many State water codes. Water banking involves an intermediary or broker buying water from those who have an excess and selling it to those who need it. If allowed, water banking would encourage conservation because the saved water could be sold. Presently, many water laws do not permit a conserver to benefit from reduced water use.

Any plan to develop a conservation or augmentation technology must recognize obstacles to its eventual use. Such obstacles may prevent the objective of the development program--technology transfer--from being realized and may render the program ineffective. Therefore, it is essential that plans for technology development include a means of overcoming obstacles that would otherwise prevent the technology from being used. (See ch. 2.)

CONCLUSIONS

Much applied research on water conservation and augmentation technologies is not part of a meaningful plan to increase usable water supplies. Although Federal agencies prepare plans, most

1/"Report on the Water Conservation Opportunities Study,"
Department of the Interior, September 1978.

2/"Better Water Management and Conservation Possible--But
Constraints Need To Be Overcome" (CED-79-1, Oct. 31, 1978).

lack essential elements. These elements include specific measurable objectives, milestones, and technology transfer goals including identification of obstacles. Also, the plans do not provide for independent periodic evaluations. As a result, some research results may sit idle, obstacles that prevent implementation may be overlooked, and technology development programs may continue indefinitely without a decision as to whether an objective has been or could be met. Although formal planning cannot guarantee the successful implementation of technologies, in our judgment it will provide greater assurance of a more effective and efficient development process. Our recommendations and agency comments are included in chapter 5.

CHAPTER 4

NEED FOR ASSIGNING RESPONSIBILITY TO IMPLEMENT SECTION 406 OF THE WATER RESEARCH AND DEVELOPMENT ACT OF 1978

Water-related research and development is fragmented among 28 Federal organizations, but no single organization coordinates these efforts on a continuous basis as required by the Water Research and Development Act of 1978 (Public Law 95-467, sec. 406). Although the need for improved coordination, as defined by the act, has been recognized for over 20 years, past efforts have not been successful. We believe the Congress should assign this responsibility to WRC provided the Congress believes it desirable for WRC to have an independent chairperson and resolves the issue of WRC's continued existence. Otherwise, we believe the Congress should establish a committee on water research under the direction of OSTP.

CURRENT APPROACH IS FRAGMENTED AMONG NUMEROUS AGENCIES

The water resources field is so broad that many different Federal agencies have specific statutory or mission responsibilities that require them to conduct water-related research and development activities. These responsibilities have evolved over many years with legislation emanating from several different congressional committees as well as agencies assuming responsibility for carrying out certain research activities to achieve their missions. For example, EPA is required by the Clean Water Act to conduct research on unnecessary water consumption which includes wastewater reuse, OWRT funds studies on wastewater reuse to increase usable water supplies, and the Bureau of Mines (BOM) and the Office of Surface Mining Reclamation and Enforcement (OSM) conduct research in the area for pollution abatement.

Initially, these research activities dealt principally with navigation and transportation, but over the years as the population grew and our frontiers expanded, more and more water functions were embraced--flood control; water supply for agricultural, industrial, and domestic purposes; hydropower; sanitation; pollution control; fish and wildlife; recreation; and many others. As new functions were added, they were either assigned to existing Federal organizations or new organizations were created. Each organization developed research and development programs to support its own water mission. By the late 1950s there were at least 25 different Federal organizations in five departments and three independent agencies that had a water research program of some sort. As a result, concern began to be expressed within and outside the Federal establishment that our national water development and research efforts were uncoordinated, overlapping, and duplicative.

Currently, 28 Federal organizations (see app. II) conduct or support water-related research and development activities in one or more fields. However, no single organization coordinates these activities on a continuous basis.

NEED FOR A FORMAL COORDINATING MECHANISM
HAS BEEN RECOGNIZED FOR MANY YEARS

Over the past 20 years, several studies have recognized the need for a formal mechanism to coordinate water-related research and development and to establish priorities based on needs. Each of these studies recognized that inherent problems existed with the fragmented structure and that the best method of overcoming these problems was to establish a formal mechanism for such a purpose.

In 1960 congressional hearings were held on the state of the Nation's water resources. As a result of the hearings, the Federal Council for Science and Technology, a former Presidential advisory group, established a task group to review Federal research activities. One of the task group's conclusions was the need for enhanced Federal agency coordination. The task group recommended the establishment of a Committee on Water Resources Research to (1) develop criteria for evaluating the components of the national water research program and (2) achieve effective coordination of the research activities of the Federal agencies involved.

COWRR was established in 1963 under the direction of the Federal Council with representatives appointed from five departments and three independent agencies and was responsible for

- identifying technical needs in various water resources research categories,
- a continuing review of the adequacy of the Government-wide water resources research program,
- facilitating interagency communication at management levels,
- identifying and eliminating duplication and overlap between two or more programs,
- recommending the allocation of technical effort among the Federal agencies,
- reviewing technical manpower needs and findings concerning the program's technical manpower base, and
- recommending management policies to improve the quality of the Government-wide research effort.

COWRR continued to operate under the direction of various agencies until the fall of 1977 when it was abolished.

The Congress also recognized the problems inherent to the fragmented approach when it enacted the Water Resources Research Act of 1964 (Public Law 88-379, sec. 305). The Congress stipulated that the President should clarify agency responsibilities for Federal water resources research and make arrangements for implementing interagency coordination of such research. The act defined coordination as including the responsibilities assigned to COWRR but did not mention the committee. The Congress reiterated its position in the Water Research and Development Act of 1978 (Public Law 95-467, sec. 406).

In 1978 CRS issued a report 1/ assessing water research policy and stated that to improve water resources research, the Congress might consider organizational changes which would provide for (1) effective coordination of research programs among Federal agencies and (2) continuous monitoring of the overall effectiveness of Federal investments in water resources research. The report further stated that unless coordination, planning, and implementation of Federal water research programs are improved, little change from the current fragmented situation will occur.

PAST ATTEMPTS AT COORDINATING RESEARCH AND DEVELOPMENT HAVE NOT BEEN SUCCESSFUL

COWRR was responsible for coordinating water research activities from its inception in 1963 until it was abolished in 1977. COWRR's most noteworthy accomplishment was the "Brown Book," which is generally recognized as one of the most comprehensive documents ever issued on water resources needs and priorities. Nevertheless, COWRR was not successful in redirecting Federal research programs based on the priorities it had established in the Brown Book. Also, COWRR directed very little attention to carrying out three of the seven functions it had been mandated to perform. (See p. 28.)

The Brown Book

The so-called Brown Book, entitled "A Ten Year Program of Federal Water Resources Research," was issued in February 1966. The report presented a basis for long-range planning of a water research program; a discussion of 14 major water research problem areas and recommendations for research in each area; a summary of then-current programs, divided into 9 major categories and 44 research subcategories; as well as recommendations for the size and scope of research work for each subcategory and for increased expenditure levels for the 5-year period, 1967-71 inclusive. The 10-year program did not contain specific recommendations as to which agency should be responsible for performing specific research assignments or as to individual agency expenditure levels.

1/"The Water Resources Policy Study: An Assessment," CRS, June 1978.

In 1969 COWRR issued a report 1/ discussing the need for revising its 10-year program because new problems were emerging, existing research requirements had been satisfied to some extent, the recommended Government-wide budget amount in the 10-year program did not go beyond 1971, and shortcomings had been identified in the 10-year program. The report identified 10 problem areas and 5 specific problems which COWRR identified as warranting immediate research support. Nevertheless, COWRR did not issue another major report 2/ until 1977, shortly before it was abolished. The 1977 report was not as comprehensive as the Brown Book, received very limited distribution, and had little impact on water resources research.

COWRR's assessment of its effectiveness

COWRR's 1977 report included an analysis of its effectiveness from 1965 to 1976. COWRR said the Brown Book was viewed and welcomed by most as a needed guide and stimulus for new and redirected activities but had proven over the past 10 years to have fallen short of the success expected. The report concluded that some necessary research had been accomplished, but it had not always been sufficient as evidenced by the fact that many of the same problems identified in 1965 still exist. The report also noted that the research classifications COWRR had established to track general areas of water research by Federal agencies had not served well as a mechanism for establishing research needs or priorities, promoting research coordination, or identifying research duplication.

Assessment of COWRR's effectiveness by other organizations

In 1969 a panel of consultants reviewed 3/ COWRR's activities and concluded that COWRR had not been successful in redirecting Federal research as recommended in the Brown Book. The consultants said redirection of research within the Federal establishment had been limited and cited COWRR being limited to a recommending role as part of the problem. The report further stated that while COWRR could coordinate activities in the sense of producing greater articulation of diverse programs by improving

1/"Federal Water Resources Research Program for Fiscal Year 1970," COWRR, 1969.

2/"Directions in U.S. Water Research: 1978-1982," COWRR, April 1977.

3/"Review of Activities of Committee on Water Resources Research," Report of Panel of Consultants, Office of Science and Technology, September 1969.

information flow, it could not coordinate in the sense of direct and active program management, and it had no authority with respect to budget allocations.

In March 1976 CRS issued a report 1/ assessing water resources research. CRS pointed out that COWRR had given inadequate attention to (1) determining the amounts of research needed on specific problem areas, (2) assessing future research priorities based on emerging or anticipated problems, or (3) determining how limited funds should be allocated within broad priority areas. CRS noted that the priorities established by COWRR related mostly to current issues and that no mechanism existed for assuring optimal allocation of funds. CRS also said that priorities are circulated to potential researchers to guide proposal design, but there is no program to earmark specific funds for a given need or to solicit research in direct fashion to satisfy this need.

In January 1977 we issued a report 2/ on the procedures followed by COWRR in carrying out its seven assigned functions. (See p. 25.) We found that COWRR had addressed the first four functions, but had directed very little attention toward fulfilling the other three. The chairman of COWRR told us that little attention had been given to the last three functions because of staff and funding limitations. Our examination of the first four functions revealed (1) no evidence indicating COWRR had evaluated the adequacy of research programs, (2) that the classification categories did not adequately reflect all water research performed by Federal agencies, (3) that COWRR had not designed a monitoring system for ascertaining the extent to which its program was being implemented in the budget process, and (4) that increased discussion of research projects at monthly meetings was needed.

Current views of COWRR's effectiveness

We discussed COWRR's effectiveness with many researchers and agency officials knowledgeable about COWRR and its effectiveness, including former COWRR representatives. Everyone agreed COWRR was ineffective primarily because it could not directly influence the budgetary process. Some officials added, however, that COWRR's limited staff and resources also impeded its effectiveness.

1/"The Water Resources Research Act of 1964: An Assessment," CRS, March 1976.

2/Letter report to the Chairman, Federal Coordinating Council for Science, Engineering and Technology on COWRR activities, January 17, 1977.

ORGANIZATIONS WHICH COULD COORDINATE WATER RESOURCES RESEARCH

Various Federal organizations could coordinate water research activities. However, we believe WRC should be assigned this responsibility because WRC is responsible for assessing the Nation's water supply situation by identifying critical water problems at the regional and local level. It would be a logical extension of WRC's existing responsibility because WRC should have a sound basis for determining the research needed to solve the Nation's water problems. However, to effectively coordinate water resources research, WRC would need a full-time, independent chairperson and funding authorization to carry out the Water Resources Planning Act of 1965, as amended. If the Congress does not believe such changes to WRC are warranted, we believe the preferred alternative to WRC would be the establishment of a COWRR-type organization under the direction of the Office of Science and Technology Policy.

