THE U.S. GEOLOGICAL SURVEY FEDERAL-STATE COOPERATIVE WATER-RESOURCES PROGRAM, FISCAL YEAR 1986

by B. K. Gilbert and W.B. Mann IV

U.S. GEOLOGICAL SURVEY
Open-File Report 87—27

1987

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

Copies of this report can be purchased from:

Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

For additional information write to:

Assistant Chief Hydrologist for Operations
U.S. Geological Survey
Water Resources Division
441 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092

CONTENTS

FIGURES

TABLES

The U.S. Geological Survey Federal-State Cooperative Water-Resources Program, Fiscal Year 1986

By Bruce K. Gilbert and William B. Mann IV

ABSTRACT

The U.S. Geological Survey's Federal-State Cooperative Water-Resources Program has been in operation for 91 years as of fiscal year (FY) 1986. Hydrologic data collection and interpretive investigations are underway in every State, Puerto Rico, and several territories in cooperation with more than 900 State, regional and local agencies. Federal funds amounted to $49.8 million in this 50-50 matching activity. Total funding was about $106 million, which included $6.9 million furnished by cooperating agencies on an unmatched basis.

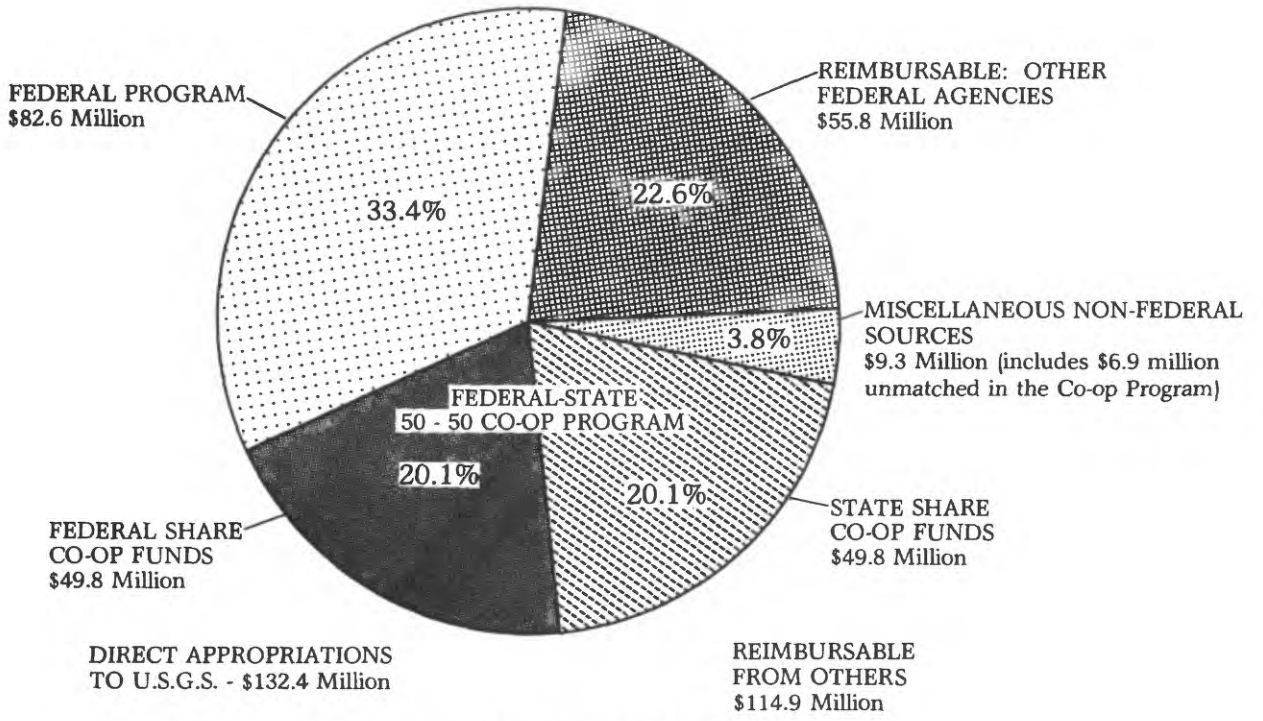
The Cooperative Program comprised more than 40 percent of the overall FY 1986 budget of the Survey's Water Resources Division. The areas of principal emphasis during the year included ground-water contamination, stream quality, water supply and demand, and hydrologic hazards.

This report presents information on program priorities and discusses investigations implemented under the merit proposal process. It also describes the status of water-use information activities, and provides several examples of current investigations.

INTRODUCTION

The U.S. Geological Survey's (USGS) Federal-State Cooperative Program has been in operation for 91 years as of FY 1986. Information on how this Water Resources Division (WRD) program functions was presented by Gilbert and Buchanan (1981 and 1983). After the Gramm-Rudman-Hollings budget reduction in 1986, $49.8 million in Federal funds were available for use in this 50-50 matching activity. Total funds amounted to about $106 million, including $6.9 million provided by State and local agencies on an unmatched basis. Cooperative Program funds comprised more than 40 percent of the Division's total actual obligations of $247 million, as shown in figure 1.

Hydrologic data collection and interpretive investigations were underway in every State, Puerto Rico, and several territories in cooperation with more than 900 State, regional, and local agencies. The locations of principal offices of the Division are shown in figure 2. The Survey's national headquarters are in Reston, Virginia. Regional headquarters are in Atlanta, Georgia; Lakewood, Colorado; Menlo Park, California; and Reston, Virginia.



FY 1986 TOTAL $247.3 MILLION

Figure 1.--Graph showing the fiscal year 1986 actual obligations for the U.S. Geological Survey's Water Resources Division.

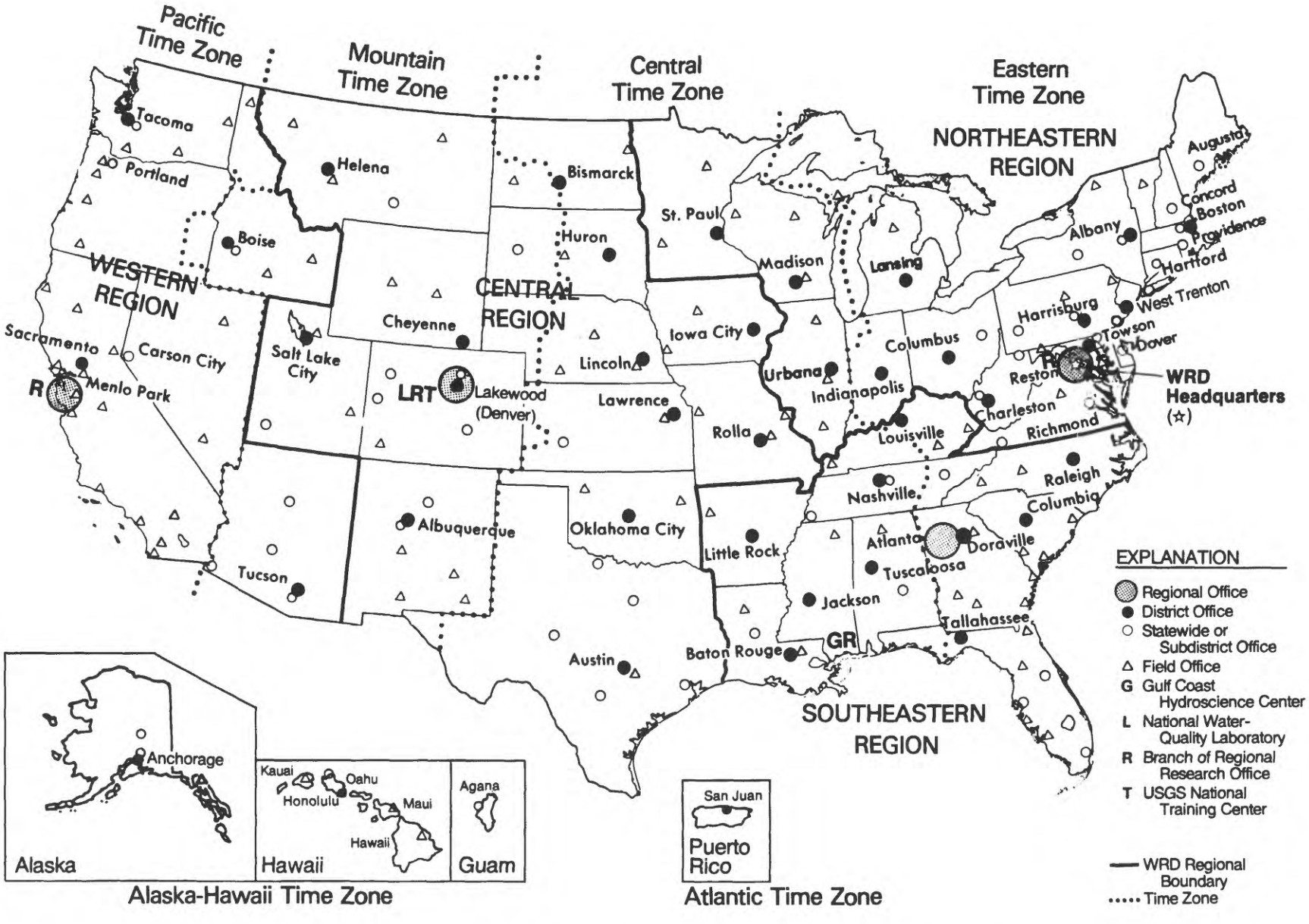


Figure 2.--Map showing location of the principal offices of the U.S. Geological Survey's Water Resources Division.

The FY 1986 Cooperative Program provided sole support for 3,449 continuous-record discharge stations (table 1) in comparison to 3,223 stations in FY 1985. However, because of decreases in funding in the Survey's Federal and Other Federal Agency Programs, the overall total of continuous-record stations in operation increased by only 60 to 7,019. Thus, the Cooperative Program is providing an increasing proportion of funding for the continuous-record discharge stations. In addition, the Cooperative Program provided sole support for 3,150 partial-record discharge stations, almost 1,300 stage-only surface-water stations, and about 29,400 stations where ground-water-level data were collected in FY 1986. The Cooperative Program supported the collection of water-quality information at 2,300 surface-water stations and at nearly 8,100 ground-water stations in FY 1986. In combination with other sources, the Cooperative Program also provided support for many additional stations as well.

