

A STUDY OF
WATER RESOURCES RESEARCH CENTERS
AND
GRADUATE PROGRAMS IN WATER RESOURCES
IN THE UNITED STATES

Prepared for the Montana Environmental Quality Council

By a Study Team Composed of

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June 1989

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Foreword

Since 1964, the U.S. Department of Interior has been a principal catalyst of water research throughout the United States. In that year, Congress passed the Water Resources Research Act¹ which enabled the Interior Department to establish the water resources research center program and to provide funding for water centers at universities in each of the states and many of the territories. To date, 54 centers have been established.

The Water Resources Research Act is attributable to the efforts of Senator Clinton Anderson (D-NM), who at the time was chairman of the Senate Committee on Interior and Insular Affairs, Resources for the Future, the Council of State Governments, and colleges and universities around the country.² The statute was patterned after the Hatch Act of 1887 which had created a system of agricultural experimentation stations at land grant colleges throughout the United States.³

In 1984, over opposition from the Reagan Administration, Congress overwhelmingly renewed its commitment to this decentralized system of water research. With passage of the Water Resources Research Act of 1984, Congress reauthorized the water resources research center program and authorized the expenditure of \$36 million for each fiscal year through FY 1989.⁴ Actual appropriations for the program, however, have been much less than the authorization. In FY 1989, Congressional appropriations were \$5.67 million for Section 104 grants and \$4.38 million for Section 105 grants. More information about this statute is provided in Chapter 1 of this report.

Authorization for the main components of the Water Resources Research Act will expire on September 30, 1989. While congressional support for the program still appears strong, bills to reauthorize the program did not pass the 100th Congress in 1988.⁵ Similar reauthorization bills have been introduced in 1989.

¹ Pub.L. No. 88-379 (Jul. 17, 1964).

² For a history of the Water Resources Research Act, see the excellent publication commemorating its 25th Anniversary, NAT'L ASS'N OF WATER INST. DIRECTORS, THE WATER RESOURCES RESEARCH PROGRAM: LESSONS FROM THE PAST, PERSPECTIVES ON THE FUTURE (nd; issued in 1989)(hereafter cited as "NAWID").

³ *Id.* at 1.

⁴ Not including an additional \$13 million each year through FY 1991 for Ogallala aquifer research and development. Act of Mar. 22, 1984, Pub. L. No. 98-242, Title III, as added Nov. 17, 1986, P.L. 99-662, Title XI, § 1121(c), 100 Stat. 4239.

⁵ E.g., H.R. 5010.

Montana's University Regents have established the state's Water Resources Research Center at Montana State University in Bozeman. At MSU, the Center is staffed by a 0.4 time Acting Director and 0.75 FTE support staff. Part-time associate directors are appointed both for the University of Montana and Montana College of Mineral Science and Technology, which builds the participation of these two institutions directly into the water research program. In FY 1988, the budget for the Water Center was \$105,130 from the USGS and \$207,402 from non-federal sources.

Although Montana's Water Center has been long-established, there has been a concern among many state decisionmakers that the full potential of the Center is not being realized. Montana's water is probably the state's cardinal natural resource and there is a growing realization of its critical importance to the economy and culture of the state. Water is basic to Montana's quality of life. Water sustains the state's principal economic activities including agriculture, recreational and tourism, and mining. The presence of sufficient, quality water will be important for economic growth in the state.

Montana's legislators have expressed a growing interest in the strength of Montana's water research and planning programs. In 1982, a major report to the legislature on water in the Missouri River Basin noted that "[t]he state needs to develop . . . a system to manage the state's water resources more efficiently, specifically identifying water resources, existing uses, and the potential for future development."⁶ In 1985, the Legislature's Select Committee on Water Marketing Final Report included several recommendations concerning the development of water data and water policy.⁷ In response to these recommendations, the permanent interim Water Policy Committee examined Montana's water research program in 1985 and 1986 with a presentation on the program and structure of Montana's Water Center and similar presentations on Utah's and Wyoming's water resource programs.