Assign responsibility to WRC

WRC was established by the Water Resources Planning Act of 1965 (Public Law 89-80) to maintain a continuing study of the Nation's water and related land resources and periodically assess the adequacy of the resources to meet present and future water requirements. As part of this responsibility, WRC assesses the Nation's long-term water supply situation and identifies critical water problems and needs at the regional and local level.

WRC reports directly to the President. It is comprised of eight Council members, a director, and 53 other employees reporting to the director. The Council members include the Secretaries of Agriculture, the Army, Commerce, Energy, Housing and Urban Development, the Interior, and Transportation and the Administrator of EPA. The President has traditionally chosen the Secretary of the Interior as chairperson of the Council. Because of their other responsibilities, each Council member designates an employee to represent him or her on the Council. However, those designated also have other responsibilities to perform within their respective departments or agencies and therefore are involved with WRC activities only on a part-time basis. It should be noted that none of the Council members or designees represent solely the interest of WRC.

Assigning WRC the responsibility for coordinating water research would be a logical extension of its existing responsibility because it would provide a sound basis for determining the research needed to solve the Nation's water problems. For example, WRC identifies regional and local water problems. A comparative assessment of the conservation and augmentation technologies discussed in chapter 2 also requires identifying regional and local water problems to determine which technologies could solve a particular problem.

Although little effort has been devoted to assigning such responsibility to WRC, we identified one report 1/ which discussed the importance of developing a closer tie between research and planning. The National Water Commission stated that if the Nation is to aggressively explore the research and development of new technologies, it is important that an agency or office charged with this mission be established. The Commission recommended that WRC

- assess research needed to support planning objectives and recommend a research program to develop the scientific and technological base necessary to cope with future problems,
- review planning reports for needed research as an aid in assessing needed research with specific priority recommendations, and
- develop guidelines for field planning entities to assist in reflecting impacts on both short- and long-range water resources planning.

We questioned various agency officials and researchers as to whether WRC could effectively coordinate water research. Almost without exception, we were told that from an organizational perspective, WRC should coordinate water research. However, considerable concern was expressed over whether WRC could be effective.

- WRC does not have the independence or authority needed to be effective. To overcome this problem, an independent chairperson reporting directly to the President would be essential.
- WRC's continued existence has been questioned. This has made it difficult for WRC to recruit and retain an effective work force. For instance, WRC has been without funding authorization since the end of fiscal year 1979 but has continued to operate with annual appropriations.

WRC's acting director said WRC could not effectively coordinate water research without obtaining independent status, funding authorization, and increased funding to carry out the additional responsibility. He said the eight Council members, including the chairperson or their alternates, are of similar stature. Consequently, decisions are not made on controversial issues. The acting director added that overcoming WRC's existing problems would improve its ability to carry out its current responsibilities and place it in a position to effectively coordinate water research.

1/"A Synopsis of the National Water Commission's Final Report," National Water Commission, June 15, 1973.

In a March 1976 report 1/ on water research, CRS mentioned that a national water resources planning program coupled with a broad-gauged research arm is worth considering. An option discussed by CRS for achieving this was transferring OWRT to WRC. The report pointed out that more harm than good would result unless the chairman of WRC receives independent status because some of WRC's existing problems would carry over to OWRT.

Establish COWRR-type organization

Section 103 of the Water Research and Development Act of 1978 requires the Secretary of the Interior to develop a 5-year water research program with goals, objectives, priorities, and funding requirements. In response to the act and a March 27, 1979, Presidential directive, OSTP and OWRT initiated an effort to develop a 5-year program with research priorities aimed at meeting future water needs. State water research institutes, other Federal agencies, and NAS are providing input into developing the 5-year program. As part of this effort, the agencies are also attempting to address the coordination requirements of section 406. A report is scheduled to be submitted to the President and the Congress in July 1981.

On September 15, 1980, the Water Resources Research Review Committee, an ad hoc committee formed by NAS, provided an interim report 2/ to OSTP and OWRT on establishing water resources research priorities. The committee stated that:

"If the water resources research programs are as important to the nation as the committee believes they are, and if the Administration hopes to mount a consistent and coordinated research program to meet future needs as required by law and indicated by the priorities set by the President in his March 1979 message on Science and Technology, it will be necessary to organize a coordinating body under strong leadership to establish and review priorities and to perform other functions similar to those of the previous Committee on Water Resources Research that operated under the Federal Council on Science and Technology from 1963 until the Council was abolished in 1976. Such a committee should cost no more than the efforts now underway to determine research priorities."

1/"The Water Resources Research Act of 1964: An Assessment," CRS, March 1976.

2/"Water Resources Research Priorities for the FY 1982 Budget," Water Resources Research Review Committee, September 15, 1980.

In April 1981 the NAS committee provided its final report ^{1/} to OSTP and OWRT. The committee discussed the following organizational structures as options for planning and managing research.

- Assign a leadership role to (1) an office independent of the major water research agencies or (2) a Federal agency with assistance and guidance from an interagency planning group.
- Establish an interagency committee headed by OSTP and located in the Executive Office to enhance its authority.
- Assign the responsibility to a strengthened WRC, as recommended by 1973 National Water Commission report. (See p. 30.)

The Director of OWRT told us the effort may result in establishing a COWRR-type organization under the direction of OSTP, but no decision has been made. Another OWRT official said a COWRR-type organization reporting to OSTP would be effective because the Office of Management and Budget (OMB) plans to start conducting interagency or "cross-cut" reviews of water resources research programs. A COWRR-type organization could provide the data needed to conduct such a review. However, an OMB official said that OMB plans to conduct only a cross-cut review of the current effort. OMB does not plan for cross-cut reviewing to become a normal part of the annual budget review process.

Other organizations that could coordinate water resources research

Agency officials and researchers identified OSTP, OWRT, and the Geological Survey as alternatives to WRC which could coordinate water resources research. Some agency officials also said the current effort involving OSTP and OWRT is an effective mechanism for coordinating water resources research.

We agree that any of these agencies or the combination of OSTP and OWRT could carry out the requirements of section 406. Nevertheless, WRC should have a better perspective of the Nation's water problems and therefore be in a better position to determine the research needed to solve the problems. Also, it may not be desirable to make changes in OSTP, OWRT, or the Geological Survey to overcome inherent problems that could hamper their ability to coordinate research. However, making changes in WRC would improve its ability to carry out its existing statutory requirements as well as improve coordination.

^{1/}"Federal Water Resources Research: A Review of the Proposed Five-Year Program Plan," Water Resources Research Review Committee, 1981.

OSTP

OSTP is a small organization in the Executive Office of the President which is responsible for assisting the President in establishing national research policy. Research involving water is only a small part of its responsibility. A lack of continuity is probably the most serious problem with OSTP coordinating research. For example, OSTP had three staff members working in the water area during the previous administration. Currently only one of these staff members is still working the area. We were told that the current administration may not support a continuation of OSTP.

OWRT and Geological Survey

OWRT and Geological Survey are Department of the Interior agencies. Consequently, neither agency has the "clout" needed to effectively coordinate research because they cannot directly influence other agencies to change their research priorities. Also, they cannot directly influence the budgetary process. For example, an OWRT official said the 5-year plan currently being developed by OSTP and OWRT would not be successful unless OSTP provided the necessary clout to obtain other Federal agencies' cooperation.

Another problem is that the appearance of a conflict of interest exists when an organization conducts or funds research and also has responsibility for determining how limited Federal funds should be allocated within broad priority categories. Both OWRT and Geological Survey spend millions annually in water resources research. The current effort by OSTP and OWRT provides an excellent example of how the appearance of a conflict of interest can occur. The September 15, 1980, NAS committee's interim report stated that desalting should be given lower priority and indicated that funding should be reduced. The Director of OWRT does not agree with the committee's position nor does he plan to reduce funding in the desalting area. If OWRT does not reduce funding in desalting, other agencies may not perceive the effort as being objective. Consequently, OSTP and OWRT may have difficulty convincing other Federal agencies to change their funding priorities.

Combination of OSTP and OWRT

The current effort involving OSTP and OWRT provides the authority needed to enhance cooperation from other agencies. OSTP's involvement also provides the authority needed to influence the budgetary process. However, OSTP's continuity problem exists, and OWRT's involvement creates the potential for a conflict of interest.

CONCLUSIONS

Water-related research and development is fragmented among 28 Federal organizations, but no single organization coordinates these efforts on a continuous basis as required by section 406 of the Water Research and Development Act of 1978. Over the past 20 years, several studies have discussed the need for effective coordination, including the establishment of priorities based on needs. One such study resulted in the establishment of COWRR, which was responsible for coordinating water resources research from 1963 until the fall of 1977. Nevertheless, COWRR was not successful in changing Federal programs based upon the priorities it had established because it could not redirect research funding to reflect the priorities it had established.

In response to the Water Research and Development Act of 1978 and a March 27, 1979, Presidential directive, OSTP and OWRT initiated an effort aimed at establishing water research priorities. This effort may result in establishing a COWRR-type organization. However, no organization coordinates water research on a continuing basis as required by the act.

Although various alternatives exist, we believe WRC, from an organizational perspective, should be responsible for coordinating water research, including establishing water research priorities. It would be a logical extension of WRC's current responsibility of assessing the Nation's water supply situation. However, to effectively coordinate water research, WRC would need an independent full-time chairperson reporting directly to the President and funding authorization to carry out the provisions of the Water Resources Planning Act of 1965, as amended. Also, WRC would probably need additional funding to effectively coordinate research under section 406 of the Water Research and Development Act of 1978.

Of the alternatives to WRC, we believe establishing a COWRR-type organization under the direction of OSTP would have the best chance of succeeding. Although COWRR was not very successful in redirecting research based on the priorities it established, it promoted information sharing among agencies and did not create the appearance of a conflict of interest. We believe a COWRR-type organization under the direction of OSTP could be effective only if OSTP has the ability to redirect research funding to reflect priorities the committee establishes. Our recommendations and agency comments are included in chapter 5.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Water-related research and development has for many years held an important role in assuring adequate usable water supplies for the Nation. However, water-related research and development efforts are scattered among 28 Federal organizations. We believe these efforts could have a greater impact and research funds would be used more effectively if a single agency had responsibility to

- comparatively assess potential water conservation and augmentation technologies and their obstacles to provide a sound basis for establishing funding priorities for the technologies;
- provide leadership and guidance to foster the development of formal plans for conservation and augmentation technologies with specific objectives, milestones, technology transfer goals, and provisions for independent periodic evaluations; and
- coordinate Federal water resources research on a continuous basis as required by the Water Research and Development Act of 1978.

The Congress recognized the problems inherent in the fragmented water research and development structure by enacting section 406 of the Water Research and Development Act of 1978. The act directed the President to clarify agency responsibility for Federal water research and provide for interagency coordination of such research. The act specified that coordination would include a continuing review of the adequacy of Federal research efforts and identification of technical needs.

We believe the requirements of section 406 are positive steps which, if implemented on a continuing basis, would improve water resources research and development. However, an organization needs to be specifically assigned responsibility for carrying out this provision on a continuing basis. Also, the act needs to be amended to require that (1) priorities for conservation and augmentation technologies be established based upon comparative assessments of the technologies and (2) formal plans for these technologies be developed to assure that research, development, and implementation efforts are carried out in a logical, systematic manner.