Approximately 500 water-resources appraisals or special studies conducted throughout the Nation were funded by the Cooperative Program in FY 1986. The water-resources appraisals are investigations of areas that range in size from small basins or counties to State and multi-State regions. These investigations provide information to define, characterize, and evaluate the extent, quality, and availability of the water resource. Increasing emphasis has been given to water-quality issues--particularly ground-water contamination, the effects of hazardous materials on the hydrologic system, river-quality assessments, nonpoint-source runoff, and acid precipitation. The special studies, which address specific hydrologic conditions and problems, are somewhat more focused and smaller in size than areal appraisals, and may involve applied research.

Two other elements of the Cooperative Program are the coal-hydrology and water-use information activities. The objective of the coal-hydrology effort is to assess hydrologic conditions and water-supply problems related to coal mining and land reclamation, as these needs are identified jointly with State and local governments. This work produced information useful for the preparation of applications for mining permits and reclamation plans by the coal industry. The data also aid State authorities in reviewing the applications and plans. In FY 1986, about $4.1 million in Federal matching funds were identified specifically for coal-hydrology work. The water-use information activity is discussed subsequently in this report.

FUNCTION OF THE PROGRAM

The Federal-State Cooperative Program serves as a principal mechanism to carry out the Geological Survey's overall program of water-resources investigations. In many places, the Cooperative Program provides the only source of support for water-data collection and investigations required to assess, on a continuing basis, the status of the Nation's water resources. Clearly, however, the Cooperative Program cannot, and does not, exist apart from other activities conducted within the overall water-resource program of the Survey.

Table 1.--Water-data collection activities of the U.S. Geological Survey, FY 1986

Types of Stations 1/	Number of Stations 2/ A. Federal Program	B. Federal-State Cooperative Program	C. Other Federal Agencies	D. Combined Support	Total
SURFACE WATER					
Discharge					
Continuous record	540	3,449	1,522	1,568	7,079
Partial record	32	3,150	345	134	3,661
Stage Only--Streams					
Continuous record	19	244	247	30	540
Partial record	1	425	32	10	468
Stage Only--Lakes/Reservoirs					
Continuous record	9	319	231	139	698
Partial record	6	281	88	35	410
Quality					
Continuous record	86	346	228	71	731
Scheduled, long-term	489	1,246	342	166	2,243
Short-term or project	24	712	84	89	909
GROUND WATER					
Water Levels					
Continuous record	98	1,952	171	238	2,459
Scheduled, long-term	595	19,680	1,318	2,393	23,986
Short-term or project	1,253	7,752	839	652	10,496
Quality					
Scheduled, long-term	40	4,521	143	236	4,940
Short-term or project	285	3,548	671	312	4,816

1/ Types of Stations

CONTINUOUS RECORD: The station is instrumented to monitor hydrologic conditions continually and, in some instances, transmit data in near real time

PARTIAL RECORD: Hydrologic information is collected only during selected periods, for example, during floods.

SCHEDULED, LONG-TERM: Hydrologic information is collected on a fixed schedule over a long period to detect trends.

SHORT-TERM OR PROJECT: Hydrologic information is collected to meet the needs of a specific study. Data supplement those available from scheduled, long-term; continuous record; and partial record stations.

2/ Number of Stations

COLUMN A - Stations totally supported by funds appropriated to the Geological Survey Federal Program subactivity.

COLUMN B - Stations supported by funds appropriated to the Geological Survey Federal-State Cooperative Program subactivity.

COLUMN C - Stations totally supported by reimbursement from other Federal agencies.

COLUMN D - Stations supported by a combination of two or more of the above.

Investigations proposed by cooperating agencies reflect the growth in emphasis on water-quality issues, as well as on other concerns regarding the availability and distribution of the resource. Overall, there is an increasing need for hydrologic information at local, State, regional, and national levels. Offerings from cooperators each year typically exceed the Federal funds available for matching by several million dollars.

Development, utilization, and conservation of the Nation's water resources require an adequate data and information base. The Cooperative Program provides much of the Nation's data and information on water quantity and quality and responds, in a timely manner, to the varying and increasing requirements of agencies at all levels of government that have responsibilities for water resources. The program priorities are developed in response to mutual local, State, and Federal needs. Projects are jointly planned by Federal and State or local representatives, assuring optimum consideration for the priorities of each, but are reviewed at the regional and national levels for program and funding priorities. Information and issues that are identified through the National Water Summary (U.S. Geological Survey, 1984, 1985, and 1986) are taken into consideration in developing program priorities for water-resources investigations in the Federal-State Cooperative Program. Overall Federal priorities as identified by the Division's regional and headquarters staffs are employed in the selection of projects for joint funding. The Cooperative Program is unique among Federal activities in that the Survey performs most of the work on behalf of the cooperating agencies.

Deterioration in the quality of water supplies for domestic, municipal, industrial, and agricultural uses is a growing problem, which can affect human health as well as the economy. In spite of considerable progress in solving complex water problems, many activities continue to have a potential for degrading the quality of the surface and ground waters. At least half of the Nation's population drinks ground water. In some places, disposal of toxic wastes has made ground water unsafe for use. At an isolated point source of contamination, such as an industrial disposal pond, the consequences may be severe in magnitude but only local in extent. In some places, however, many separate agricultural and industrial activities located over a large area are contributing to widespread contamination. The Nation's rivers have historically been used for water supply, dilution and transport of waste, recreation, commerce, and for production of fish and other aquatic crops. These uses are not all compatible, and water managers are faced with resolving increasing conflicts among the many water users.

In FY 1986, the Survey further placed high priority on providing technical assistance to State and local governments on ground-water contamination and related issues. This, in part, supports efforts such as the U.S. Environmental Protection Agency Ground-Water Protection Strategy, which was released in August 1984. These areas will continue to receive priority. A growing number of requests for assistance is expected from State agencies responsible for ground-water protection and for controlling sources of contamination.

THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

The Department of the Interior (DOI), in consultation with other Federal agencies and States, has begun pilot studies associated with the testing and evaluation of concepts for a National Water-Quality Assessment (NAWQA) Program to help support the development of national, regional, and local policy related to water quality. This activity was first funded as a $2.4 million Federal program line item in the Survey's FY 1986 budget. The initial funding was earmarked to support the planning and phased implementation of a prototype National Water Quality Assessment Program. Funding in FY 1987 has been increased to $7.0 million. The Federal-State Cooperative Program also will be used to support State and local involvement in activities related to NAWQA. A national water-quality assessment effort would build upon the ongoing water-quality activities of the Survey, as well as those of other Federal, State, and local agencies.

A primary element in developing a National Water-Quality Assessment Program has been interagency coordination to ensure widespread usefulness of new data. The Survey and the Department have engaged in extensive consultation with representatives of State and local governments, and other Federal agencies who are potential beneficiairies and participants in a National Water-Quality Assessment Program. Through these efforts, a sound framework for interagency cooperation and participation is being developed that will ensure that the program is appropriately responsive to the information needs of the water-resources community.

If the pilot studies prove successful, and if it is decided to implement a National Water-Quality Assessment Program, decisionmakers at the Federal, State, and local levels would be provided with timely, scientifically sound, and nationally consistent information on water-quality conditions and trends. To achieve these purposes, the program approach currently being tested focuses on both ground water and surface water. The information developed by such a program will identify problem areas (and nonproblem areas as well) and assist in measuring progress toward national water-quality objectives.

WATER-USE INFORMATION PROGRAM

The Survey's National Water-Use Information Program has been part of the Federal-State Cooperative Program since 1978. Water-use information is compiled, stored, and disseminated both locally and nationally. The program makes accurate, consistent, and timely water-use information available to local water policy makers, planners, managers, and other potential users in order to help resolve many critical water problems that involve resource allocation, environmental impact, future water and energy development, and water quality. Additionally, water-use information is aggregated regionally and nationally to support water-resources assessments at those levels.

The National Water-Use Information Program is a logical part of the Cooperative Program. Close working relationships have been established with State and local agencies that collect water-use information. The Survey acts as a focal point to bring together the State and local agencies involved with water-use activities, and provides assistance in data-collection techniques, data management, and data accuracy. The detailed water-use information is incorporated into the Survey's program to complement data on availability and quality of the Nation's water resources.

Current Activities

Currently, 48 States and Puerto Rico are participating in the Water-Use Information Program at various funding levels, thereby providing a nationwide framework for the collection and analysis of water-use information. Information is collected on where and how much fresh and saline surface and ground water is withdrawn, how much water is consumed, where and how much water is returned to the hydrologic system, and which factors influence water use. The annual Federal matching funds for water-use activities in fiscal years 1978 to 1986 are shown below.

Fiscal Year	Federal Matching Funds (Dollars in Thousands)
1978	$1,000
1979	2,000
1980	3,202
1981	3,353
1982	3,203
1983	3,182
1984	2,682
1985	3,875
1986	3,670

Since 1950, the Survey has published a report every 5 years on the use of water in the United States. Estimates of 1985 water use were compiled for the following water-use categories during 1986: water supply, domestic, commercial, industrial, mining, power generation (fossil fuel, geothermal, nuclear, and hydroelectric), agriculture (non-irrigation), irrigation, and sewage treatment. The estimates are available in each District and are aggregated by both hydrologic subregions and counties. These estimates are also available on the National Water-Use Data System in Reston, Virginia, where they are aggregated by hydrologic regions and by States. The reliability of the water-use information has improved with each year the program has been in operation.

Each State has a computerized State Water-Use Data System (SWUDS) to facilitate the storage and retrieval of water-use information for individual (site specific) users or facilities. Twenty-two States and Puerto Rico have installed the SWUDS developed by the Survey, and 15 States have a system of their own design, as of 1986.

The Water-Use Program is evolving and standard methods and techniques for collecting the data are being developed and tested. Some of the water-use investigations supported through the Cooperative Program are listed in table 2. The projects suggest the wide range of activities and the many problems being addressed.