The Water Policy Committee for the next biennium (1987-88) built upon the earlier committee's work and expressed even greater interest in Montana's Water Center. The Committee heard presentations by Commissioner of Higher Education and center staff. The Committee requested a report by the Commissioner on how Montana's Water Center might be improved. In response, the Commissioner sponsored a Symposium on Water Research and Education, held June 13, 1988, to which people from universities, state agencies, and the public were invited to discuss Montana's water research needs and the possible role of the Center. In October 1988, the

⁶ MONT. DEPT OF NATURAL RESOURCES & CONSERVATION, A WATER PROTECTION STRATEGY FOR MONTANA (1982).

⁷ REPORT OF THE SELECT COMMITTEE ON WATER MARKETING (Jan. 1985).

Commissioner presented the Water Policy Committee with a formal report on how Montana's Water Center might be improved. One of his principal commitments was to appoint a Water Research Policy Board "to give overall direction to the research program."⁸

This report has been commissioned by the Montana Environmental Quality Council to provide state legislators, the university system, and the Water Research Policy Board with better information about the choices available for Montana's water research and education efforts. The report provides a survey of the structure, program, and funding of other Water Centers around the country; a survey of graduate-level, water resource management programs at selected universities around the country; and a preliminary assessment of funding sources that might be available to Montana's Water Center.

This project began with an extensive interview with Howard Peavy, the Acting Director of the Montana Water Resources Research Center. Howard is active in the National Association of Water Institute Directors and was able to provide the researchers with many useful names and materials. The project continued with numerous telephone interviews with USGS officials involved in the water center program, and the agency provided much helpful information on water centers throughout the country and its own grants program. The survey was also sent to all 54 state and territorial water centers requesting information on their finances, staffing, and structure (see Appendix A). Each center was requested to provide its most recent annual report and list of research projects and publications. The characteristics of America's water centers are discussed in Chapter 2 of the report.

The authors also identified the 26 colleges and universities in the United States which appear to have some form of graduate-level water resource management program. University catalogs and other descriptive information were obtained from these institutions. In several cases, additional information on these programs was gained through personal and telephone interviews. The characteristics of these graduate programs in water resource management are described in Chapter 3.

The authors also conducted a preliminary assessment on non-state funding sources that might provide assistance to the Montana Water Center. This assessment started with research concerning the prospects for reauthorization of the the federal Water Resources Research Act. Other federal agency support for water research was also investigated. Foundations that have consistently funded water research or water policy development projects were identified. This information is set forth in Chapter 4. This

⁸ Krause, Water Research, Information and Education Programs 3 (Oct. 1988).

assessment of funding prospects must be considered preliminary. Further work must be done to identify funding possibilities for research programs that will benefit Montana.

The report concludes in Chapter 5 with a set of recommendations for Montana policymakers on the opportunities for research, education, and funding that might be available as decisions are made concerning the future of Montana's Water Center. This report only identifies opportunities; decisions concerning the type of water center needed in Montana are appropriately made by the university system, with recommendations from the new Interagency Water Research Policy Board, and by the legislature.

Information About the Authors

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Chapter 1:

The State-Federal Partnership in Water Resources Research

A. The Water Resources Research Act

America's unique state-federal water research partnership was made possible by passage of the Water Resources Research Act of 1964.⁹ While the original act authorized establishment of water research institutes in all 50 states, as well as a competitive grants program, amendments in 1971 allowed institutes to be established in the District of Columbia, the Virgin Islands, Puerto Rico, and Guam.¹⁰ Since then, institutes have been established in all 50 state, the District of Columbia, and the three territories.

The water research program was continued by Congress with the passage of the Water Research and Development Act of 1978¹¹ which involved consolidation of similar research programs within the Department of Interior. In March 1984, Congress again reauthorized the water research program and this current authorization will expire on September 30, 1989.

Upon passage of the original legislation in 1964, then-Secretary of Interior, Stewart Udall established the Office of Water Resources Research (OWRR) within his Department.¹² Following the passage of the 1971 legislation, the OWRR was merged with the Office of Saline Water to form the Office of Water Research and Technology.

In 1982, however, the Reagan Administration reorganized various functions at the Department of Interior, the Office of Water Research and Technology was eliminated, and its functions were distributed widely within the Department.¹³ Shortly thereafter, however, further reorganization measures resulted in the consolidation of the institute program and the matching programs within the U.S. Geological Survey where they now reside.

⁹ Pub. L. No. 88-379 (July 17, 1964).

¹⁰ Pub. L. No. 92-175 (Dec. 7, 1971).