RECOMMENDATIONS TO THE CONGRESS

We recommend that the Congress amend section 406 of the Water Research and Development Act of 1978 to require WRC to coordinate water-related research provided the Congress believes it desirable to have an independent, full-time WRC chairperson and resolves the issue of WRC's continued existence. Otherwise,

we recommend that the Congress amend section 406 to establish a water resources research committee reporting directly to OSTP. This committee should be composed of representatives from the major Federal organizations involved in water resources research.

We also recommend that the Congress amend section 406 of the act to require the Federal organization the Congress chooses to coordinate research to:

- Establish priorities for water conservation and augmentation technologies based upon the results of overall comparative assessments of these technologies.
- Provide leadership and guidance to other agencies in developing formal multiagency and single-agency plans for the technologies with specific objectives, milestones, technology transfer goals, and provisions for independent, periodic evaluations.
- Make recommendations annually to the Congress concerning the adequacy of the funding levels of water research, development, and technology transfer activities.
- Consider the data developed pursuant to section 103 of the act in coordinating research and establishing research priorities.

AGENCY COMMENTS AND OUR EVALUATION

This section contains the major comments received from the agencies responding to our request for comments, and our evaluation of the comments. None of the comments required us to modify our conclusions, although we made suggested changes in the body of the report where appropriate. Appendixes IV to X also show our evaluation of these comments. The Department of Commerce did not provide comments within the time granted.

WRC generally agreed with our conclusion that water-related research could be handled more effectively if a single entity had responsibility for coordinating water-related research, including (1) establishing priorities for technologies based on a comparative assessment of the technologies and (2) assisting in developing formal plans for the technologies. However, WRC did not discuss whether it should have responsibility for coordinating water-related research activities. Instead, WRC stated that it would not expect to be able to serve as the research coordinating entity because the current administration proposes not to fund WRC beyond fiscal year 1981. WRC also stated that it currently does not have funds to undertake a research coordination responsibility.

OSTP also agreed with our concern about coordinating water-related research activities and stated that this is a longstanding issue that each administration has attempted to improve. OSTP stated that the report is inconsistent with the current administration's proposed budget reform in that no funding has been provided beyond fiscal year 1981 for WRC. In addition, OSTP said it would not be in a position to discuss who should coordinate research until a new director for OSTP is chosen and additional evaluation is performed.

USDA believes an interagency committee reporting to OSTP should be established to coordinate water-related research. USDA said this would be a more workable solution than assigning the responsibility to WRC. It believed OSTP would be in a better position to put water research into perspective with other research priorities and needs.

USDA's preferred choice was our alternative to WRC. We believe WRC would be in a better position to coordinate water-related research than an interagency committee reporting to OSTP provided WRC is given an independent chairperson and the issue of its continued existence is resolved. It currently is responsible for assessing the Nation's water supply situation and identifying regional and local water problems. Water research coordination would be a logical extension of this responsibility, because regional and local water problems must be known before the potential of various technologies can be adequately determined. The OSTP committee approach could be effective only if OSTP has the ability to redirect research funding to reflect priorities the committee establishes. We agree, however, that OSTP would be in a better position than WRC to put water-related research into perspective with non-water-related research.

Also, USDA believes a comparative assessment of technologies could be costly and should not be the only means of establishing water research priorities. We believe the decisionmaking process would be improved if funding levels are based on the expected contribution specific technologies would make toward solving water supply and quality problems. This is discussed in further detail on pages 12 and 13 of the report. We also believe that it would be less costly to comparatively assess the technologies than to continue funding technologies which may not contribute significantly toward solving water problems.

The National Science Foundation stated that the report appears to confuse planning for developing a specific technology with planning a research program which may lead to a potentially useful technology. We made minor changes throughout the report to clarify our position. We believe formal plans are needed for those technologies that are technically feasible and in the applied research stage.

The Department of the Interior agreed that research to develop and implement technologies to conserve and augment water supplies

could help alleviate the serious water problems facing the Nation and that more effective use of research funds is needed. However, the Department of the Interior did not believe WRC should coordinate research. Instead, the Department plans to establish an Office of Water Policy that will (1) provide policy development in conjunction with State Governors and (2) coordinate water programs within the executive branch.

We believe the proposed Office of Water Policy will have difficulty coordinating water programs outside the Department of the Interior because the new water office will not have the clout needed to influence other agencies to change their research priorities. Also, the appearance of a conflict of interest exists when an organization that conducts research, such as the Department of the Interior, has responsibility for establishing research priorities for other Federal organizations, such as the Department of Agriculture.

The Department of the Army expressed concern that adoption of our recommendations could result in limited funding for research and development to accomplish specific agency missions. It believes that each agency responsible for water resources development programs should establish its own priorities and justify budget requests to meet its research and development needs. It believes the mission agencies have a better perspective of the research and development needed to achieve their respective missions than would WRC or OSTP.

We believe that because WRC currently is responsible for assessing the Nation's water supply situation and identifying regional and local water problems, it would have a better perspective of the Nation's water problems and the types of research needed to solve the problems. Also, as noted by USDA, OSTP would be able to put water-related research into perspective with non-water-related research. We believe either organization would have a better perspective than mission agencies of the Nation's water-related research and development needs, which may, at times, conflict with the needs of a particular mission agency. However, the mission agencies, by participating in the coordination process, could acquire a broader perspective of national needs.

EPA agreed with our recommendations and stated that, within the limits of available resources, it had implemented the recommendations.

DESCRIPTION OF TECHNOLOGIES AND
VIEWS CONCERNING THEIR POTENTIAL
FOR SOLVING WATER PROBLEMS

Federal agencies conduct or support research on many technologies which may ultimately conserve or augment water supplies. Some of these technologies appear to have more potential for solving water supply problems than others. However, there is considerable disagreement as to which technologies have the most potential. Below is a brief description of the technologies we reviewed and agency officials' and researchers' views of their relative potential.

CLOUD SEEDING

Cloud seeding involves depositing dry ice or silver iodide crystals into certain types of clouds to increase snowfall in high mountain areas, thereby enhancing spring and summer runoff. Also, research is conducted to increase rainfall in specified target locations.

The potential of cloud seeding for augmenting water supplies is not certain. There have been conflicting views and considerable debate as to whether cloud seeding increases snow- or rainfall enough to augment water supplies. The evidence is not overwhelming either way. WPRS believes the 1975 results of a pilot project on increasing runoff into the Colorado River provide strong evidence that a 10- to 20-percent increase in seasonal snowfall, or about 1.6 million acre-feet annually, can be achieved. A statistical analysis of the project performed by an independent consulting firm showed that the methods applied during the project failed to show any statistically significant increase in precipitation as a result of cloud seeding. The firm added, however, that a correctly designed and operated winter cloud seeding program has the potential of producing significant increases in precipitation and streamflow.

Many researchers believe that snow- or rainfall cannot be increased without adversely affecting other areas. Also, some researchers argue that even if cloud seeding increases winter snowpack, subsequent spring runoff will not be enhanced significantly. One researcher said a 15-percent change in snowfall accumulation is statistically insignificant in measuring the impact of cloud seeding. Another researcher said cloud seeding is still in the basic research stage because no one knows if the technology will increase usable water supplies. He added that, considering the current status of the technology, WPRS could probably obtain the same research results by spending \$100,000 annually, instead of the current level of about \$10 million annually. He also said that he is certain that cloud seeding will some day work and perhaps increase precipitation by 20 to 30 percent, but research should proceed at a moderate pace.

The Federal Government has supported weather modification programs for more than 30 years. Currently, the Federal organizations involved in cloud seeding include WPRS, the National Oceanic and Atmospheric Administration, and the National Science Foundation. During fiscal year 1980, these agencies spent about \$9.4, \$4.5, and \$0.4 million, respectively. Private industry is also involved. WPRS' chief, Division of Research, said private industry probably spends over \$5 million annually, but it may be considerably higher. He said the exact amount industry spends is not known because private industry generally does not reveal its expenditure levels.

DESALTING SEA AND BRACKISH WATER

In 1952 statutory authority was provided for the Saline Water Conversion Program to research and develop ways to convert sea and other saline water into useful water--a program responsible for much of the desalting technology in use in the world today. However, a practical, low-cost desalting method has not been achieved.

Years of research and development and the expenditure of about \$318 million have resulted in proof that desalting is technically feasible. Nevertheless, large quantities of water cannot be produced at the relatively low cost originally envisioned. Because all of the known processes use a lot of energy, the recent increases in energy costs compound the problem of achieving low-cost water and make the possibility of a dramatic breakthrough even more unlikely.

Although desalting may not make the deserts bloom as originally envisioned, it may have specific applications in certain locations. For example, two recent studies sponsored by OWRT evaluated and ranked 45 locations in the Nation where desalting demonstration plants could be constructed to help alleviate water supply problems. OWRT's Deputy Director said desalting was not compared against other technologies because the purpose of the studies was to identify the best locations for desalting demonstration plants. The Deputy Director also provided us the following statement which he believes illustrates the importance of desalting to helping solve the Nation's water problems.

"OWRT believes that desalting technology is not fully developed, notwithstanding the great advantages which have been made and the existence of operating plants. Although one distillation process has been graduated from the OWRT R&D program, other processes remain under investigation that promise to desalt water with as little as 1/8th the amount of energy used in earlier plants. Membrane processes have been given the largest share of OWRT's R&D attention and offer energy-savings

half of that required for the older distillation process. Membranes, with further R&D, can cut today's energy requirement by half again. Capital costs can be similarly reduced.

"OWRT points out that R&D findings do not support the view that thermal processes (distillation and freezing) are inherently inefficient from an energy standpoint. Modern distillation technology is readily adaptable for making effective use of any form of low level thermal energy such as solar or spent steam which would otherwise be unsuitable for the production of electrical power. And, while costs for producing desalinated water appear high, OWRT studies have shown that desalination can be a feasible alternative supply."

OWRT is the primary Federal organization involved in desalting, but the Bureau of Land Management (BLM) and WPRS are also involved to some extent. During fiscal year 1980 OWRT spent about \$11.2 million and BLM and WPRS spent about \$250,000 and \$5,000, respectively. OWRT's Assistant Director for Technology Development said private industry spends from \$2 million to \$5 million annually on desalting research and technology improvements.

EVAPORATION REDUCTION

Reservoirs and canals in the arid lands are subject to heavy evaporation losses, but because evaporating water is invisible, these losses are often not recognized. A 1974 NAS report ^{1/} stated that the evaporation losses from small reservoirs, stock tanks, and farm ponds with large, open surface areas often exceed the amount of water productively used. Other reports have also discussed the large amount of evaporation that takes place in large lakes and reservoirs in the Western States.

Basically, evaporation reduction can be achieved by reducing the surface area exposed to the sun or lowering the surface temperature of a body of water, thereby reducing the amount of evaporation. Over the years, various techniques for achieving this have been studied, including

- spreading an alcohol film across a body of water;
- placing floating blocks, rafts, or beads on the water surface;
- storing the water in sand- and rock-filled dams for subsequent retrieval and use;

^{1/}"More Water for Arid Lands, Promising Technologies and Research Opportunities," NAS, 1974.