Table 2.--Selected water-use investigations in the Federal-State Cooperative Program, fiscal year 1986

State	Water-Use Activities
Arizona	Methods of estimating the variability in regional evapotranspiration are being developed by comparing two energy budget approaches at the Maricopa Agricultural Center.
Arkansas	The Arkansas Soil and Water Conservation Commission has chosen the Geological Survey's State Water-Use Data System to store site-specific information for about 20,000 wells. This complies with a 1985 State legislative requirement that pumpage data be reported for all wells 5 inches or more in diameter.
Florida	A cooperative agreement has been implemented with the St. Johns Water Management District to coordinate water-use activities among the five water-management districts in Florida, and to assemble water-use data for the entire State in a standardized format.
Idaho	Techniques to monitor irrigation withdrawals and return flows in the Snake River Basin have been developed.
Illinois	Intensive collection and analysis of water-use data in the cities of Kankakee and Rockford are being used to assess the pattern of withdrawals, consumptive use, and deliveries in urban areas.
Iowa	Enhancements to the Iowa State Water-Use Data System have been developed to improve reports and graphics.
New Jersey	Comprehensive water-use data are being collected in the four States comprising the Delaware River Basin and stored in a newly developed data base that will be used by the Delaware River Basin Commission to improve management of water resources in the Delaware Basin.
New Jersey	Water-use data are being analyzed with statistical models to estimate historical, current, and future water use in a heavily urban area around the city of South River.

New York	Water-use data are being evaluated for the eight States and two Canadian provinces that comprise the Great Lakes basin. Specifications are being developed for a centralized data base to store the information. The data base will be used by the Council of Great Lakes Governors to monitor withdrawals in the basin.
New York	Water withdrawals and other hydrologic data provide input to a Geographic Information System that will be used to locate areas that are susceptible to ground-water contamination in Duchess County--a heavily industrial area north of New York City.
Oregon	Methods have been developed to estimate, store, and retrieve water-use data on minicomputers and micro-computers.
Oregon	Techniques are being developed to determine water deliveries by water suppliers when total water withdrawals are known.
Tennessee	The Tennessee District convened an irrigation symposium to establish a means for the State and Federal agencies to exchange information on current and proposed irrigation.
Virginia	Existing data bases for water use, hydrogeology, land use, and water quality are being incorporated into a Geographic Information System for an area around Norfolk. The system will be used by Federal, State, and local water-resource agencies.
Washington	Crop-water requirements are being determined through the use of remote sensing on the Columbia Plateau.
Wyoming	Geographic Information System technology is being used to determine irrigation consumptive use in the Wind River area.

More than 100 water-use reports have been published as a result of the program. They include information brochures, data reports, and interpretive and analytical reports, most published by State cooperators.

Future Direction of the Program

Emphasis will be placed on interpretation and analysis of water-use information and on quality-assurance procedures as the National Water-Use Information Program matures. This will include the analysis of water-use processes, ways in which they may be altered, and the effect of the processes on water quality and the environment.

The Water-Use Program is supporting the development of a data base which will merge water-use information with other hydrologic data to establish a geographic information system. This system will enhance the capability to analyze the effects of water use on the hydrologic system and will provide improved information for the planning and management of the Nation's water resources.

INVESTIGATIONS IMPLEMENTED UNDER THE MERIT-PROPOSAL PROCESS

The Survey instituted a process in FY 1983 that formalized procedures for evaluating and funding selected proposals for water-resources investigations as part of the Federal-State Cooperative Program. Most Federal matching funds are allocated on a priority basis by the Division's four Regional Offices after ranking the work proposed in their respective geographical areas of responsibility. Under the new merit-proposal process, $1 million of Federal matching funds each year from 1983 through 1986 has been earmarked specifically for highest priority investigations anticipated to make substantive technical contributions to the science of hydrology. Thus, with the funds provided by cooperating agencies, a total of about $2 million is allocated to the merit program annually.

Merit proposals are reviewed and evaluated separately by members of the Survey's regional and headquarters staff. The group prepares a consolidated ranking, and funds are distributed to investigations in priority order. It is probable that all the merit investigations would have been funded regardless of this process. However, overall program development has been strengthened because of the increased deliberation during the ranking procedure, and there has been added incentive for the improved planning of high-quality proposals.

Some 53 merit investigations have been implemented in fiscal years 1983-86. Table 3 shows the State, the year started, the title, and the status of each of these by Survey Region. Plans are to continue with the merit proposal process and possibly increase the level of funding if circumstances permit.

Table 3.--Status of investigations implemented under the merit-proposal process in the Federal-State Cooperative Program, by Water Resources Division Region, fiscal years 1983-86

State, Year Started, Project Number	Title of Investigation	Status
	Northeastern Region	
MA 83-059	Techniques for estimating reaeration coefficients and traveltimes in Massachusetts streams	Reports published and in preparation
MA 83-060	Quality of precipitation from air masses moving over Massachusetts	Report in preparation
MA 84-068	Hydrology of a flood-plain wetland and its influence on streamwater quality in Massachusetts	Work underway
MA 85-071	Hydrologic and water-quality characteristics of the Dickey Brook watershed before limited clear-cutting operations	Work underway
MA 86-074	Water-table mapping with demonstration of ground-penetrating radar, Cape Cod, Massachusetts	Work underway
MA 86-076	Chemistry of precipitation during storm events	Work underway
NJ 84-072	Atmospheric deposition effects on water resources in the New Jersey Pinelands	Reports published and in preparation
NJ 84-078	Lead contamination in Ocean County	Reports published and in preparation
NJ 86-087	Corrosiveness of ground water in the coastal plain of New Jersey	Work underway

NY 85-156	Analysis of solute transport in the upper glacial and Magothy aquifers on Long Island, New York	Reports in preparation
NY 86-165	Sorptive and transport characteristics of PCB congeners in the upper Hudson River	Suspended until fiscal year 1987
PA 85-158	Lower Susquehanna nutrient control	Work underway
PA 85-159	Assessment of nutrient sources in the Susquehanna River basin	Work underway
	Southeastern Region	
FL 83-400	Saltwater intrusion models for selected areas, west-central Florida	Work underway
FL 83-405	Effects of flooding on sources and transport of pathogenic bacteria in the Apalachicola River and Estuary	Reports published and in preparation
FL 84-412	Lake Lucerne water budget, Polk County	Work underway
FL 85-438	Tide-induced circulation and flushing using tide gates in residential canals at Cape Coral	Work underway
FL 85-439	Migration of landfill leachate in a highly permeable surficial aquifer underlying an urbanized area, Palm Beach County	Work underway
FL 86-449	Simulation of a saltwater plume from a flowing well in a surficial aquifer, Dade County	Work underway
GA 84-083	Simulation of flood flow in fractured limestone formations near Brunswick	Reports published and in preparation
GS 84-084	Simulation of flood hydrographs for Georgia streams	Reports published and in preparation

LA 83-077	Transport of suspended and associated chemical constituents in the lower Mississippi River	Reports published and in preparation
LA 84-084	Containment of organic waste in low permeability clays of the Mississippi Embayment, southwest Louisiana	Report in preparation
LA 85-088	Flood characteristics of coastal streams in Louisiana	Work underway
NC 85-081	Effects of land-management practices on sediment and chemical transport in Guilford County	Work underway
TN 85-064	Channel evolution in adjusting streams in west Tennessee	Reports published and in preparation
TN 86-069	Pesticide transport at North Hollywood Dump, Memphis	Work underway
	Central Region	
IA 86-055	An accounting of organic pesticide residues for Old Mans Creek, Iowa	Work underway
KS 83-134	Transit losses during conveyance of releases from reservoir storage, eastern Kansas	Report published
KS 85-139	Relation of trihalomethane formation to physical, chemical, and biological characteristics of small water-supply lakes in eastern Kansas	Report in preparation
KS 85-150	Transport, effects, and fate of atrazine in a large water-supply lake, north-central Kansas	Work underway
KS 85-151	Movement and persistence of agricultural pesticides in the saturated and unsaturated zones, Kansas	Work underway

NM 83-244	Urbanization effects upon surface and subsurface flow to the Rio Grande, Albuquerque metropolitan area, New Mexico	Reports in preparation
NM 85-256	Water consumption in alluvial basins of the Rio Grande valley	Work underway
NM 86-258	Determination of vertical hydraulic conductivity and ground-water velocity from temperature profiles in wells	Work underway
ND 83-113/114	Hydrochemical impacts of surface mining of lignite--the sulfur cycle	Reports published and in preparation
ND 84-125/126	Hydrogeochemical consequences of hazardous waste disposal associated with surface mining, in situ ashing, and reclamation of lignite uranium deposits in western North Dakota	Reports published and in preparation
ND 85-131	Heat and Moisture Transport Model for seasonally frozen soils in North Dakota	Work underway
OK 83-067	A method of evaluating the severity of droughts in Oklahoma	Report in preparation
OK 86-080	Hydrogeologic characteristics of selected shaley formations in Oklahoma	Work underway
WY 86-094	The occurrence, mobility, and geochemical controls affecting selenium concentration in ground water and associated rocks disturbed by Mining, Powder River basin, Wyoming	Work underway
	Western Region	
AK 83-150	Hydrology and geochemical processes at a sub-arctic landfill at Fairbanks	Reports published and in preparation

AK 84-161	Eutrophication of south-central Alaska lakes	Reports in preparation
AZ 84-078	Distribution and movement of trichloroethylene in ground water in the Tucson area	Report in preparation
CA 83-426	Ground-water investigations in Owens Valley	Reports published and in preparation
CA 84-419	Estimating tidal and residual circulation, San Francisco Bay hydrodynamics	Work underway
CA 86-459	Documenting land subsidence by use of the global positioning technique	Report completed
NV 86-135	A gravitational technique for monitoring changes in ground-water levels in Nevada	Work underway
NV 86-140	Rates of ground-water discharge by evapotranspiration in southern Nevada	Work underway
OR 86-138	Iron geochemistry of the Dunes aquifer near Coos Bay	Work underway
WA 83-286	Stillaguamish River basin instream flow and water quality	Report in preparation
WA 85-303	Rainfall-runoff models for small basins in metropolitan areas of western Washington	Work underway
WA 85-305	Crop water determination through remote sensing	Work underway

EXAMPLES OF CURRENT INVESTIGATIONS

Several examples of Cooperative Program investigations underway in FY 1986 are furnished below:

Hydrologic appraisal of potential landfill sites, San Diego County, California--The Survey, in cooperation with San Diego County, is conducting an investigation in response to the County's need for additional landfill sites. Increasing urban population growth generated this need. The objectives are to: (1) develop methods for the selection and evaluation of potential landfill sites that are hydrologically suitable (2) select sites for preliminary evaluation and (3) provide hydrologic and geologic data to aid in the site evaluation. To date, 13 potential sites have been identified for evaluation by use of existing topographic, geologic, and hydrologic information, field observations, and geophysical measurements.