¹¹ Pub. L. No. 95-467 (Oct. 17, 1978).

¹² NAWID at 4.

¹³ "The institutes program was placed in the newly formed Office of Water Policy (OWP) The matching grants program was placed in the Bureau of Reclamation, and the WRSIC [Water Resources Scientific Information Center] program went to the Water Resources Division of the U.S. Geological Survey. The saline water program was dropped." *Id.*

The structure of the Water Resources Research Act of 1984¹⁴ is straightforward. Section 10301 of the statute sets forth Congress' findings and declarations. The findings emphasize the importance to water for the nation's economy, environment, and social well-being but that the quantity and quality of water is threatened. Congress declares that research, technology, policy formation, and graduate education are all important to safeguard the nation's water. Section 10302 states the congressional purpose for the statute. Simply, the act's purpose is to meet the needs identified in the preceding section: to protect our country's waters by promoting and coordinating water resources research and education.

1. Section 104 Program

Section 10303 (commonly known as the Section 104 program) provides for the establishment of water resources research centers in each of the states and territories, specifies the work of the centers, provides for periodic evaluation of the centers, and authorizes funds for distribution to the centers.

The basic statutory mandate to the centers contained in this section is as follows:

Each institute shall--

- (1) plan, conduct, or otherwise arrange for competent research with respect to water resources, including investigations and experiments of either a basic or practical nature, or both; promote the dissemination and application of the results of these efforts; and provide for the training of scientists and engineers through such research, investigations, and experiments, and
- (2) cooperate closely with other colleges and universities in the State that have demonstrated capabilities for research, information dissemination, and graduate training in order to develop a statewide program designed to resolve state and regional water and related land problems.

The act instructs that centers are to be established at a state's land grant institution unless the legislature designates another institution.¹⁵ States are authorized to organize regional water centers (in which case the basic USGS grants for each state would be available to the regional center).¹⁶ Centers are to be evaluated every four years by a team selected by USGS that includes "employees of the Department of Interior, university faculty or

¹⁴ 42 U.S.C. §§ 10301-10309 (1988).

¹⁵ *Id.* at § 10303(a).

¹⁶ *Id.* The authors are not aware of any regional centers being established under this provision although centers do frequently cooperate on specific research projects.

administrators, water research institute directors from other institutes, State or local water resource agency personnel, and private citizens"17

Ten million dollars each year is authorized for distribution as grants by USGS to each of the water centers. Each federal dollar received by a center under the 104 program must be matched by two non-federal dollars.¹⁸ In FY 89, Congress appropriated \$5.6 million for the Section 104 program, or about \$105,000 for each of the 54 institutes. For FY 90, the Bush Administration has requested \$2.8 million for the institute program.¹⁹ Figure 1 presents the funding for the program from FY 65 to FY 89.

Prior to the receipt of the money, each center must have a water research program approved by the Department of Interior that includes assurances that the "program was developed in close consultation and collaboration with the director of that State's Department of water resources or similar agency, other leading water resources officials within the State, and interested members of the public."²⁰ A center's program must include "plans to promote research, training, information dissemination, and other activities meeting the needs of the State and Nation, and shall encourage regional cooperation among institutes in research into areas of water management, development, and conservation that have a regional or national character."²¹

2. Section 105 Program

Section 10304 (commonly known as the Section 105 program) establishes a program of national competitive grants for a broad range of water research projects. These grants, available on a 1:1 matching basis, are available to water centers, other educational institutions, state and local agencies, private foundations, private firms, and individuals. The statute authorizes \$20 million per year for these grants although Congress appropriated only \$4.4 million for the competitive grants program in FY 89. For FY 90, the Bush Administration has requested \$1.8 million for the competitive grants program.²²

17 *Id.* at §10303(e).

18 *Id.* at §10303(c). The matching requirement was 1:1 for FY85 and FY86, 1:1.5 for FY87 and FY88, and 1:2 for FY 89.

19 Western States Water 2 (No. 778, Apr. 14, 1989).

20 *Id.* at §10303(d).