- minimizing the water surface area in contact with air by storing water in deep, narrow containers;
- planting trees to form a wind barrier; and
- using electrical pumps to mix cooler, lower level reservoir water with warmer, upper level water.

During the 1950s and 1960s, WPRS spent about \$2.5 million on a program for increasing water supplies by evaporation reduction through the use of alcohol films. Although WPRS' research results showed that alcohol films could reduce evaporation, winds on large reservoirs created waves causing the monomolecular films to break up.

In March 1970 the Stanford Research Institute, under a WPRS contract, issued a report 1/ on WPRS' evaporation reduction program which resulted in WPRS terminating its program. The Institute concluded that research and development involving alcohol films probably was not cost effective. Currently, the Institute is conducting a followup study on the technology. WPRS' chief, Applied Sciences Branch, Division of Research, said the report, which will discuss only alcohol films, will probably be issued by July 1981. He said the report will probably conclude that evaporation reduction using alcohol films would be costly but may be cost effective in certain locations. He said the Institute's initial estimate is that it will cost at least \$53 per acre-foot of saved water.

Most agency officials and researchers were skeptical about the likelihood of increasing usable water supplies through the use of any method, considering the costs involved and the environmental problems to be overcome. However, of the various evaporation reduction methods, researchers believed destratification 2/ had the most potential. An April 1980 report that compared 13 alternatives for solving Tucson's water shortage problems ranked destratification as having more potential than the other alternatives. (See p. 11.) Also, one researcher said he developed a statistical model in 1974 which illustrates that destratification can substantially reduce evaporation. He said the cost of energy would not be a problem because the water saved by mixing could be used to generate over three times as much hydroelectric power as would be used to mix the water. Another researcher said evaporation suppression may be the most economical way of increasing

1/"Evaluation of the Bureau of Reclamation's Evaporation Reduction Research Program," Stanford Research Institute, March 1970.

2/Destratification involves using electrical pumps to mix cooler, lower level reservoir water with warmer, upper level water, thereby reducing evaporation losses.

water supplies in arid lands and that the amount of Federal funding that has gone into the area is negligible compared with its potential.

During fiscal year 1980 BLM spent \$7,000 on reducing evaporation from stock tanks. WPRS' \$9,900 purchase order with the Stanford Research Institute was the only other Federal involvement in the area.

IRRIGATION EFFICIENCY IMPROVEMENTS

Various technologies for improving on-farm water management have been developed to help farmers, but implementation has been limited. They range from the expensive, sophisticated drip or trickle irrigation systems, which can double irrigation efficiency, to simple, inexpensive improvements in irrigation scheduling (a systematic determination of when to irrigate and how much water to apply).

Agency officials and researchers spoke favorably of the benefits of improving irrigation efficiency, especially through the use of irrigation scheduling. However, most agency officials and researchers stressed the non-water-supply-related benefits. One researcher said proper use and application of irrigation water could increase crop yield by up to 25 percent. Other researchers and agency officials said it could reduce soil erosion, conserve energy, and improve water quality. Some also said water supplies would be increased, whereas others said excessive irrigation is not necessarily wasteful because the water may not be lost to the basin. The excessive use of one irrigator may be the supply of another. Nevertheless, considerable disagreement exists over how much excess water is recoverable.

Agency officials and researchers were less optimistic about the benefits of using drip or trickle or sprinkler irrigation systems because of the high capital costs involved. For example, one researcher said trickle irrigation has not been used much because it is costly in relation to other alternatives. He said its most practical application is for high-value crops, such as orchards.

The Federal agencies involved in improving irrigation efficiency include SEA-AR, SEA-Extension, WPRS, and OWRT. During fiscal year 1980, these agencies spent about \$4.8, \$0.8, \$0.4, and \$0.3 million, respectively. Also, a few private companies provide consulting services to farmers to demonstrate the cost effectiveness of irrigation scheduling.

RAINWATER HARVESTING

Rainwater harvesting utilizes natural or man-made catchments to capture sparse rainfall and divert it to storage before it is

lost through runoff or evaporation. The catchment may consist of contoured earth with wax or sodium chloride added to make the soil less water permeable, or it may be constructed by laying plastic, asphalt, or concrete over the contoured surface. Especially suited to small-scale uses in remote, arid areas, rainwater harvesting can be used to provide water for potable needs, crops, livestock, and wildlife.

Since the early 1930s, the Bureau of Indian Affairs has constructed numerous catchments on Indian lands in the Southwest. However, success with the catchments has been limited primarily because proper maintenance has not been performed. Also, the Forest Service and BLM have constructed numerous water harvesting catchments to provide water for wildlife and cattle using current techniques.

We discussed the potential of improving the water supply situation by constructing additional water harvesting catchments with agency officials and researchers with expertise in the area. They said no estimates have been made concerning the extent water harvesting could increase usable water supplies. They added, however, that the technology probably has considerable additional potential in arid areas for small-scale use, such as providing water to livestock and wildlife.

One researcher said the technology's greatest potential involves providing water for dryland farming. He said water harvesting has developed to the stage where a demonstration project would be valuable to show the technology can be used for crop cultivation. The researcher also stated that the technology should be given as much attention as desalting sea and brackish water and may contribute more to enhancing water supplies than cloud seeding. However, the Department of Agriculture contends that rainwater harvesting for crop cultivation has already been demonstrated a number of times.

Currently, the Federal agencies conducting rainwater harvesting research include BOM, SEA/AR, and BLM. During fiscal year 1980 these agencies spent \$257,000, \$282,000, and \$10,000, respectively. Also, BLM, the Bureau of Indian Affairs, and the Forest Service spent several million dollars constructing water harvesting catchments during fiscal year 1980. A Forest Service official said his agency spent about \$4.8 million, but BLM and Bureau of Indian Affairs officials could not readily provide such data to us.

RECYCLE AND REUSE OF WASTEWATER

OWRT defines wastewater recycle as the internal use of water by the original user prior to discharge to a treatment system or other point of disposal. The term "reuse" is applied to wastewater that is discharged and then withdrawn by a user different from the discharger. Many organizations and researchers refer to these terms collectively as "wastewater reuse."

An April 1979 report 1/ sponsored by OWRT indicates that the gross potential for making more efficient use of water supplies through increased recycle and reuse of wastewater is substantial. For example, the report estimated that industrial recycling in California could increase from a 1975 level of 5.8 billion gallons per day to 23.8 billion gallons per day by the year 2000. This would be equivalent to about 20.2 million acre-feet per year. Even more interestingly, the report concluded that recycling in the Texas Gulf region could increase by 111.8 billion gallons per day, or about 125.2 million acre-feet per year, during the same period.

Other reports also substantiate OWRT's claim of the technology's potential. In a June 1973 report, 2/ the National Water Commission concluded that the potential for reuse of treated municipal and industrial wastewater is considerable. Also, NAS' 1974 report on more water for arid lands stated:

"The important advantage of water reuse is that it can, if properly managed, reduce by severalfold the demand on water from natural sources. Continuously recycling 50 percent of the wastewater in effect doubles the water supply.

"In some arid locations reusing wastewater in industry may provide additional water needed to permit industrialization that would not otherwise be feasible."

One area of controversy involves providing water for potable use. NAS' September 1980 interim report listed this area as being of "critical" importance. By contrast, an OWRT official stated that it would be more cost effective to use these funds in other wastewater recycle and reuse programs. His rationale was that wastewater for potable use is more costly because the water must be purified to a greater degree than water for many other uses, such as certain industrial uses. He said recycling and reuse of wastewater for nonpotable purposes would serve the objective of enhancing potable water supplies by freeing up existing water for potable use. The National Water Commission's 1973 report on water policies for the future supports this contention. The report stated that as direct reuse 3/ by industry increases, the water which industry would otherwise use can be released for other purposes, including human consumption. This would, in

1/"Water Reuse and Recycling, Volume 1, Evaluation of Needs and Potential," OWRT, April 1979.

2/"Water Policies for the Future," National Water Commission, June 1973.

3/The Commission used the term "direct reuse" instead of "recycling."

effect, increase the supply of water available for potable use. The report further stated that direct use of water for human consumption should be deferred until it is demonstrated that virological and other possible contaminations do not present a significant health hazard.

Currently, the primary organizations involved in the technology include OWRT, EPA, the Corps of Engineers, SEA/AR, BOM, and WPRS. During fiscal year 1980 these agencies spent about \$3.8, \$1.1, \$0.9, \$0.7, \$0.3, and \$0.07 million, respectively. Also, OSM plans to initiate a \$133,000 program during fiscal year 1981.

SALT TOLERANT PLANTS

Saline water is abundant but is not often used for irrigation or other purposes. Also, freshwater supplies in the West are becoming more saline, which reduces crop yield. Some reports suggest that developing plants more tolerant to high levels of salinity could

- free up freshwater supplies for other puposes by substituting saline water for irrigating crops,
- increase the crop yield of plants that use irrigation water with relatively high levels of dissolved salts, and
- open up additional areas of the arid West to cultivation.

NAS' 1974 report on more water for arid lands stated that saline water holds exciting possibilities for the future, but it is not likely to convert vast stretches of arid lands into cultivated fields. Many crops, for instance, cannot tolerate high levels of salinity. The report also stated, however, that if saline water could be used for irrigation, more desert land could be cultivated, and nonsaline water currently used in agriculture could be released for human consumption in urban areas and reduce the need for expensive desalination schemes. NAS concluded that breeding and selecting plants which can tolerate higher levels of mineral content is needed. Nevertheless, the feasibility of using saline water for crop irrigation over an extended period of time has not been demonstrated.

During fiscal year 1980, SEA/AR, OSM, BLM, OWRT, and the Department of Energy spent about \$1.77 million developing salt/drought tolerant plants. During this period, these organizations spent about \$1,488,000, \$92,000, \$30,000, \$69,000, and \$90,000, respectively.

TOWING ICEBERGS

Eighty-five percent of the world's freshwater is trapped as ice in the polar regions but is generally considered unusable. Some experts have speculated that Antarctic icebergs could be economically recovered by towing them to water-short regions and then

melting them for freshwater. Although most discussion has centered around towing the icebergs to arid regions of the Southern Hemisphere, a few experts contend that icebergs could be towed to southern California.

Although no one has initiated a pilot project to tow icebergs to southern California, a Geological Survey employee is participating in an experiment aimed at towing an Antarctic iceberg to Australia. The project will be funded by the Saudi-Arabian Government and is scheduled to start in the fall of 1982. The Geological Survey official participating in the experiment said the cost of the iceberg water to Australia may be only one-tenth the cost of desalted sea or brackish water. He said iceberg water may also be cheaper than desalting for the United States. Also, a July 1978 National Oceanic and Atmospheric Administration report ^{1/} on using icebergs for freshwater states that recent estimates indicate iceberg water can be made available for use at 20 to 50 percent of the cost of desalted seawater.

In January 1978 WPRS reviewed a Rand Corporation report on iceberg towing and concluded:

"Theoretical studies will never uncover all the real problems. Some operational experience is desirable to assess the severity of the known problems and to uncover those hitherto unforeseen. In view of the potential rewards, it is believed that a further investment of public funds may pay off handsomely."

A private consultant told us he is trying to initiate a pilot project to tow an iceberg to southern California. He said it will cost about \$70 million, and plans are for the project to be privately funded without Government participation. The objective will be to determine the feasibility of towing an iceberg to southern California.