Artificial recharge of the Oakley Fan Area, Cassia County, Idaho--In cooperation with the West Cassia County Soil Conservation District, the Survey has constructed a ground-water flow model of the Oakley Fan area to assess the hydrologic effects of artificially recharging depleted aquifers during nonirrigation periods with water from the Snake River. Several small-scale artificial-recharge demonstration projects have been conducted by local water users in 1985 and 1986. Observation wells located downgradient from the injection wells responded strongly to the recharge. In 1986, about 9 cubic feet per second of tributary runoff were directed into an unused irrigation well for 41 days. By the time the experiment was completed, water levels in an observation well located about 1/2 mile away had risen about 13 feet. If the model indicates no undesirable effects from artificial recharge over large parts of the area, additional testing will be conducted.

Water quality of Cedar Creek, west-central Illinois--In cooperation with the Illinois Environmental Protection Agency, the Survey has underway an investigation to describe the low-flow water quality of Cedar Creek in west-central Illinois and to identify the effect of combined-sewer overflows and urban runoff on that water quality. Measurements of traveltimes and reaeration rates have been used to develop a water-quality model. Initial results indicate that high sediment-oxygen demands may be the primary cause of low dissolved-oxygen concentrations in the creek. Data are being collected to define the frequency and duration of overflows from combined-sewer overflow structures. Intensive monitoring of the quantity and quality of combined-sewer overflows, as well as flow from several storm sewers and tributaries, will be used to estimate the pollutant loads contributed from various sources. Findings of this study may be used by the Illinois Environmental Protection Agency in the review and possible revision of current management practices and stream-quality standards.

Nonpoint-source pollution to the Patuxent River estuary, Maryland--The Patuxent River basin significantly impacts the water quality of Chesapeake Bay. Sources of water-quality degradation include runoff from agricultural, forested, and urban areas. In cooperation with the Maryland Department of Health and Mental Hygiene, the Survey is conducting an investigation to develop an improved understanding of the relations among the factors influencing nonpoint sources of contamination. A water-quality model will be constructed as a planning tool to estimate loadings under actual and proposed land-treatment scenarios.

Exploration of buried-drift aquifers in Minnesota--Demands for water from sand and gravel aquifers deeply buried in drift are increasing in many areas of Minnesota. Lack of data on the location and properties of the aquifers makes planning for their development difficult, and the cost for extensive exploratory drilling to obtain such information is high. In cooperation with the Minnesota Department of Natural Resources, the Survey is making significant progress in the use of seismic refraction and reflection techniques to define the geometry of the aquifers for guidance in designing programs for geologic and hydraulic testing.

Maps of the Madison Aquifer, Montana--The Survey, in cooperation with the Montana Bureau of Mines and Geology, has been developing a series of geohydrologic maps of the aquifer in the Mississippian Madison Limestone and other aquifers in Montana. The maps, which show structure contours and water-quality characteristics, were originally intended for use in identifying water supplies for energy development. The map series have become extremely useful to farmers, ranchers, planners, and regulatory officials. Recently, the U.S. Environmental Protection Agency (USEPA) used this information in its Underground Injection Control Program; the maps assisted in the evaluation of requests for permits for disposal of oil-field brines.

Seaward extent of fresh ground water near Atlantic City, New Jersey--In 1985, the Survey, in cooperation with the New Jersey Department of Environmental Protection, drilled two observation wells offshore from Atlantic City to estimate the seaward extent of fresh ground water and to evaluate the likelihood of saline ground-water intrusion. The Atlantic City area was selected for study because ground-water levels are as much as 80 feet below sea level, increasing the potential for intrusion of saline water into landward parts of the "800-foot sand" of the Miocene Kirkwood Formation, locally a major source of potable water. Preliminary information suggests that an unexpectedly large body of fresh water in the "800-foot sand" extends seaward from Atlantic City. Thus, the usable freshwater resource of the area may potentially be greater than anticipated.

Hydrologic models of the ground-water system on Long Island, New York--Hydrologic models have been developed to provide quantitative estimates of the characteristics and operation of the Long Island ground-water flow system under predevelopment, present, and historic drought conditions. Simulations have been made to test the potential for using ground-water as an occasional supplement to New York City's surface-water supply and to test several postulated scenarios for the year 2020.

Effects of land use on streams in North Carolina--The North Carolina Department of Natural Resources and Community Development and the Survey are cooperating on the examination of the relations among land use, water quality, and aquatic biota. The study is focusing on concentrations of suspended sediment, heavy metals, and nutrients in three streams in the North Carolina Piedmont. One of the streams drains a predominantly forested area, one drains an agricultural area, and one drains an urban area. The biological health of each stream is being measured by monitoring the macroinvertebrate communities. The data show that all three land-use types contribute suspended sediment to the receiving stream, but highest concentrations are found in the urban stream. In general, metals are also highest in the urban stream, but nutrients are substantially higher in the agricultural stream. Macroinvertebrate populations are good at both forested and the agricultural streams but very poor at the urban stream. Preliminary findings are that land-use controls (such as minimum setback requirements and low density zoning) and good land-management practices are likely to benefit stream-water quality.

Islandwide survey of volatile organic compounds in ground water, Puerto Rico--In cooperation with the Puerto Rico Department of Health and the Puerto Rico Aqueduct and Sewer Authority, the Survey conducted a comprehensive evaluation of volatile organic compounds (VOCs) in public supply wells throughout the island. Samples were analyzed from about 250 wells. The results showed that 16 wells contained VOCs in concentrations that exceed proposed U.S. Environmental Protection Agency standards for drinking water, and an additional 50 wells contained traces of VOCs. Trichloroethylene was the most prevalent compound detected. This investigation provided factual information about organic contamination in public water sources and will assist in the design of cleanup strategies in several critical areas.

Stream-channel evolution, western Tennessee--Straightening and deepening of stream channels throughout much of western Tennessee in the last 30 years have caused substantial aggradation and degradation in those streams and associated tributaries, and may have contributed to several bridge failures. The Survey is conducting a cooperative study with the Tennessee Department of Transportation to assess, quantitatively, channel changes over time and space. Degradation causes severe bank failure and consequent channel widening, which continue through aggradation phases. Bank-widening rates of about 8 feet per year have been observed along highly unstable reaches.

Ground water in Salt Lake County, Utah--In cooperation with the Central Utah Water Conservancy District, the Survey developed a three-dimensional flow model to simulate possible changes of ground-water levels in Salt Lake Valley as the result of hypothetical pumpage at double the present rate for all large wells (larger than 150 gallons per minute), as well as pumpage from a postulated well field. At the increased rate of pumpage, drawdowns are projected to reach 40 to 60 feet in the area east of the town of Sandy. About 75 percent of the increased withdrawal would be salvaged from water that otherwise would have been discharged to the Jordan River and its tributaries. Assuming the withdrawal of 30 cubic feet per second at the postulated well field, it would require about 3,900 years for the saline ground water from beneath Great Salt Lake to travel 7 miles to the well field. This model is expected to help understand several pressing problems regarding development of ground water by local municipalities and water-supply entities. Eventually, the model may be used to determine optimum patterns of wells and rates of ground-water withdrawal in the county.

Sensitivity of streams to acid precipitation, Shenandoah National Park, Virginia--The Survey, in cooperation with the University of Virginia, made synoptic surveys of 56 streams in Shenandoah National Park to evaluate their sensitivity to acid precipitation and to determine the degree of drainage-basin acidification. A model to predict the alkalinity concentration of receiving waters was developed using detailed information on the geology underlying drainage basins. Model results indicate that all streams in the Park show signs of drainage-basin acidification from acid precipitation. However, the effects of acidification are greatest in the southwestern part of the Park, because the underlying siliceous rocks have low buffering capacity. The model is expected to be a useful tool for predicting the sensitivity to acid precipitation of unsampled streams within the Park and of streams in similar setting elsewhere.

Flood capacity of the Puyallup River, Washington--In cooperation with the Washington Department of Ecology, the Survey is investigating (1) present and past flood-carrying capacities and streambed elevations of the river channels (most of which are leveed) in the lower Puyallup River basin; (2) sediment processes in the rivers; (3) salmon and steel head habitat in the rivers; and (4) the relations between proposed changes in river channels for flood control and the previous three conditions. This information is needed by governmental agencies that wish to make changes in the river channels for improving or maintaining present flood protection, and governmental agencies and Indian tribes that wish to maintain or improve present fish habitat in the rivers. Data show that many feet of sediment have either aggraded or degraded at gaged locations, possibly associated more with human activities than with natural events. Sediment processes and fish habitat are still under investigation.

Water-use in the Great Lakes Basin--The governors and premiers of the eight States and two Canadian Provinces of the Great Lakes-Saint Lawrence River Basin signed the Great Lakes Charter in February 1985, establishing an unprecedented commitment to cooperate in managing water resources for the benefit of the region as a whole. The Charter also recommended formation of a Water Resources Management Committee composed of representatives of each jurisdiction. The Committee is charged with identifying specific water-use data required to develop a uniform and accurate water-use data base for the region and for developing and designing a system for the collection and exchange of comparable water-resources-management data. The committee's parent organization--the Council of Great Lakes Governors--entered into a cooperative agreement with the Survey to achieve these goals. The task of determining the type and availability of water-use data in each State and Province has been completed, and a regional data base has been designed, including hardware and software requirements. Determination of gaps and inconsistencies among regional water-use data has begun, and suggestions will be provided for ways of obtaining missing data and for making data more compatible. Completion and implementation of the proposed centralized data base will represent a significant step toward organized and efficient management of the region's water resources.