21 *Id.*

22 Western States Water, *supra* note 19, at 2.

FIGURE 1: FEDERAL FUNDS APPROPRIATED TO WATER RESOURCES RESEARCH PROGRAM (FY65-FY89)(\$1000's)

Fiscal Year	Institute Program		Competitive Grants	
	Authorization	Appropriation	Authorization	Appropriation
1965	3,825	2,985	1,000	250
1966	4,462	4,462	2,000	1,500
1967	4,462	4,462	3,000	2,000
1968	5,100	5,100	4,000	3,000
1969	5,100	5,100	5,000	3,000
1970	5,100	5,100	5,000	3,000
1971	12,750	5,100	5,000	3,000
1972	12,750	5,100	5,000	3,000
1973	13,125	5,100	5,000	3,000
1974	13,350	5,640	5,000	3,000
1975	nr	nr	nr	nr
1976	13,500	7,162	5,000	3,750
1977	13,500	5,730	5,000	3,200
1978	13,500	5,730	5,000	3,500
1979	8,100	5,940	6,000	4,980
1980	9,450	5,940	8,000	4,980
1981	8,100	6,210	8,000	5,480
1982	8,640	5,961	9,000	-0-
1983	6,210	6,210	-0-	-0-
1984	6,210	6,210	-0-	-0-
1985	10,000	5,886	20,000	2,543
1986	10,000	6,159	20,000	4,767
1987	10,000	5,677	20,000	4,381
1988	10,000	5,677	20,000	4,381
1989	10,000	5,677	20,000	4,381

nr - not reported in source
Source: NAWID, The Water Resources Research Program 5 (nd).

The research undertaken under the Section 105 program should be in the national interest and should involve the nation's best graduate students. Although the Secretary of Interior is given some discretion to determining the type of projects that are in the national interest, Congress has indicated that the following research should be supported under the 105 program:

- (1) Aspects of the hydrologic cycle;
- (2) Supply and demand for water;
- (3) Demineralization of saline and other impaired waters;
- (4) Conservation and best use of available supplies of water and methods for increasing such supplies;
- (5) Water reuse;
- (6) Depletion and degradation of groundwater supplies;
- (7) Improvements in the productivity of water when used for agricultural, municipal, and commercial purposes;
- (8) The economic, legal, engineering, social, recreational, biological, geographic, ecological, and other aspects of water problems;
- (9) Scientific information dissemination activities, including identifying, assembling, and interpreting the results of scientific and engineering research on water resource problems; and
- (10) Providing a means for improved communication of research results, having due regard for the varying conditions and needs for the respective States and regions.²³

3. Other Provisions

The 1984 Water Resources Research Act has other provisions that are minor or not of relevance to Montana. The administrative costs of institutes or other grantees are limited to 15 percent.²⁴ Section 10305 authorizes competitive grants of \$6 million per year for technology development,²⁵ but this program has not been funded by Congress. A section of the original statute that is not codified establishes the Ogallala Aquifer Research and Development project and authorizes \$13 million per year for a range of water research projects in the High Plains region of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming.²⁶

²³ 42 U.S.C. §10307.

²⁴ *Id.* at §10306.

²⁵ *Id.* at 10305.

²⁶ Pub. L. No. 98-242, Title III (1984), as amended by Pub. L. No. 99-662, Title XI, §1121(c), 100 Stat. 4239 (1986).

B. Reauthorization Issues

The House of Representatives passed H.R. 1101 on June 6, 1989, by a vote of 136 to 74. Introduced by Rep. George Miller (D-CA) and former Rep. Dick Cheney (R-WY), the bill authorizes \$205 million for the five-year period of FY 90 to FY 94. The bill would allow the spending of \$10 million annually for the 54 water centers plus an additional \$5 million annually for research on regional or interstate water problems and issues identified by the Secretary of Interior and the institutes.

The proposed legislation also authorizes spending of \$20 million annually for the USGS's competitive grant program. It also provides authority for high priority research in such areas as groundwater and climate, as well as \$6 million annually for technology development grants (which have not been funded in the past).

The bill reduces the current 2:1 matching grant requirement, which has been burdensome for many institutions, and reinstates the previous 1:1 matching requirement.