Most agency officials and researchers did not express a view concerning the potential of the technology. However, one California State official said the idea is ridiculous. Also, a few reports mentioned the potential environmental and legal problems associated with towing icebergs.

TRANSPIRATION REDUCTION

Up to 99 percent of the water absorbed by plant roots passes into the atmosphere as water vapor. This process, generally referred to as transpiration, would increase usable water supplies if a practical way could be found to reduce the transpiration rate or eliminate plants that transpire large amounts of water. Various techniques for achieving this have been studied, including

^{1/}"Icebergs for Use as Freshwater," National Oceanic and Atmospheric Administration, July 1978.

- selected eradication or control of phreatophytes; 1/
- coating plant leaves, including phreatophytes, with a film that forms an antitranspirant barrier;
- substituting crops with low transpiration rates for crops with higher rates; and
- genetically reducing the transpiration rate of crops.

Over the past 20 years, several reports have discussed the potential of saving water by controlling or eliminating phreatophytes. Generally, the reports pointed out that most phreatophytes are low-value plants that cover 16 million acres of land and consume from 20-25 million acre-feet of water annually. A WPRS official told us that the extent to which phreatophyte control can contribute to increasing water supplies is still questionable. Also, a researcher said the water saving benefits of phreatophyte eradication cannot be determined because the resulting reduction in transpiration is offset by an increase in evaporation once the phreatophytes are removed. Furthermore, several reports have mentioned that the benefits of phreatophyte control and/or eradication are minimal because various environmental and social problems are associated with their control or removal. One researcher told us that phreatophyte eradication would create severe soil erosion problems.

Some researchers contend that coating plant leaves with an antitranspirant barrier could save considerable amounts of water. Also, the 1974 NAS report on water for arid lands stated that great potential exists, but research has been meager and not overly encouraging. However, not everyone is as optimistic. A WPRS official said transpiration reduction does not appear to have much potential for saving water. A researcher said antitranspirant spraying is of questionable value.

Two researchers who believe antitranspirant spraying has enormous potential told us that more water is lost through transpiration than any other area of the water cycle. They said it has enormous potential because only a small portion of the water that transpires through plants is needed for plant growth. One of the researchers added, however, that antitranspirant spraying is currently not economical and only reduces plant transpiration for a short period of time.

Most agency officials and researchers did not express a view of the potential for reducing transpiration by other methods. However, one researcher said the potential is good for developing plant strains that transpire less water.

1/Phreatophytes are plants whose main source of water is the water table or capillary fringe just above it.

The Forest Service, the Fish and Wildlife Service, and BLM spent \$51,800, \$50,000, and \$3,000, respectively, on phreatophyte control. OWRT, the only Federal agency involved in antitranspirants during fiscal year 1980, spent \$39,600. The Forest Service and the Department of Energy spent \$207,200 and \$122,000, respectively, on crop substitution. The amounts spent on drought tolerant crops are included under salt tolerant plants. (See p. 46.)

ESTIMATED FEDERAL EXPENDITURES IN WATER RESOURCESRESEARCH AND DEVELOPMENT FOR FISCAL YEAR 1981 (Note a)

<u>Organization</u>	<u>Amount</u>	
		(thousands)
Department of Agriculture:		
Economics and Statistics Service	\$ 1,070	
Forest Service	8,900	
Agricultural Research	36,849	
Cooperative Research	4,700	
Extension Service	2,510	
Soil Conservation Service	<u>(b)</u>	\$54,029
Department of the Interior:		
Bureau of Land Management	800	
Bureau of Mines	2,000	
Office of Surface Mining	800	
Office of Water Research and Technology	33,690	
Fish and Wildlife Service	17,500	
Geological Survey	28,950	
Water and Power Resources Service	<u>12,873</u>	96,613
Department of Health and Human Services:		
Food and Drug Administration	400	
National Cancer Institute	2,771	
National Eye Institute	1,165	
National Institute of Allergy and Infectious Diseases	3,240	
National Institute of Environmental Health Services	1,625	
National Toxicology Program	<u>2,500</u>	11,701

a/These estimates were obtained from a December 1980 draft report entitled, "Proposed U.S. National Water Resources Research Development, Demonstration and Transfer Program." The data included in the draft was prepared by the Federal organizations involved in water-related research activities to assist OSTP and OWRT in establishing water research priorities. (See p. 31.) The Deputy Director of OWRT told us that this is the most current data available, but that the administration's proposed budget revisions may change these estimates.

b/The director of engineering, Soil Conservation Service, said his organization provides technical assistance to land users in all categories included in appendix I except cloud seeding, desalting, and iceberg towing. The director said the Service's fiscal year 1980 expenditures were about \$210 million. The Service did not identify how much it spent on each of the technologies discussed in appendix I.

APPENDIX II

APPENDIX II

<u>Organization</u>	<u>Amount</u>
	(thousands)
Department of Transportation:	
U.S. Coast Guard	\$ 3,600
Federal Highway Administration	1,200
St. Lawrence Seaway Development Corporation	<u>540</u> \$ 5,340
Department of Energy	37,970
Environmental Protection Agency	92,400
National Oceanic and Atmospheric Administration	35,902
U.S. Army Corps of Engineers	31,880
National Aeronautics and Space Administration	4,625
National Science Foundation	4,600
Tennessee Valley Authority	<u>5,360</u>
Total	<u>\$380,420</u>

ORGANIZATIONS CONTACTED

Agency for International Development
Arlington, Va.

Arizona Ground Water Commission
Phoenix, Ariz.

Arizona State Water Commission
Phoenix, Ariz.

California Department of Water Resources
Sacramento, Calif.

Corps of Engineers
Washington, D.C.

Department of Agriculture:
Economics and Statistics Service
Washington, D.C.
Forest Service
Ft. Collins, Colo.
Laramie, Wyo.
Washington, D.C.
Agricultural Research
Boise, Idaho
Ft. Collins, Colo.
Kimberly, Idaho
Oakland, Calif.
Phoenix, Ariz.
Riverside, Calif.
Tucson, Ariz.
Washington, D.C.
Extension
Burlington, Colo.
Washington, D.C.
Soil Conservation Service
Boise, Idaho
Washington, D.C.

Department of Commerce:
Economic Development Administration
Washington, D.C.
National Oceanic and Atmospheric Administration
Rockville, Md.

Department of Energy
Washington, D.C.

Organizations Contacted

Department of the Interior:

Bureau of Indian Affairs
Phoenix, Ariz.
Bureau of Land Management
Washington, D.C.
Bureau of Mines
Washington, D.C.
Fish and Wildlife Service
Denver, Colo.
Washington, D.C.
Geological Survey
Reston, Va.
Office of Surface Mining
Washington, D.C.
Office of Water Research and Technology
Washington, D.C.
Water and Power Resources Service
Boise, Idaho
Denver, Colo.
Sacramento, Calif.
Washington, D.C.

Department of Transportation:

Coast Guard
Washington, D.C.

Environmental Protection Agency
Washington, D.C.

Idaho Department of Water Resources
Boise, Idaho

National Academy of Sciences
Washington, D.C.

National Aeronautics and Space Administration
Washington, D.C.

National Science Foundation
Washington, D.C.

Office of Management and Budget
Washington, D.C.

Office of Science and Technology Policy
Washington, D.C.

Orange County Water District
Fountain Valley, Calif.

Organizations Contacted

Water Resources Council
Washington, D.C.

State universities and
water research institutes:

Arizona State University
Tempe, Ariz.

Colorado State University
Ft. Collins, Colo.

Kansas State University
Manhattan, Kans.

Montana State University
Bozeman, Mont.

New Mexico State University
Las Cruces, N. Mex.

North Dakota State University
Fargo, N. Dak.

Oklahoma State University
Stillwater, Okla.

Oregon State University
Corvallis, Oreg.

South Dakota State University
Brookings, S. Dak.

Texas A & M University
College Station, Tex.

University of Arizona
Tucson, Ariz.

University of California
Berkeley, Calif.
Davis, Calif.
Richmond, Calif.
Riverside, Calif.

University of Idaho
Moscow, Idaho

University of Nebraska
Lincoln, Nebr.

Organizations Contacted

University of Nevada
Reno, Nev.

University of Wyoming
Laramie, Wyo.

Utah State University
Logan, Utah

Virginia Polytechnic Institute and State University
Blacksburg, Va.

Washington State University
Pullman, Wash.

Private companies:

Aero Systems, Inc.
Lafayette, Colo.

Camp, Dresser and McKee, Inc.
Austin, Tex.

Colorado International Corp.
Boulder, Colo.

Culp, Wesner & Culp Engineering
El Dorado Hills, Calif.

Fluor Corp.
Irvine, Calif.

James M. Montgomery Consulting Engineers
Pasadena, Calif.

Laser Alignment, Inc.
Grand Rapids, Mich.

Laserplane Corp.
Dayton, Ohio

PRC-Toups Corp.
Orange County, Calif.

Union Carbide Corp.
Oak Ridge, Tenn.

Organizations Contacted

Private individuals:

John L. Hult
Santa Monica, Calif.

Jack C. Jorgensen
Washington, D.C.



UNITED STATES WATER RESOURCES COUNCIL

SUITE 800 • 2120 L STREET, NW WASHINGTON, DC 20037

APR 2 1981

Mr. Henry Eschwege
 Director
 General Accounting Office
 Washington, DC 20548

Dear Mr. Eschwege:

In response to your March 18, 1981, letter, I am submitting the comments of the Water Resources Council staff on the draft GAO report, "Water Resources Research -- Improvements Needed to Successfully Develop and Implement Conservation and Augmentation Technologies."

We basically agree with the report's conclusion that Federal water resources research could be handled more effectively if Congress were to assign a single entity the responsibility and authority to coordinate agency research, assess technologies and rank research needs, and require research and development plans with specific objectives, milestones, technology transfer goals, and provisions for periodic independent evaluations.

Although the report addresses research, its recommendations appear to involve a mix of research and development or implementation activities. While we agree with the objective of increasing the ratio of research results that are practically applicable to those that are more purely exploratory, broad and not immediately useful, we believe that we should continue to support some (perhaps 20 percent) non-targeted research to add to our basic pool of knowledge. Nevertheless, such non-directed research could be encouraged in those general areas most likely to involve further development of useful technologies. By definition, "research" includes these longer-term, less-targeted activities as well as the immediately useful applied research and development activities. Tight product definition is probably more useful in the area of technology transfer than in the area of basic research. In the area of basic research it is important to ensure that areas are not unknowingly overlooked. A coordinating entity must be careful to avoid the risk of stifling creativity and focusing even more effort on "high-technology" solutions where simpler measures may suffice. For example, demand reduction techniques (e.g., water banking, water metering, realistic pricing, increasing block rates) may have a higher potential pay-off but require

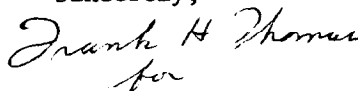
sociological, legal or institutional research rather than the physical science research more commonly funded.

[GAO COMMENT: The scope of our assignment did not involve determining a preferred mix of basic and applied research. Also, chapter 3, which calls for developing formal plans, involves only those technologies that are determined in a comparative assessment (ch. 2) to be technically feasible and in the applied research stage. Chapter 4 pertains to all water-related research, including basic research. In addition, the technologies discussed in appendix I should be viewed as only a partial list of potential solutions. It was not within the scope of our assignment to identify and discuss all potential solutions, such as seepage control, realistic pricing, etc.]