PROGRAM PRIORITIES

The issues described in this section were identified through consultation with Federal, State, and local agency officials by the Survey's Water Resources Division District Chiefs and other senior managers. They represent a national perspective of priority issues that need to be addressed in the Federal-State Cooperative Program to serve the Federal interest as well as State and local needs. The issues continue to reflect the strong interdependence of the Cooperative Program, the Federal Program, and the program activities conducted by the Survey with funds provided by other Federal agencies.

Major Issues of National Concern

Four issues of national concern have emerged as highest priority in developing the FY 1987 Cooperative Program:

Ground-Water Contamination--Studies are needed of the movement and fate of contaminants, including toxic wastes, in ground-water systems. Naturally occurring and human-caused contaminants are both of interest. There is a particular need for investigations on the effects of waste disposal practices, runoff from urban, industrial, and agricultural nonpoint sources, and saltwater encroachment induced by pumping. Studies will

address flow dynamics, solute-transport processes, chemical and biological processes, and the present water quality against which future changes can be compared. Emphasis will be placed on studies that advance knowledge of controlling processes, such as solute transport, organic biodegradation, and movement of contaminants between ground-water and surface-water environments.

Stream Quality--There is an increasing need for appraisals of the water quality of stream systems, particularly with respect to the occurrence and movement of toxic substances, and the effect of contamination on stream ecology. Investigations are needed that assess stream quality, including sediment chemistry as related to land use, stream biota, ground-water contribution of contaminants, and overland runoff. Cooperative investigations supporting and complementing the NAWQA Program will have high priority in program formulation. Such studies would include (1) expansion of data bases on chemical properties, particularly toxic substances, and on the processes governing erosion, sediment transport and deposition; (2) measurement of the effects of land-use changes, including urban development; (3) study of the effects of suspended and deposited sediments on land and water resources; and (4) understanding the transport of toxic substances and other constituents sorbed or attached to sediment.

Water Supply and Demand--Increasing diversion, withdrawal, and use of water place stress on the quantity and quality of existing supplies, thereby raising costs of delivery and treatment and presenting ever more difficult problems of allocation and quality management. Information defining present water use is required to quantify such stresses over time and space. Flow-system simulation is essential to anticipate stress response, especially for stream-aquifer systems. Topics for study will include streamflow response to drought conditions and system response to projected uses and supply-augmentation schemes.

Hydrologic Hazards--Economic losses from floods, mudflows, debris flows, sedimentation, and other hydrologic hazards amount to billions of dollars annually. These hazards are related not only to meteorological conditions, but also to such phenomena as landslides, volcanic eruptions, and earthquakes. Studies are needed to define the magnitude and probability of occurrence of hazardous hydrologic events and to improve understanding of the processes that cause them. Hazard studies in urban environments and flood-risk analyses associated with design of structures will be included in this category.

Major Issues of Regional Concern

Three additional issues are considered to have high priority for new work, but their importance may differ depending on regional interests. These issues are:

Hydrologic Effects of Fossil Fuel and Mineral Extraction--The mineral extraction industries, oil- and gas-production and processing, solid-fuel mining and processing (such as coal and oil shale), and metallic- and nonmetallic-mining industries greatly affect hydrologic systems. Effects may relate to a wide spectrum of hydrologic phenomena, including interaction of subsurface fluids with different chemical and physical characteristics, large-scale aquifer dewatering to permit mining, disruption of surface drainage, and disturbance of geochemical equilibria. Investigations will include studies of the hydrologic effects of land reclamation, mining, and waste disposal.

Wetlands, Lakes, and Estuaries--Because of their importance to fish and wildlife resources, wetlands, lakes, and estuaries deserve special attention. These areas are especially sensitive to human encroachment. There are growing concerns with lake eutrophication and the decrease in effectiveness of tidal flushing of estuaries. Studies will address the availability, movement, and quality of water and will emphasize physical, chemical, and biological processes.

Acid Rain--Interpretive studies of the effects of precipitation chemistry on water quality and the interaction of acid rain with biological systems will receive priority attention in terranes that have limited ability to buffer ground and surface waters, and in urban settings that produce large loads of atmospheric pollutants.

Hydrologic data are of increasing importance to Federal, State, and local agencies. Accurate, reliable data are the foundation of present and future interpretive studies and continue to be a major part of the hydrologic program of the U.S. Geological Survey. The new NAWQA Program will rely heavily on past, present, and future data to assess the health of the Nation's water resources. Research activities leading to the discovery of new principles or techniques will also be included in the Cooperative Program, as appropriate.

SUMMARY

The U.S. Geological Survey's Federal-State Cooperative Water Resources Program has served the Nation since 1895. As the largest major component of the Survey's total water-resources investigations program, it represents a working partnership with State and local interests. Today, the Cooperative Program is a composite of activities covered by agreements with cooperators in all the States, Guam, Puerto Rico, and several territories. Through this network of contacts, the program continues to evolve so as to be able to respond to changing priorities.

Details of the activities in the program are negotiated at State or local levels by representatives of the Survey and representatives of the cooperating agencies. Implementation of the work is principally by Survey personnel, but there is an accountability for performance to the State and local partners. The Nation's ability to cope with the challenges of problems in water management rests largely on data and information provided by the Cooperative Program in preceding years. The need for hydrologic data, investigations, and research clearly will continue to be great. The Federal-State Cooperative Program is one proven way to develop water-resources information such that Federal and State interests are equally represented.

REFERENCES CITED

Gilbert, B. K., and Buchanan, T. J., 1981, The U.S. Geological Survey Federal-State Cooperative Water Resources Program: U.S. Geological Survey Open-File Report 81-691, 27 p.

Gilbert, B. K., and Buchanan, T. J., 1983, Highlights of the 1983 Federal-State Cooperative Water Resources Program: U.S. Geological Survey Open-File Report 83-763, 36 p.

U.S. Geological Survey, 1984, National Water Summary 1983--Hydrologic Events and Issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

U.S. Geological Survey, 1985, National Water Summary 1984--Hydrologic Events, Selected Water-Quality Trends, and Ground-Water Resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

U.S. Geological Survey, 1986, National Water Summary 1985--Hydrologic Events and Surface-Water Resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

APPENDIX

COOPERATORS BY STATE, FISCAL YEAR 1986

Alabama:
- Alabama Department of --
  - Environmental Management
  - Highways
- Alabama Surface Mining Commission
- Autauga County Commission
- Birmingham, City of
- Coffee County Commission
- Dauphin Island Water Authority
- Geological Survey of Alabama
- Heflin, City of
- Huntsville, City of, Public Works
- Jefferson County Commission
- Montgomery, City of, Water Works and Sanitary Sewer Board
- Tuscaloosa, City of
- University of Alabama

Alaska:
- Alaska Department of --
  - Fish and Game
  - Natural Resources, Division of --
  - Minerals and Geology
  - Technical Services
  - Transportation and Public Facilities
- Alaska Power Authority
- Anchorage, Municipality of --
  - Department of Health and Human Services
  - Department of Planning
  - Department of Solid Waste Services
  - Water and Wastewater Utility
- Dillingham, City of
- Fairbanks North Star Borough
- Juneau, City and Borough of
- Kenai Peninsula Borough
- Matanuska Susitna Borough
- Petersburg, City of
- Sitka, City and Borough of

Arizona:
- Arizona Department of --
  - Health Services, Bureau of Water Quality Control
  - Water Resources
- Arizona Municipal Water Users Association
- Arizona Stateland Department
- Gila Valley Irrigation District
- Maricopa County --
  - Flood Control District
  - Municipal Water Conservation District No. 1
- Metropolitan Water District of Southern California
- Salt River Valley Water Users Association
- San Carlos Irrigation and Drainage District

Arizona--Continued
- Show Low Irrigation Company
- Tucson, City of
- University of Arizona, Board of Regents

Arkansas:
- Arkansas Department of --
  - Parks and Tourism
  - Pollution Control and Ecology
- Arkansas Geological Commission
- AR-OK Arkansas River Compact Commission
- Arkansas Soil and Water Conservation Commission
- Arkansas State Highway and Transportation Department

California:
- Alameda County --
  - Flood Control and Water Conservation District (Hayward)
  - Flood Control and Water Conservation District, Zone 7
  - Water District
- Antelope Valley-East Kern Water Agency
- California Coastal Conservancy
- California Department of --
  - Boating and Waterways
  - Health Services
  - Parks and Recreation
  - Water Resources --
    - Central District (Sacramento)
    - Northern District (Red Bluff)
    - San Joaquin District (Fresno)
- California Regional Water Quality Control Board --
  - Lahontan Region (South Lake Tahoe)
- California Water Resources Control Board
- Carpinteria County, Water District
- Casitas Municipal Water District
- Coachella Valley Water District
- Contra Costa County --
  - Department of Health Services
  - Flood Control and Water Conservation District
- Crestline-Lake Arrowhead Water Agency
- Desert Water Agency
- East Bay Municipal Utility District
- East Valley Water District
- El Dorado County
- Fresno Metropolitan Flood Control District
- Georgetown Divide Public Utility District
- Goleta County Water Distict
- Humboldt Bay, Municipal Water District
- Imperial County, Department of Public Works
- Imperial Irrigation District
- Indian Wells Valley Water District

California--Continued
Inyo County Water Department
Jurupa Community Services District
Kings River Conservation District
Los Angeles Department of Water and Power
Madera Irrigation District
Marin County, Department of Public Works
Marin Municipal Water District
Merced, City of
Merced Irrigation District
Modoc County, Department of Public Works
Mojave Water Agency
Montecito Water District
Monterey County Flood Control and Water Conservation District
Orange County --
Environmental Management Agency
Water District
Oroville-Wyandotte Irrigation District
Pacheo Pass Water District
Paradise Irrigation District
Rainbow Municipal Water District
Rancho California Water District
Riverside County Flood Control and Water Conservation District
Sacramento Municipal Utility District
Sacramento Regional County Sanitation District, Department of
Public Works
San Benito County Water Conservation and Flood Control District
San Bernardino County Flood Control District
San Bernardino Valley Municipal Water District
San Diego, City Water Utlities
San Diego County, Department of --
Planning and Land Use
Public Works
San Francisco, City and County of, Hetch Hetchy Water and Power
San Francisco Water Department
San Luis Obispo County, Engineering Department
San Mateo County --
Department of Public Works
Santa Barbara, City of, Department of Public Works
Santa Barbara County --
Flood Control and Water Conservation District
Water Agency
Santa Clara Valley, Water District
Santa Cruz County --
Flood Control and Water Conservation District
Santa Maria Valley Water Conservation District
Scotts Valley Water District
Siskiyou County Flood Control and Water Conservation District
Sonoma County--
Planning Department
Water Agency