As the COWRR experience indicates, any entity selected to coordinate research would need either the authority to redirect agency research funding proposals to reflect established priorities or preferably the authority to recommend funding priorities directly to the Office of Management and Budget. Such an entity also would need to be separate from the agencies funding research and would need a staff with diverse backgrounds and competencies to provide a balanced assessment and analysis.

Your report recommends that "The Congress amend Section 406 of the Water Research and Development Act of 1978 to require WRC to coordinate water resources research provided the Congress believes it desirable to have an independent WRC Chairman and funding authorization to carry out the Water Resources Planning Act of 1965." The WRC does not have funding available in Fiscal Year 1981 to undertake the research coordination responsibility and the Administration budget for Fiscal Year 1982 proposes to zero fund all Council programs. Thus, we would not expect to be able to serve as the research coordination entity.

Sincerely,



Gerald D. Seinwill
Acting Director

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20500

April 3, 1981

Mr. Morton A. Myers
Director
General Accounting Office
441 G Street, N.W.
Room 5033
Washington, D.C. 20548

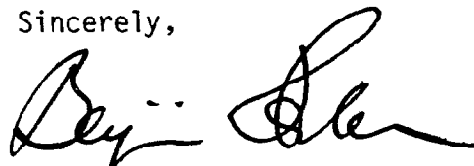
Dear Mr. Myers:

I am responding to the General Accounting Office draft report entitled "Water Resources Research--Improvements Needed to Successfully Develop and Implement Conservation and Augmentation Technologies." I agree with the General Accounting Office's (GAO) concern about coordinating Federal water resources research. This is a longstanding issue and one that each administration has attempted to improve by directing research towards high priority items. Some of the recent efforts by the Office of Science and Technology Policy are discussed in the draft report. I expect this coordination process to include a report to the President and Congress in the near future and a cross-cut review with the Office of Management and Budget for the FY 1983 budget.

I note that the draft report does not consider changes proposed in the President's Budget Revisions transmitted to the Congress on March 10. One of the draft report's recommendations is inconsistent with these changes in that no funding has been provided beyond FY 1981 for the Water Resources Council, the focal point for coordination of the report's proposed reforms. Also, the Budget Revisions proposed zero funding for the Office of Water Research and Technology and its water research programs.

Our Office is not prepared at this time to comment further on potential reorganization for coordinating water resources research. We will be studying this matter in more detail after a new director of the Office of Science and Technology Policy is chosen and after the National Academy of Sciences report, described in the GAO draft report, is delivered.

Sincerely,



Benjamin Huberman
Acting Director

[GAO COMMENT: We are aware of the current administration's position concerning the Water Resources Council. However, we believe our recommendations are still pertinent because the Congress has yet to decide whether it will go along with the administration's proposal not to fund the Council beyond fiscal year 1981.]




DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

APR 10 1981

SUBJECT: Comments on GAO Draft Report Entitled, "Water Resources Research--
Improvements Needed to Successfully Develop and Implement
Conservation and Augmentation Technologies"

TO: Henry Eschwege
Director - Community & Economic
Development Division - GAO

THROUGH: John B. Crowell
Assistant Secretary 
Natural Resources & Environment

Stephen B. Dewhurst
Director - OBP&E

We are pleased to provide the Department of Agriculture's comments regarding your proposed draft report to Congress entitled, "Water Resources Research--Improvements Needed to Successfully Develop and Implement Conservation and Augmentation Technologies."

We generally concur that improved planning and assessment of options for coordination of Federal water research are needed. However, while water resources research may appear fragmented at the Federal level, this, by itself, does not translate into an inefficient use of funds. Most agencies, including the Science and Education Administration, direct their research dollars toward problems that directly impact their broad missions and responsibilities. Perceived duplications of effort are commonly found to be the result of using broad classifications. For example, the mere existence of an agricultural research program in each of the 50 States can hardly be interpreted as a fragmented approach to research and an ineffective use of taxpayers' dollars. The report gives little recognition to the integrating role of the scientific literature and general awareness that exists within the scientific community of the work of others.

We do not agree with the concept of assigning responsibility for the coordination of these programs to the Water Resources Council. We believe that a more workable solution would be for that assignment to go to an interagency committee reporting to the Office of Science and Technology Policy (OSTP). We believe that OSTP would be in a better position to put water research into perspective with other research priorities and needs. Further, OSTP would draw upon existing groups such as the Water Resources Council, the Universities Council on Water Research (UCOWR) and the Joint Council on Food and Agricultural Sciences. The Joint Council would provide input not only from USDA agencies, but from the Agricultural Experiment Stations and private business interests.

[GAO NOTE: Page and other references have been changed to agree with the final report.]

Henry Eschwege

Input from agriculture is particularly important because of the high proportion of water used for irrigating cropland, pasture and range.

With regard to the recommendation that conservation and augmentation technologies be comparatively assessed, we agree that comparative analysis of different proposals can provide certain measurements and performance indicators that may be used to establish priority research proposals. However, we do not recommend that this type of analysis be used as the only means of establishing priorities. The purpose of research is to develop new methods and procedures and determine their effectiveness in addressing the problems. Comparative analysis can only be speculative and judgmental and may improperly assess the value of research. In addition, assessments can be extremely costly; e.g., \$6 million authorized for the one study cited on page 9. Therefore, we agree that a judgmental assessment of expected returns from a proposal will be of value, but should not be the limiting factor in final selection or rejection of a proposal.

Attached are specific comments referenced to page numbers in the report.

We sincerely appreciate the opportunity to review and comment on the proposed draft.



ANSON R. BERTRAND
Director
Science and Education

Attachment

DRAFT GAO REPORT

Water Resources Research--Improvements Needed to Successfully
Develop and Implement Conservation and
Augmentation Technologies

SPECIFIC COMMENTS

Summary - Line 1 -- The U.S. is facing problems every year, not just at times.

[GAO COMMENT: Deleted "at times" from cover summary.]

Summary - Line 7 -- The \$380 million budget should be called "water-related research and development," not water research. The inventory and elsewhere in the report includes a broad array of topics, such as weather, climate, erosion, etc., and this should be made more clear in the report and not just in the appendix. Also, much of the work is not research; extension work sponsored by SEA is only one small example. As indicated in the General Comments, failure to make this distinction weakens the report and implies that the research effort is much greater than it really is.

[GAO COMMENT: The suggested change was made.]

Page i, Para. 4 -- The major emphasis on the Tucson "assessment" as a model and several other sections for improved planning is misplaced for these reasons:

- The assessment was self-serving and considered only ways to get more water for Tucson.
- The small amount of evaporation from western reservoirs compared to the amount of evaporation from crop and rangelands is minor, and the example does not make a strong case for assessment.
- As indicated in the report, destratification has not been technically proven or evaluated and placing so much emphasis on that mechanism is not justified in the report, or for the city of Tucson.

[GAO COMMENT: We agree that the Tucson assessment considered only ways to get more water for Tucson, Arizona, and that an assessment for one locality does not reflect what the relative funding levels of various technologies should be. Other technologies may be the preferred option in other localities. However, regional and local assessments are needed in order to perform an overall assessment that would rank the technologies for the purpose of establishing research priorities.]

Page 1 - -- Why quote a 1968 report on the situation in the High Plains
Para. 3 of Texas? More recent data are available to show that the
 decline in irrigation is already occurring. Research
 studies have predicted this decline for many years.

[GAO COMMENT: We are aware that other studies also discuss the water situation in the High Plains region. However, we believe the 1968 report is an excellent example to illustrate that an awareness of the problem has existed for many years.]

Page 6 -- Comparative Assessment: The comparative assessment may be
 useful in specific situations. However, it appears to apply
 to existing technologies which may be the result of previous
 research. As described in the report, it does not produce
 new technology.

[GAO COMMENT: A comparative assessment of technologies is needed to establish research priorities for the technologies based on their expected contribution toward solving water problems.]

Page 8 - -- Should be 16 million acres. Also, mention should be made
Footnote of the extremely high costs of phreatophyte control (see
 also page 48).

[GAO COMMENT: Suggested change to 16 million acres was made. A discussion of the cost of phreatophyte control would not be appropriate under the caption "Environmental obstacles." Also, we recognize that additional obstacles to implementing certain technologies, such as the cost of controlling phreatophytes, may not be discussed in the report.]

Page 9, Line 10 -- The report needs to be more careful about use of terms such
 as "actually used," and a discussion of consumptive use vs.
 non-consumptive use is warranted. The same comment pertains
 to p. 22 for "water banking," which could be a major deter-
 rent to conservation because it gives a bonus to those who
 do nothing. Also on this page and elsewhere, economics must
 be considered in addition to legal and social issues. Farmers
 have a long history of quickly adopting practices that in-
 crease their net income.

[GAO COMMENT: Except for gross use, the appropriation doctrine is primarily concerned with the amount of water given to an irrigator, not the amount actually consumed by his crops. As for water banking, we do not believe it would give a bonus to those who do nothing, because the more efficient an irrigator, the more water the irrigator would have to sell. We agree that economics, which is discussed under "Technical obstacles" on page 8, should be considered in comparatively assessing technologies.]

Page 10, Number 4 -- Insert "suppression" after evaporation.

[GAO COMMENT: Added.]

Page 13 -- The emphasis is on research with a high probability of success. Some researchers argue that some effort should be devoted to basic research where the possibility of a payoff may be relatively remote.

[GAO COMMENT: We believe those technologies with the most potential for solving water problems should receive the highest level of Federal funding. However, we are not suggesting that basic research be discontinued.]

Page 17, Lines 1-3 -- How can an agency such as OWRT "assure that anyone will develop a water conservation and augmentation technology?"

[GAO COMMENT: The Department of Agriculture misquoted our statement. We stated that OWRT "...cannot assure that completed water research projects will be used by anyone to develop a water conservation or augmentation technology."]

Page 17, Last Para. -- The comments about SEA-AR's National Research Programs (NRP's) and top of p. 18 do not tell the whole story. The NRP's were not intended to be the totality of planning in SEA, but rather a first step and an overall framework for planning, evaluation, and execution of research programs. Other more specific planning documents were developed later, but the report does not mention them. Neither does the report mention the large number of location and program reviews conducted by SEA, most of which involve potential users of research and cooperators from other agencies. Again, the lack of differentiating between research and technology development and transfer is apparent.

[GAO COMMENT: We are aware that other documents exist, such as regional plans and progress reports. However, they are not meaningful plans to assist in technology development and/or increase the likelihood of user acceptance.]

Page 17, Last Para., and p. 18, 1st line -- This sentence should be revised as follows to better reflect the scientific input:

"However, the plan is basically a compilation of research approaches that were judged by agency scientists to merit further attention within projected manpower and funding constraints."

[GAO COMMENT: Suggested change was made.]

In the same paragraph is stated that "many projects" were completed when the NRP's were published and two are cited. Two is not "many." The results of the projects cited were analyzed and published later; i.e., the projects were not fully completed in 1976. Also, it is implied that the NRP, or plan, was for 1976 only; the NRP's were designed to cover research efforts for five years. One should anticipate a few changes at the project level during five years.