California--Continued
Tahoe Regional Planning
Terra Bella Irrigation District
Tulare County, Flood Control District
Turlock Irrigation District
United Water Conservation District
University of California--Berkeley
Water Resources Center, Davis
University of California--Riverside
Cooperative Extension
Riverside, Cooperative Extension
Ventura County, Public Works Agency
Western Municipal Water District
Woodbridge Irrigation District
Yolo County, Flood Control and Water Conservation District
Yuba County Water Agency

Colorado:
Arkansas River Compact Administration
Arvada, City of
Aspen, City of
Aurora, City of
Boulder, City of
Boulder, County of, Department of Public Works
Breckenridge, Town of
Castle Rock, Town of
Cherokee Water and Sanitation District
Cherry Creek Basin Authority
Colorado Department of --
Health
Natural Resources
Colorado Division of Mined Lands Reclamation
Colorado Division of Water Resources, Office of the State Engineer
Colorado Geological Survey
Colorado River Water Conservation District
Colorado Springs, City of --
Department of Public Utilities
Office of the City Manager
Delta County, Board of County Commissioners
Denver, City and County, Board of Water Commissioners
Denver Regional Council of Governments
Dolores Water Conservancy District
Douglas County Planning Department
Eagle County, Board of Commissioners
Englewood, City of
Evergreen Metropolitan District
Fort Collins, City of
Fountain Valley Authority
Fruita, City of
Garfield, County of
Glendale, City of

Colorado--Continued
Glenwood Springs, City of
Grand County Board of Commissioners
Kiowa-Bijou Ground Water Management District
Larimer-Weld Regional Council of Governments
Longmont, City of
Lost Creek Ground Water Management District
Lower Fountain Water-Quality Management Assoc.
Metropolitan Denver Sewage Disposal District No. 1
Mineral, County of
Moffat County Commissioners
Northern Colorado Water Conservancy District
North La Junta Water Conservation District
Pikes Peak Area Council of Governments
Pitkin County, Board of Commissioners
Pueblo, City of, Board of Water Works
Pueblo Civil Defense Agency
Pueblo West Metro Water District
Purgatoire River Water Conservancy District
Rio Blanco County, Board of County Commissioners
Rio Grande Water Conservation District
Southeastern Colorado Water Conservancy District
Southwestern Colorado Water Conservancy District
St. Charles Mesa Water Association
Steamboat Springs, City of
Thornton, City of
Trinchera Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
Water Users No. 1 (Rangely)
Yellow Jacket Water Conservancy District

Connecticut:
Connecticut Department of Environmental Protection
Fairfield, Town of, Conservation Commission
New Britain, City of --
Board of Water Commissioners
Simsbury, Town of
South Central Connecticut Regional Water Authority
Torrington, City of

Delaware:
Department of Natural Resources and Environmental Control
Geological Survey

District of Columbia:
Department of Public Works

Florida:
Big Cypress Basin Board
Boca Raton, City of
Bradenton, City of
Brevard County, Board of County Commissioners
Broward County --
Environmental Quality Control Board
Utility Division
Water Resources Management Division
Cape Coral, City of
Clearwater, City of
Cocoa, City of
Collier, County of
Mosquito Control District
Coordinating Council on the Restoration of Kissimmee River Valley and Taylor Creek-Nubbins Slough Basin
Daytona Beach, City of
Englewood Water District
Escambia County, Board of County Commissioners
Escambia County, Utilities Authority
Flagler County, Board of County Commissioners
Florida Department of --
Natural Resources, Division of Marine Resources
Transportation
Florida Division of Recreation and Parks (Hope Sound and Tallahassee)
Florida Institute of Phosphate Research
Florida Keys Aqueduct Authority
Fort Lauderdale, City of
Fort Walton Beach, City of
Gainesville, City of
Hallandale, City of
Hendry County
Highland Beach, Town of
Hillsborough, County of
Hollywood, City of
Indian River County, Department of Planning and Human Resources
Jacksonville Beach, City of
Jacksonville, City of --
Department of Health and Environmental Services
Department of Planning
Water Service Division
Jacksonville Electric Authority
Production Engineering Division
Research and Environmental Affairs
Juno Beach, Town of
Jupiter Inlet District
Lake County, Pollution Control Department and Board of County Commissioners
Lee County, Board of County Commissioners
Leon County, County Courthouse
Leon County, Department of Public Works

Florida--Continued
- Manatee County, Board of County Commissioners
- Marion County, Board of County Commissioners
- Metropolitan Dade County, Department of Environmental Resources Management
- Miami-Dade Water and Sewer Authority
- Northwest Florida Water Management District
- Old Plantation Water Control District
- Orange County, Board of County Commissioners
- Palm Beach County, Board of County Commissioners
- Palm Beach County Solid Waste Authority
- Pasco, County of, Utilities Department
- Perry, City of
- Pinellas County
- Plant City
- Polk County, Board of County Commissioners
- Pompano Beach, City of, Water and Sewer Department
- Quincy, City of
- Reedy Creek Improvement District
- Sanibel, City of
- Sarasota, City of
- Sarasota, County of
- South Dade Soil and Water Conservation District
- South Florida Water Management District
- Southwest Florida Regional Planning Council
- Southwest Florida Water Management District
- St. Johns, County of
- St. Johns River Water Management District
- Stuart, City of
- Sumter County, Recreation and Water Conservation and Control Authority
- Suwannee River Authority (Live Oak)
- Suwannee River Authority (Trenton)
- Suwannee River Water Management District
- Tallahassee Bureau of Water Resources Management
- Department of Environmental Regulations
- Tallahassee, City of,--Underground Utilities, Electric Department, Streets and Drainage
- Tampa, City of
- University of Florida, Center for Wetlands
- University of Central Florida, College of Engineering
- Walton, County of
- West Coast Regional Water Supply Authority
- Winter Park, City of

Georgia:
- Albany, City of
- Albany Water, Gas, and Light Commission
- Bibb County, Board of County Commissioners
- Brunswick, City of
- Clayton County, Water Authority

Georgia--Continued
- Consolidated Government of Columbus
- Covington, City of
- Forest Park, City of
  - Transportation
    - Materials & Research
- Georgia Department of --
  - Natural Resources --
    - Environmental Protection Division
    - Geological Survey
    - Water Management Branch
  - Transportation
- Gwinnett, County of
- Helena, City of
- Macon-Bibb County, Water and Sewage Authority
- Moultrie, City of
- Thomaston, City of
- Thomasville, City of
- Valdosta, City of

Hawaii:
- Hawaii Department of --
  - Health
  - Land and Natural Resources --
    - Division of Water and Land Development
  - Transportation
- Honolulu, City and County --
  - Board of Water Supply
  - Department of Public Works

Idaho:
- Idaho Department of --
  - Fish and Game
  - Health and Welfare
  - Water Resources
- Middleton, City of
- Orofino, City of
- Shosone, County of
- Sun Valley Water and Sewer District
- Teton County, Board of County Commissioners
- The Shoshone Bannock Tribes, Fort Hall Indian Reservation
- University of Idaho
- Water District No. 1--Idaho Falls
- West Cassia Soil and Water Conservation District

Illinois:
- Bloomington and Normal Sanitary District
- Cook County, Forest Preserve District
- Decatur, City of
- Dupage County Public Works

Illinois--Continued
- Illinois Department of--
  - Energy and Natural Resources, State Water Survey Division
  - Nuclear Safety
  - Transportation, Division of Water Resources
- Illinois Environmental Protection Agency
- Metropolitan Sanitary District of Greater Chicago
- Springfield, City of

Indiana:
- Carmel, Town of
- Elkhart, City of, Water Works
- Indiana Department of --
  - Environmental Management
  - Highways
  - Natural Resources --
    - Division of Water
- Indianapolis, City of, Department of Public Works

Iowa:
- Carroll County Health Department
- Charles City, City of
- Clear Lake, City of
- Cedar Rapids, City of
- Des Moines, City of
- Des Moines Water Works
- Fort Dodge, City of
- Gutherie County Health Department
- Iowa Department of --
  - Natural Resources--Des Moines
  - Natural Resources--Iowa City
    - Geological Survey Bureau
  - Transportation, Highway Division
- Iowa State University
- Marshalltown, City of, Water Pollution Control Plant
- Sioux City, City of
- University of Iowa --
  - Institute of Hydraulic Research
  - University Hygienic Laboratory
  - University Physical Plant
- Union Electric Company
- Waterloo, City of--
  - Sewage Disposal Plant

Kansas:
- Arkansas River Compact Administration
- Hays, City of
- Kansas Department of --
  - Health and Environment
  - Transportation
- Kansas Geological Survey

Kansas--Continued
- Kansas State Board of Agriculture, Division of Water Resources
- Kansas Water Office
- Sedgwick County, Department of Environmental Resources
- Southwest Kansas Ground Water Management District No. 3
- Western Kansas Ground Water Management District No. 1
- Wichita, City of

Kentucky:
- Elizabethtown, City of
- Jefferson County Public Works and Transportation Department
- Kentucky Department of --
  - Natural Resources and Environmental Protection Cabinet
  - Transportation Cabinet, Division of Design
- Kentucky Geological Survey
- Louisville, City of
- University of Louisville
- University of Western Kentucky