[GAO COMMENT: We provided only two examples to illustrate our point. However, we identified many projects in the plan that were completed or essentially completed before the plan was issued. For example, the plan lists eight projects under evaporation and seepage reduction. Of these, five were either completed or essentially completed before the plan was issued. At the time we interviewed agency researchers, no work had yet been performed on the other three projects.]

The subject report does not mention the technical literature, models, and other types of communications as a part of and a base for research planning, coordination, and assessment. The report should, at least, mention technical communications and systems.

[GAO COMMENT: Although technical literature, models, and other types of communication may be useful, they are not germane to a discussion of the need for developing formal plans.]

Page 18

-- " --research projects should not be selected with emphasis on the researcher's qualifications". Actually, the researcher's qualifications, if properly measured, are an important criterion in predicting the quality of his research.

[GAO COMMENT: Statement revised.]

Page 18,
Last Para.

-- Did the Forest Service really "develop. . . snow fences. . .?" Snow fencing has been widely used for probably 50 years. The Forest Service is criticized for developing plans for "only" 5 years rather than "long-term" plans. What is GAO's definition of "long-term?" WPRS receives the same criticism as the Forest Service on p. 20.

[GAO COMMENT: Sentence revised to reflect that the Forest Service performed work on the use of snow fences rather than developed snow fences. With respect to time frames, we believe a formal plan should cover the expected time required to develop and transfer a technology. It could be a few years for some technologies and 20 years or more for other technologies.]

Page 21 - -- Here and elsewhere, e.g., p. 18, the report implies
 Para. 3 that needed research on agricultural water was discontinued
 for lack of planning. The report might have mentioned that
 overall agricultural research support for soil and water prob-
 lems has been static since 1966. The research effort devoted
 to the category called Water and Watersheds declined 16 per-
 cent between 1970 and 1979. SEA-AR (formerly ARS) had to
 close 22 soil and water research locations between 1970 and
 the present for lack of funds and manpower. During the same
 period, the size and complexity of research problems grew
 apace. The amount of planning, assessing, and priority set-
 ting for soil and water research in AR during this period was
 huge.

[GAO COMMENT: It was not within the scope of our assignment to determine whether overall agricultural research support for soil and water programs has been static since 1966.]

Page 22 - -- Check this reference. It may be the interagency task force
 Footnote 1/ report on irrigation water use and management. USDA was a
 participant in this study.

[GAO COMMENT: Reference is correct.]

Page 25 - -- Could the director of OWRT abolish COWRR? Probably he
 Last Sentence abolished the position of COWRR coordinator in the Department
 of the Interior.

[GAO COMMENT: Deleted reference that COWRR was abolished by the Director of OWRT.]

Pages 41-43 -- The small funding for evaporation reduction can be used as an
 example that the present systems of planning, assessing, and
 coordinating is working. The need for and potential of
 evaporation control was recognized decades ago. Much basic
 and applied research in the U.S., Canada, Russia, and Australia
 has been conducted from time to time, but with limited
 practical payoff because of the fundamental fact that solar
 energy heats and evaporates water. No potential for break-
 through is apparent at this time, including destratification;
 no scientists are willing to spend much time on this subject
 without some kind of scientific lead and/or assurance of
 long-term funding. One research area for evaporation sup-
 pression that has had great payoff is mulch tillage for
 wheat production.

[GAO COMMENT: Since the Department of Agriculture has not performed any work in the area of destratification, we question whether it can adequately judge the merits of evaporation reduction by destratification. Furthermore, several researchers were involved in the Tucson study, which ranked evaporation reduction by destratification as having more potential for solving Tucson's water problems than other alternatives. We believe the Department of Agriculture is incorrect in assuming that all scientists are against the technology.]

Page 43 -- Nebraska's AGNET system for irrigation scheduling should be at least mentioned in the section on irrigation efficiency. This computerized program based on SEA-AR research has been used for a number of years in six states and just last summer was adopted by two more. The large savings in water, energy, and nitrogen fertilizer are well documented by research in Nebraska.

[GAO COMMENT: It was not within the scope of our assignment to discuss all work related to the technologies.]

Page 43, Para. 5 -- SEA-AR spent \$4.8 rather than \$4.9 million in FY-80.

[GAO COMMENT: Revised.]

Page 44 - -- Water harvesting for crop cultivation has been demonstrated a
Para. 3 number of times, at Akron, CO, for example. Harvesting snow for crop production has been demonstrated at Sidney, MT; Mandan, ND; and Akron, CO.

[GAO COMMENT: Report revised to reflect comment.]

Page 44, Para. 4 -- SEA-AR spent \$282,000 in FY-1980.

[GAO COMMENT: Revised.]

Page 46 - -- SEA-AR spent \$0.7 million in FY-1980.
Para. 1

[GAO COMMENT: Revised.]

Page 46 - -- SEA-AR spent the following amounts in FY-1980:
Para. 4

\$315,000 -- salt tolerant plants
502,000 -- drought tolerant field crops
140,000 -- drought tolerant forages
531,000 -- basic research on drought tolerance

The report needs to be revised accordingly.

[GAO COMMENT: Revised.]

Page 46 - Para. 2-- The report implies large savings in fresh water by use of
and elsewhere salt water for irrigation. The feasibility of this approach over long periods has not been demonstrated and this should be indicated clearly.

[GAO COMMENT: Report revised to reflect the intent of the comment.]

Page 46, Para. 2 -- This statement is ambiguous. Freshwater with high levels of dissolved salts is saline.

[GAO COMMENT: Statement was rewritten to clarify point.]

Page 46, Para. 2 -- Opening vast areas of the arid West is a sure-fire way to magnify water problems, not solve them; this is especially true for use of saline waters. The term "vast" probably overstates the case in terms of the absolute amount of water of any kind available for irrigation.

[GAO COMMENT: Statement revised to reflect the intent of the comment.]

Page 48, Para. 3 -- Past research, both basic and applied, shows that anti-transpirant spraying has little or no potential for water savings. Reductions in water loss generally are proportional to reductions in uptake of carbon dioxide and final yields, i.e., water use efficiency remains the same. On the same basis, developing plants that transpire less water without concomitant yield reductions may be impossible because of reduced CO₂ transfer through the stomates.

[GAO COMMENT: On page 48 we point out that various opinions exist concerning the potential of antitranspirant spraying.]

Page 50 -- Forest Service figure should be - \$10,200.

[GAO COMMENT: Since all estimates for fiscal year 1981 are subject to change, we have reported the data included in a December 1980 draft report entitled "Proposed U.S. National Water Resources Research, Development, Demonstration and Transfer Program." The amounts included in the draft report were prepared by the Federal organizations involved in water-related research activities.]

Summary -- Overall, the report gave little attention to the land sources of water (about 60 percent of the nation's water supply comes from forested land). Likewise, the opportunities to manipulate vegetative cover on that large water source base to provide additional flow at low unit cost was not adequately reported. The 1980 Resources Planning Act Assessment outlines water yield increase opportunities through vegetative manipulation. It reports a potential increase in annual water yield from Western commercial forest lands of 1.8 million acre feet at a 1967 equivalent cost of \$1.23 per year per acre foot (Publication FS-345, page 496). This report also gives an array of other water yield opportunities at varying costs.

The Forest Service water research program is also discussed in this report (page 536). It is this long term base of studies of the impact of vegetation manipulation which permits the prediction of subsequent potential water yield improvements outlined above.

[GAO COMMENT: We agree that the technologies discussed in this report are not a complete list of potential solutions. It was not within the scope of our assignment to identify and discuss all potential solutions, such as seepage control, realistic pricing, etc.]

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

OFFICE OF AUDIT
AND OVERSIGHT

April 1, 1981

Mr. Morton A. Myers
Director, Program Analysis Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Myers:

We appreciate having the opportunity to comment on the GAO Draft Report, "Water Resources Research--Improvements Needed to Successfully Develop and Implement Conservation and Augmentation Technologies", and have a few observations. The remarks on page 18 that "research projects should not be selected with emphasis on researcher's qualifications" might be read to imply that GAO feels that a researcher's qualifications are not important. A slight rewording could indicate more clearly that qualifications to carry out the work are essential but that, for mission agencies, other factors are more important in selection of projects within the bounds set by capabilities.

[GAO COMMENT: Revision made.]

The whole report seems geared to planning for the development of a particular conservation or augmentation technology with its stress on specific measurable objectives, milestones including a program termination date, technology transfer goals and independent periodic evaluations. This is appropriate for a development project, assuming a particular conservation or augmentation technology has been singled out for development. However, the report goes on to confuse the development of a particular technology with the process of planning a research program in water resources.

This apparent confusion between the two is illustrated on page 16 in the last paragraph which says: "Many Federal agencies fund or develop technologies that could conserve or augment water supplies. However, some agencies' research and development efforts are not included in formal plans. Other research is part of plans, but the plans lack elements that are needed to enhance efficient development and user acceptance."

Plans to enhance efficient development and user acceptance are appropriate to a development plan for a particular technology. They are premature and a possible waste of time in planning a research program, because the results of the research may well be negative, either technically or economically. If one could be sure in advance that a particular research program would be successful, both technically and economically, then of course one could plan to enhance efficient development and user acceptance from the very beginning. However, the ability to predict success is beyond the state-of-the-art in the administration of research at the present time. Many mission-oriented agencies look to

[GAC NOTE: Page and other references have been changed to agree with the final report.]

their research programs mostly as insurance against future technical problems that they may encounter. For example, EPA has a substantial amount of what they call "anticipatory research" for this reason.

If research results and the need for them coincide in time, research utilization is swift and sure. Most of the time they do not. The one usually arrives before the other. When the technical need arrives first, as it often does, engineers press forward with empirical solutions, or in many cases, full-scale trial and error solutions, without waiting for the research results to show up. That is why the practice of engineering has so many empirical practices and procedures. That is also why much of NSF's basic research support in water resources and environmental engineering goes to providing a scientific foundation for these empirical practices and procedures.


When the research results arrive first, before the critical need for them does, and they look promising, then of course a development plan is needed, and we have the problem of getting acceptance and a plan for using it and so forth. The GAO report is really addressed to this issue, and the example they choose is a good one - the use of destratification in a reservoir to reduce its evaporation losses.

To sum up, the report appears to confuse planning for development of a specific technology with planning a research program which may lead to a potentially useful technology. This may well be because the words research and development are usually used in tandem. Although related, research and development are different, and planning for them must also reflect these differences.

[GAO COMMENT: We made minor changes throughout the report to clarify our position. Basically, chapter 2 states that technologies should be comparatively assessed to assist in establishing research priorities, and chapter 3 states that formal plans should be developed based on the results of the comparative assessment of technologies. As stated on page 3 of the report, we believe that formal plans should be developed only for those technologies that are determined to be technically feasible and in the applied research stage. However, such plans should include all the elements of effective planning, including identification of technical, environmental, legal, and social obstacles and how they will be overcome.]

We hope these comments will be useful to you.

Sincerely yours,


Jerome H. Fregeau
Director



United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

Mr. Henry Eschwege
Director
Community and Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

APR 15 1981

Dear Mr. Eschwege:

With regard to the draft report, entitled, Water Resources Research--
Improvements Needed to Successfully Develop and Implement Conservation and
Augmentation Technologies, the following comments and suggested revisions are
offered.