Louisiana:
- Capital-Area Groundwater Conservation Commission
- E. Baton Rouge Parish
- Jefferson Parish, Department of Public Utilities
- Louisiana Department of --
  - Environmental Quality,
  - Natural Resources --
    - Louisiana Geological Survey
    - Office of Conservation
  - Transportation and Development --
    - Office of Highways
    - Office of Public Works
- Sabine River Compact Administration
- Slidell, City of

Maine:
- Androscoggin Valley Regional Planning Commission
- Cobbossee Watershed District
- Maine Department of --
  - Conservation, Geological Survey
  - Environmental Protection

Maryland:
- Anne Arundel County, Planning and Zoning Office
- Baltimore County --
  - Department of Permits and Licenses
  - Department of Public Works
  - Office of Planning and Zoning
- Calvert, County of
- Caroline, County of
- Carroll County, Board of County Commissioners
- Howard County, Department of Public Works

Maryland:--Continued
- Maryland Department of --
  - Health and Mental Hygiene, Office of Environmental Programs
  - Transportation, State Highway Administration
- Maryland Geological Survey
- Maryland Water Resources Administration
- Montgomery County --
  - Department of Environmental Protection, Office of Environmental and Energy Planning
  - Division of Storm Water Management
- Poolesville, Town of
- St. Marys County, County Commissioners
- Upper Potomac River Commission
- Washington Suburban Sanitary Commission

Massachusetts:
- Barnstable County, County Commissioners
- Brewster, Town of
- Harwich, Town of
- Massachusetts Department of --
  - Environmental Management
    - Division of Water Resources
  - Environmental Quality Engineering
    - Division of Water Pollution Control
  - Fisheries, Wildlife and Environmental Law Enforcement
    - Division of Fisheries & Wildlife
  - Public Works
- Massachusetts Hazardous Waste Facility
- Metropolitan District Commission, Water Division

Michigan:
- Ann Arbor, City of
- Battle Creek, City of
- Cadillac, City of
- Clare, City of
- Coldwater, City of, Board of Public Utilities
- Elsie, Village of
- Flint, City of, Department of Public Works and Utilities
- Genesee County Drain Commission, Division of Water and Waste Services
- Grand Traverse, County of
- Huron-Clinton Metropolitan Authority
- Imlay, City of
- Kalamazoo, City of, Department of Public Utilities
- Lansing, City of, Board of Water and Light, Water and Stream Division
- Macomb County
- Mason, City of

Michigan--Continued
- Michigan Department of --
  - Agriculture, Soil and Water Conservation Division
  - Natural Resources
  - Transportation
- Oakland County, Drain Commission
- Otsego County, Road Commission
- Portage, City of
- Wayne County Environmental Health Division
- Ypsilanti, City of

Minnesota:
- Beltrami County, Soil & Conservation District
- Elm Creek Conservation Commission
- Fond du Lac Reservation Business Commission
- Lower Red River Watershed Management District
- Metropolitan Waste Control Commission
- Minnesota Department of --
  - Natural Resources, Division of Waters
  - Transportation
- Red Lake Reservation Business Commission
- St. Paul Water Utility, Water Purification Plant
- University of Minnesota
- Wes Min Resource, Conservation and Development Association
- White Earth Reservation Business Commission

Mississippi:
- Gulf Regional Planning Commission
- Harrison County --
  - Board of Supervisors
  - Development Commission
- Jackson, City of
- Jackson County --
  - Board of Supervisors
  - Port Authority
- Mississippi Department of --
  - Highways
  - Natural Resources --
    - Bureau of Geology
    - Bureau of Land and Water Resources
    - Bureau of Pollution Control
- Mississippi Research and Development Center
- Pat Harrison Waterway District
- Pearl River Basin Development District
- Pearl River Valley Water Supply District

Missouri:
- Little River Drainage District
- Missouri Department of --
  - Conservation
  - Natural Resources --
    - Division of Environmental Quality, Lab Service Program
    - Division of Geology and Land Survey
    - Health
    - Land Reclamation Commission
- Missouri Highway and Transportation Commission
- Springfield, City of, City Utilities, Engineering Department

Montana:
- Daniels, County of
- Helena, City of
- Montana Bureau of Mines and Geology
- Montana Department of --
  - Fish, Wildlife, and Parks
  - Health and Environmental Sciences
  - Highways
  - Natural Resources and Conservation
  - State Lands
- Salish and Kootenai Tribes of Flathead Reservation
- State of Montana, Governor's Office
- University of Montana

Nebraska:
- Central Platte Natural Resources District
- Kansas-Nebraska Big Blue River Compact Administration
- Lincoln, City of
- Little Blue Natural Resources District
- Nebraska Department of --
  - Environmental Control
  - Water Resources
- Nebraska Natural Resources Commission
- University of Nebraska, Conservation and Survey Division

Nevada:
- Carson City, Department of Public Works
- Clark County Public Works Department
- Douglas County, Department of Public Works
- Elko County
- Las Vegas Valley Water District
- Mackay School of Mines
- Nevada Bureau of Mines and Geology
- Nevada Department of --
  - Conservation and Natural Resources --
    - Division of Environmental Protection
    - Division of Water Resources
  - Transportation
- Nevada Senate Interim Finance Committee

Nevada--Continued
- Nye County
- University of Nevada-Reno

New Hampshire:
- Conway, Town of
- New Hampshire Water Resources Board

New Jersey:
- Camden County, Board of Chosen Freeholders
- Delaware River Basin Commission
- Greenwich, Township of
- Logan, Township of
- Morris County, Municipal Utilities Authority
- New Jersey Department of Environmental Protection,
  - Division of Water Resources
- North Jersey District Water Supply Commission
- Passaic Valley Water Commission
- Somerset County, Board of Chosen Freeholders
- West Windsor Township

New Mexico:
- Alamogordo, City of
- Albuquerque, City of
- Albuquerque Metropolitan Arroyo Flood Control Authority
- Canadian River Municipal Water Authority
- Costilla Creek Compact Commission
- El Paso Water Utilities Public Service Board
- Highlands University
- Jemez River Indian Water Authority
- Las Cruces, City of
- Navajo Indian Nation, Navajo Tribal Council
- New Mexico Bureau of Mines and Mineral Resources
- New Mexico Department of Highways
- New Mexico Environmental Improvement Division
- New Mexico Interstate Stream Commission
- Office of State Engineer
- Pecos River Commission
- Pueblo of Acoma
- Pueblo of Laguna
- Pueblo of Zuni
- Raton, City of
- Rio Grande Compact Commission
- Santa Fe Metropolitan Water Board
- Vermejo Conservancy District

New York:
- Amherst, Town of, Engineering Department
- Auburn, City of
- Brookhaven, Town of
- Chautauqua, County of, Department of Planning and Development

New York--Continued
- Cheektowaga, Town of
- Cornell University --
  - Department of Natural Resources
  - Department of Utilities
- Council of Great Lakes Governors
- Dutchess County Environmental Management Council
- Heritage Task Force
- Hudson-Black River Regulating District
- Irondequoit Bay Pure Waters, Department of Engineering
- Kiryas Joel, Village of
- Monroe, County Department of Health
- Montgomery, County of, Department of Planning and Development
- Nassau, County of,
  - Department of Public Works (Bellmore and Mineola)
  - Department of Health
- New York City --
  - Department of Environmental Protection, Air Resources-Water Resources-Energy
- New York State Department of --
  - Environmental Conservation --
    - Division of Water
  - Transportation, Bridge and Construction Bureau
- New York State Power Authority
- Nyack, Village of, Board of Water Commissioners
- Oneida, County of, Planning Department
- Onondaga, County of --
  - Department of Drainage
  - Water Authority
- Orange, County of, Department of Public Works
- Oswego, County Health Department
- Putnam, County Health Department
- Suffolk, County of --
  - Department of Health Services
  - Water Authority
- Sullivan, County of, Planning and Economic Development Department
- Temporary State Commission on Tug Hill
- Ulster, County of, County Legislators
- Westchester, County of --
  - Department of Planning
  - Department of Public Works

North Carolina:
- Ayden, Town of
- Charlotte, City of
- Durham, City of, Department of Water Resources
- Farmville, Town of
- Greene, County of
- Greensboro, City of, Department of Public Works
- Greenville Utilities
- Guilford, County of, S.W.C.D.

North Carolina--Continued
- Jacksonville, City of
- Jones, County of
- Kinston, City of
- La Grange, Town of
- New Bern, City of
- North Carolina State Department of --
  - Human Resources
  - Natural Resources and Community Development
  - Transportation, Division of Highways
- North Carolina State University
- Onslow, County of
- Orange, County of
- Orange Water and Sewer Authority
- Pinetops, Town of
- Raleigh, City of
- Rocky Mount, City of
- Snow Hill, Town of
- Stantonsburg, Town of

North Dakota:
- Dickinson, City of
- Lower Heart River Water Resources District
- North Dakota State Health Department
- North Dakota State University
- Oliver County, Board of Commissioners
- Public Service Commission
- State Water Commission

Ohio:
- Akron, City of
- Canton, City of, Water Department
- Columbus, City of
- Freemont, City of
- Geauga, County of
- Lucas, County of
- Miami Conservancy District
- Northwood, City of
- Ohio Department of --
  - Natural Resources
  - Transportation
- Ohio Environmental Protection Agency
- Richwood, City of
- Ross, County of
- Sandusky, County of
- Seneca Soil and Water District
- Williams, County of
- Wood, County of

Oklahoma:
- Ada, City of

Oklahoma--Continued
- Altus, City of
- Central Oklahoma Master Conservancy District
- Fort Cobb Reservoir Master Conservancy District
- Foss Reservoir Master Conservancy District
- Lawton, City of
- Lugert-Altus Irrigation District
- Mountain Park Master Conservancy District
- Oklahoma City, City of
- Oklahoma Department of --
  - Health
  - Transportation
- Oklahoma Geological Survey, University of Oklahoma
- Oklahoma Water Resources Board
- Tulsa, City of

Oregon:
- Benton County, Board of County Commissioners
- Confederated Tribes of --
  - Umatilla Indian Reservation
  - Warm Springs Indian Reservation
- Coos Bay-North Bend Water Board
- Douglas, County of, Department of Public Works
- Eugene, City of, Water and Electric Board
- Lane Council of Governments
- McMinnville, City of, Water and Light Department
- Oregon Department of --
  - Fish and Wildlife
  - Transportation, Highway Division
  - Water Resources
- Portland, City of, Portland Water Bureau

Pennsylvania:
- Allentown, City of
- Bethlehem, City of
- Chester, County of, Water Resources Authority
- Erie County Department of Health
- Harrisburg, City of, Department of Public Works
- Indiana, County of
- Lancaster County Planning Commission
- Letort Regional Authority
- Media Borough Water Department
- Millcreek, Township of
- Neshaminy Water Resources Authority
- Philadelphia, City of, Water Department
- Pennsylvania Department of --
  - Environmental Resources --
    - Abandoned Mine Reclamation Bureau
    - Bureau of Forestry
    - Mining and Reclamation Bureau
    - Oil and Gas Management Bureau

Pennsylvania--Continued
    - Office of Resources Management, Bureau of Water Resources Management
    - Waste Management Bureau
    - State Parks Bureau
    - Topographic and Geologic Survey Bureau
    - Water Quality Management Bureau
- Susquehanna River Basin Commission
- University Area Joint Authority
- Warren County Commissioners
- Washington County --
  - Conservation District
  - Supervisors
- Williamsport, City of

Rhode Island:
- Narragansett Bay Water Quality Commission
- Rhode Island State Department of Environmental Management, Division of Water Resources
- State Water Resources Board

South Carolina:
- Charleston, Commission of Public Works
- Cooper River Water Users Association
- Grand Strand Water and Sewer Authority
- Myrtle Beach, City of
- South Carolina State --
  - Department of Highways and Public Transportation
  - Geological Survey
  - Health and Environmental Control
  - Public Service Authority
  - Water Resources Commission
- Spartanburg Water Works
- Waccamaw Regional Planning and Development Commission

South Dakota:
- East Dakota Water Development District
- Oglala Sioux Tribe
- Rapid City, City of
- Sioux Falls, City of
- South Dakota Department of --
  - Game, Fish, and Parks, Division of Wildlife
  - Water and Natural Resources --
    - Geological Survey Division
    - Water Rights Division
    - Water Quality Division
  - Transportation
- South Dakota School of Mines and Technology
- Watertown, City of
- West Dakota Water Development District

Tennessee:
- Alcoa, City of
- Bartlett, City of
- Dickson, City of
- Eastside Utility District
- Lawrenceburg, City of
- Lincoln County Board of Public Utilities
- Memphis, City of --
  - Light, Gas, and Water Division
  - Public Works Division
- Metropolitan Government of Nashville and Davidson County
- Murfreesboro Water and Sewer Department
- North Stewart Utility District
- Safe Growth Team
- Shelby, County of, Public Works
- Tennessee Department of --
  - Conservation, Geology Division
  - Health and Environment
    - Division of Superfund
    - Division of Surface Mining and Reclamation
    - Office of Groundwater Protection
    - Office of Water Management
  - Transportation, Division of Structures
- Tennessee Tech University
- Tennessee Wildlife Resources Agency
- University of Tennessee, Water Resources Research Center

Texas:
- Abilene, City of, Water Utilities
- Alice, City of
- Arlington, City of, Public Utilities
- Athens Municipal Water Authority
- Austin, City of, Public Works Department
- Bexar-Medina-Atascosa Counties, Water Improvement District No. 1
- Bistone Municipal Water Supply District
- Brazos River Authority
- Carrollton, City of
- Coastal Industrial Water Authority
- Colorado River Municipal Water District
- Corpus Christi, City of, Public Works
- Dallas, City of,
  - Public Works
  - Water Utilities
- Dallas, County of, Public Works Department
- Dallas-Ft. Worth Airport
- Edwards Underground Water District
- El Paso, City of, Public Service Board
- Fort Bend, County of
- Franklin, County of, Water District
- Gainesville, City of
- Galveston, County of

Texas--Continued
- Garland, City of, Public Works Department
- Georgetown, City of
- Graham, City of
- Greenbelt Municipal and Industrial Water Authority
- Guadalupe-Blanco River Authority
- Harris, County of, Flood Control District
- Harris-Galveston Coastal Subsidence District
- Houston, City of, Public Works Department
- Lower Colorado River Authority
- Lower Neches Valley Authority
- Lubbock, City of, Water Utilities
- Mackenzie Municipal Water Authority
- Nacogdoches, City of
- North Central Texas Municipal Water Authority
- Northeast Texas Municipal Water District
- Orange, County of
- Red Bluff Water Power Control District
- Reeves, County of, Water Improvement District No. 1
- Runaway Bay, City of
- Sabine River Authority of Texas
- Sabine River Compact Administration
- San Angelo, City of
- San Antonio, City of --
  - Engineering Department
  - Public Service Board
  - Water Board
  - Waste Water Management
- San Antonio River Authority
- San Jacinto River Authority
- Tarrant, County of, Water Control and Improvement District No. 1
- Texas Parks and Wildlife Department
- Texas Water Commission
- Texas Water Development Board
- Titus, County of, Fresh Water Supply District No. 1
- Trinity River Authority
- Upper Guadalupe River Authority
- Upper Neches River Municipal Water Authority
- Upper Trinity Basin Water Quality Compact
- West Central Texas Municipal Water District
- Wichita, County of, Water Improvement District No. 2
- Wichita Falls, City of, Public Works
- Willow Fork Drainage District
- Wood, County of

Utah:
- Bear River Commission
- Salt Lake, County of --
  - Board of County Commissioners
  - Division of Flood Control and Water Quality

Utah--Continued
- Utah Department of --
  - Natural Resources --
    - Oil, Gas, and Mining Division
    - Water Resources Division
    - Water Rights Division
    - Wildlife Resources Division
  - Transportation
- Utah Health Department --
  - Division of Environmental Health
- Utah Geological and Mineral Survey

Vermont:
- Vermont Department of --
  - Water Resources and Environmental Engineering

Virginia:
- Alexandria, City of, Department of Transportation and Environmental Services
- Charles City, County of
- Hanover, County of
- James City, County of --
  - Department of Public Works
  - Service Authority
- New Kent, County of
- Newport News, City of, Department of Public Utilities
- Northern Virginia Planning District Commission
- Roanoke, City of, Utilities and Operations
- Southeastern Public Service Authority of Virginia
- University of Virginia, Department of Environmental Sciences
- Virginia Department of Highways and Transportation
- Virginia Division of Mined Land Reclamation
- Virginia State Water Control Board
- Williamsburg, City of
- York, County of

Washington:
- Bellevue, City of, Public Works Department
- Centralia, City of, Light Department
- Chelan, County of, Public Utility District No. 1
- Cowlitz County Board of Commissioners
- Douglas, County of, Public Utilities District #1
- Hoh Indian Tribe
- Kitsap County Board of Commissioners
- King, County of, Department of Public Works
- Lewis, County of, Board of Commissioners
- Municipality of Metropolitan Seattle
- Pend Oreille, County of
- Pierce, County of, Department of Public Works
- Pullman, City of
- Puyallup Indian Nation
- Quinault Indian Business Committee

Washington--Continued
- San Juan County Board of Commissioners
- Seattle, City of --
  - Department of Lighting
  - Department of Parks and Recreation
- Skagit, County of, Department of Public Works
- Snohomish, County of
- South King County Regional Water Association
- Tacoma, City of --
  - Public Utilities Department
  - Public Works Department
- Washington Department of --
  - Ecology
  - Emergency Management
  - Fisheries
  - Natural Resources
  - Transportation
- Whatcom, County of, Department of Public Works
- Yakima Tribal Council

West Virginia:
- Marshall County Commission
- Morgantown, City of, Water Commission
- Washington Public Service District
- West Virginia Department of --
  - Highways
  - Natural Resources --
    - Division of Water Resources
- West Virginia Geological and Economic Survey

Wisconsin:
- Bad River Tribal Council
- Beaver Dam, City of
- Dane, County of --
  - Department of Public Works
  - Regional Planning Commission
- Delavan Lake Sanitary District
- Delavan, Town of
- Fond du Lac, City of
- Forest County Potawatomi Community
- Fox Valley Water Quality Planning Agency
- Green Lake Sanitary District
- Lac du Flambeau Indian Reservation
- Madison Metropolitan Sewerage District
- Medford, City of
- Menominee Indian Tribe of Wisconsin
- Middleton, City of
- Morris Lake Management District
- Norway, Town of
- Okauchee Lake Management District
- Oneida Tribe of Indians
- Park Lake Management District

Wisconsin--Continued
- Powers Lake, District of
- St. Croix Tribal Council
- Southeastern Wisconsin Regional Planning Commission
- Stockbridge-Munsee Tribal Council
- Thorp, City of
- University of Wisconsin -- Extension, Geological and Natural History Survey
- Waukesha Water Utility
- Waupun, City of
- Wisconsin Department of --
  - Natural Resources
  - Transportation --
    - Division of Highways
- Wolf Lake Management District
- Wood, County of

Wyoming:
- Afton, Town of
- Cheyenne, City of
- Lincoln, County of, County Commissioners
- Sublette, County of
- Uinta, County of, County Commissioners
- Wyoming Attorney General
- Wyoming Department of --
  - Agriculture
  - Economic Planning and Stabilization Board
  - Environmental Quality
  - Highways

Wyoming--Continued
- Wyoming State Engineer
- Wyoming Water Development Commission

Commonwealths and Territories

- American Samoa, Government of
- Guam, Government of
- Government of the Northern Mariana Islands
- Federated States of Micronesia --
  - State of Kosrae
  - State of Pohnpei
  - State of Truk
  - State of Yap
- Puerto Rico:
  - Puerto Rico Aqueduct and Sewer Authority
  - Puerto Rico Department of --
    - Agriculture
    - Health
    - Natural Resources
    - Transportation and Public Works
  - Puerto Rico Electric Power Authority
  - Puerto Rico Environmental Quality Board
  - Puerto Rico Industrial Development Company
  - Puerto Rico Planning Board
  - University of Puerto Rico, Center for Energy & Environmental Research
- Republic of Palau

* U.S. GOVERNMENT PRINTING OFFICE:1987- 181-407:40085