We agree with the general thesis of the report that research to develop and implement technologies to conserve or augment water supplies could help alleviate the serious water problems facing the Nation. The concurrent thesis that there is need for more effective use of research funds already being appropriated and spent is without doubt.

The report amplifies the thesis and provides a critique of the present Federal system for water resources research, claiming there are 28 executive branch agencies involved, with an expenditure of \$380 million scheduled for fiscal year 1981. The Office of Water Research and Technology says their figures from the same list of agencies on this subject are much less. It would be well to verify the accuracy of your statistics.

[GAO COMMENT: We obtained our data from a December 1980 draft report entitled "Proposed U.S. National Water Resources Research, Development, Demonstration and Transfer Program." The data included in the draft report was prepared by the Federal organizations involved in water-related research activities. The Deputy Director of OWRT said OWRT does not have more current information.]

The report notes the significance of the present water situation by referring to the continued expected growth in water use and the consequent prospect of water shortages, particularly in the two-thirds of the nation west of the Mississippi River. The traditional water management means to meet the situation are said to be insufficient for the future because of the lack of large reservoir storage sites and environmental difficulties. Therefore, research and development for conservation and augmentation technologies are asserted to

[GAO NOTE: Page and other references have been changed to agree with the final report.]

be of increasing importance and necessity. This may be a modest over simplification, however, for the marginal benefit of conservation and augmentation technologies is already increasing relative to that dam.

The GAO appraisal of current and past federal water research experience concluded there was little or no correlation between the potential of some technologies and their level of funding. Cloud seeding and reservoir evaporation reduction are discussed in this regard with the conclusion that the latter has been much underfunded despite its prospects. The efforts of the Office of Water Research and Technology in evaluation of the potential of waste water reuse and recycling through national and regional reviews is described as a good example of the usefulness of assessment before a full-scale research task is undertaken. The assessment, according to GAO, should include examination of any technical, legal, social, and environmental obstacles anticipated with application of the technology.

The GAO also stresses the desirability of formal research planning as the means to achieve acceptance and application of the technology. The elements of an effective research plan are stated and discussed persuasively. The review of several federal agency plans revealed a lack of some of the critical elements. These agency plans are specifically referred to and discussed noting the deficiencies.

The report goes on to say that the need for improved water research has been recognized for over 20 years and was stressed again in the Water Research and Development Act of 1978, P.L. 95-467, Section 406, but that progress has been scant in implementation. GAO then concludes coordination should be assigned to the Water Resources Council, but only if the Congress provides for an independent chairman along with adequate funding for this purpose.

We disagree with the conclusion that the Water Resources Council should have the responsibility for the research coordination function. This Administration has already decided that the Water Resources Council and the Office of Water Research and Technology should be discontinued and that much of the present research responsibilities can be met by the states and the private sector. An Office of Water Policy is to be established to serve the Secretary with regard to the water resources aspects of his responsibility as Chairman of the Cabinet Council on Natural Resources and the Environment. The Cabinet Council is one of several, appointed by the President, to provide for more effective policy coordination and program management.

The new water office will provide for policy development in conjunction with the state governors and will coordinate water programs within the executive branch. The particulars of these general functions have yet to be stated, and it may be that a research relationship will be included. Therefore, until the full expression of this office's responsibility is completed, we will not say more about organization or function.

However, we suggest the following comments on individual paragraphs and pages of the draft report to improve accuracy and clarity.

DIGEST. TECHNOLOGIES NEED TO BE COMPARATIVELY ASSESSED

Page i, Last paragraph.

The statement is made that federally-funded evaporation reduction studies were never over a few thousand dollars. OWRT has, in fact, funded several projects on E/T suppression, which had clearly totalled more than just a few thousand dollars as the paragraph says.

[GAO COMMENT: We agree that Federal funding of evaporation reduction has exceeded a few thousand dollars. On page 42, we state that WPRS spent about \$2.5 million during the 1950s and 1960s. WPRS' work involved the use of alcohol films. We were referring to evaporation reduction by destratification. However, we have revised the paragraph to reflect Federal efforts in all aspects of evaporation reduction rather than just one evaporation reduction technique.]

Page 3, CHAPTER I, INTRODUCTION, Para. 1.

The statement that the COWRR committee was abolished by OWRT in the fall of 1977 is not accurate. COWRR was a creature of the FCCSET or FCST, not OWRT, its predecessor, OWRR, or even the Department of the Interior. The purposes of COWRR were no longer being met and the members no longer looked at research requirements critically. It would be more accurate to say COWRR had become little more than a chowder and marching society.

[GAO COMMENT: Deleted reference that COWRR was abolished by the Director of OWRT.]

Page 6. Line 5.

A reference is made to desalting using a "lot" of energy. "Lot" is a subjective item. The amount of energy necessary may be quite reasonable depending on the cost effectiveness and the value of the results.

[GAO COMMENT: We agree. Also, in some instances, desalting may be the only viable alternative for solving water problems in certain locations. This is discussed on page 7.]

Page 6, Para. 1.

Reference is made to evaporation reduction by destratification. Apparently, OWRT's WRSIC files were not searched for research already done. A search would have shown that work has been going on since the 1950's and the comment that R&D in this area "has never received over a few thousand dollars" would be seen as an understatement.

[GAO COMMENT: We disagree. We had previously searched OWRT's WRSIC files but did not find any evidence indicating that evaporation reduction by destratification had received over a few thousand dollars. To our knowledge, the only research performed on evaporation reduction by destratification was done by a university researcher in Logan, Utah. This is discussed on page 21. Also, on April 16, 1981, we again requested OWRT to search its files. OWRT's search revealed that we are correct.]

A reference that should be cited is: Committee Print No. 1, "Control of Evaporation Losses," Memorandum from the Chairman to Members of the Senate Committee on Interior and Insular Affairs, together with a Staff Study, dated April 14, 1958.

The GAO Special Report to the Congress, dated May 1, 1979, "Desalting Water Probably Will not Solve the Nation's Water Problems, but Can Help" presents a more comprehensive picture of the future role of desalting than given in the subject draft report under review.

[GAO COMMENT: We agree the report presents a more comprehensive picture of desalting. However, the report does not discuss the importance of comparatively assessing technologies to assure that those with the most potential receive the highest level of Federal funding.]

In general, you have been most helpful in focusing our attention as we develop an Office of National Water Policy.

Sincerely,



Deputy Assistant Secretary for
Land and Water Resources



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY

WASHINGTON, D.C. 20310

May 13, 1981

13 MAY 1981

Mr. Henry Eschwege
Director, Community and Economic
Development Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in reply to your letter of March 18, 1981, to the Secretary of Defense regarding your draft report on "Water Resources Research--Improvements Needed to Successfully Develop and Implement Conservation and Augmentation Technologies," (GAO Code 085510) (OSD Case #5667).

Oral comments were provided to GAO representatives at a meeting on March 31, 1981. GAO's responses to those oral comments were discussed at a meeting between our representatives on May 12, 1981, and, with one exception, the proposed revisions satisfied the earlier concerns.

We are still concerned that establishment of priorities by the WRC, as proposed in your draft report, at the bottom of page 35, or OSTP, as suggested in the revised Cover Summary, could result in limited funding for research and development to accomplish specific agency missions. We believe that each agency responsible for water resources development programs should establish priorities and justify budget requests to meet their research and development needs. We do not concur in the view that the coordinating agency would have a better perspective of research and development required to carry out specific programs than would the operating agencies. Our efforts of cooperation to make research information freely available to others will be intensified, better to insure that duplication and overlap will be avoided.

Sincerely,

A handwritten signature in cursive script, appearing to read "Robert K. Dawson".

Robert K. Dawson
Deputy Assistant Secretary of the Army
(Civil Works)



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

3 APR 1981

OFFICE OF
PLANNING AND MANAGEMENT

Mr. Henry Eschwege, Director
Community and Economic Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

The Environmental Protection Agency (EPA) has reviewed the General Accounting Office (GAO) draft report entitled "Water Resources Research--Improvements Needed To Successfully Develop and Implement Conservation and Augmentation Technologies."

The Agency believes that the draft report's recommendations are appropriate, and, within the limits of available resources, we have implemented the recommendations through our programs. EPA agrees with the GAO recommendation that a more highly coordinated effort among agencies would be beneficial and may help to focus efforts on high priority areas. We believe that assessment of potential water conservation and augmentation technologies and a leadership role in this area, as recommended, are appropriate, although EPA has made only a modest investment in this area.

Attached are specific comments relating to the draft report which we feel should be considered.

We appreciate the opportunity to comment on the draft report prior to its issuance to Congress.

Sincerely yours,

Roy N. Gamse

for
Roy N. Gamse
Acting Assistant Administrator
for Planning and Management

Enclosure

[GAO NOTE: Page and other references have been changed to agree with the final report.]

Specific Comments

1. The report does not distinguish clearly between the broad field of water research and the relatively narrow area of conservation and augmentation technologies. The first paragraph of the cover summary, for example, mentions the development and implementation technologies that conserve or augment water supplies; yet, in the next sentence, reference is made to water research, without a clear distinction between the two areas. If the report is about conservation and augmentation as the title suggests, it should be confined to those subjects. To illustrate this point, EPA's Office of Environmental Engineering and Technology is involved in water research studies; however, it directs comparatively little attention to water conservation or water augmentation work. The Denver Potable Reuse project, totally funded in FY 1979, will be this office's only active project in potable reuse during FY 1981. Therefore, the report's citation of EPA's research budget for FY 1981 is misleading, since there are no funds dedicated to work on water conservation and flow augmentation.

[GAO COMMENT: We made changes throughout the report to clarify this point. Basically, chapters 2 and 3 pertain to conservation and augmentation technologies. Chapter 4 pertains to the broad field of water-related research, including conservation and augmentation technologies.]

2. On page 20, 3rd paragraph, the draft report implies that EPA water conservation work is not well coordinated with other agencies. While one can always suggest additional coordination, there is cooperation at the program level. For example, EPA is one of the sponsors for a "National Water Conservation Conference - Publicly Supplied Potable Water" to be held April 14-15, 1981. Other agencies involved in this conference include the National Bureau of Standards (NBS), the Office of Water Research and Technology (DOI), the U.S. Army Corps of Engineers (COE), the U.S. Department of Housing and Urban Development (HUD), and the U.S. Water Resources Council (WRC). In addition, EPA, with seven other agencies, is sponsoring the Water Reuse Symposium II, August 23-28, 1981, in Washington, D.C.

[GAO COMMENT: We stated that EPA's plans ". . . do not show how other agency research will impact on EPA's program or whether EPA's research could benefit other agencies." We acknowledge that discussion of how one agency's program could benefit other agencies' programs may take place during conferences and symposiums. However, we believe formal plans would assist in the overall technology development and implementation effort and bring better focus to such conferences and symposiums.]

3. This report is out of date since there have been extensive budget and organizational changes in the Federal agencies since this draft report was prepared. Perhaps GAO should review the report in the light of present budgetary and organizational circumstances.

[GAO COMMENT: We agree that the currently planned expenditures in water-related research may be different from that included in the report. However, it is the most current data available. We are also aware that the current administration is in favor of making certain organizational changes, such as terminating the Water Resources Council. Nevertheless, congressional action will be necessary for some of these changes to occur.]

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