The Bush Administration opposes H.R. 1101 in its present form. The Administration has requested only \$4.6 million per year for both the institute and competitive grants program. The Administration also opposes the new regional water research grants program, the technology development grants, grants for groundwater and climatology research, and reduction in the matching requirements.²⁷

H.R. 1011 is almost identical to H.R. 5010²⁸ which passed the House of Representatives in 1988 but was not acted upon by the Senate. In the Senate, reauthorization of the water research program got enmeshed in a debate over groundwater legislation. Some Senators, dissatisfied with "unimaginative programs" run by many of the centers, supported restructuring water research programs around five national groundwater institutes funded by the Environmental Protection Agency. The perceptions of many Senators and their staff are that the USGS program is too concerned with "rigor" while the EPA offers "relevance."²⁹ It is unlikely that the USGS water research program will be dramatically changed this year. Senator Moynihan (D-NY), who had led the debate on both groundwater and water research issues during the 100th Congress, is not as active on these issues during the current session of Congress. A form of H.R. 1011 will likely pass the Senate this year or next.

²⁷ Western States Water 2 (No. 787, Jun. 16, 1989).

²⁸ H.R. 5010, 100th Cong. 2d Sess (1988).

²⁹ Interview with N. Stockholm, former Assoc. Counsel, Senate Environ. & Pub. Works Comm. (May 9, 1989).

C. Montana's Water Resources Center

Montana's Water Resources Center was originally established by the Montana University System Board of Regents on December 8, 1964. In September 1985, the Regents promulgated a "Charter for the Montana University System Water Resources Center" (see Appendix B). The charter indicates that the Water Center is a cooperative activity of Montana State University, the University of Montana, and Montana College of Mineral Science and Technology. Faculty at all units of the Montana university system are eligible to participate in the Water Center's programs.

The Charter also specifies that the Director of the Center is appointed by the President of MSU after consultation with the other two participating institutions. The Director is responsible to MSU's Vice President for Research. At present, directorship of the Center is a part-time position with the incumbent allocating 40 percent of his time to the Center and the remainder of his time to the Civil Engineering Department where he has a regular teaching load. Under the Charter, the Director of the Center is located at MSU.³⁰

Associate Directors are appointed for the other two cooperating institutions. The Director and Associate Directors comprise the Coordinating Council which has as its principal task "the development of criteria for research and information transfer projects and the allocation of funds to approved projects."³¹

Two committees are also specified by the Charter: an advisory committee of state, local and federal government officials who identify "areas where research and/or information transfer projects are needed and shall review proposed projects for relevancy to state and regional need;"³² and a peer review committee comprised of faculty and off-campus experts who review and recommend research and information projects to the Coordinating Council.

Recently, the Commissioner of Higher Education appointed an Interagency Water Research Advisory Board to provide assistance to the Center in developing policies for research and education. This Advisory Board will meet for the first time in summer 1989.

³⁰ The Charter indicates that "[t]he Director's office shall be maintained at Montana State University . . . as required by the enabling federal legislation." Charter at 1 (1985). This is a misstatement. The organic federal law requires that a state's water center be established at the land grant institution "or at some other institution designated by act of the legislature of the State concerned." 42 U.S.C. § 10303(a) (1988).

³¹ Charter at 1.

³² *Id.* at 2.

The Center's most recent five-year research plan extended from 1982 to 1987. For the period, the Center committed itself to research activities in six areas:

1. Assist in developing a comprehensive state water resources management plan including benefits and costs to agriculture, industry, energy, and recreation.
2. Assist in the formulation, development, and operation of a state water resources data collection and service center.
3. Develop cost effective methods and incentives for greater conservation of water in agriculture, industry, and energy.
4. Develop new and improve current methodologies for assessing minimum stream flow requirements for all activities dependent on surface water and risks associated with different levels of flood mitigation and protection.
5. Assist in developing a state plan for management and protection of groundwater and surface water.
6. Assist in developing methodology for rapidly identifying pollutants, establishing their sources, and predicting their level of toxicity in surface and groundwaters.³³

In a recent year (1987), Montana's Water Center had five research projects underway.³⁴ Six publications also resulted in that year from work that had been funded by the Water Center.³⁵

³³ WATER RESEARCH IN MONTANA: 1981 ANNUAL REPORT OF THE MONTANA WATER RESOURCES RESEARCH CENTER (Feb. 1982). In their 1982 evaluation of Montana's Water Center, USGS evaluators concluded that "[t]he seven [sic] problem categories in the Five-Year Plan are so broad as to be nearly meaningless in guiding water research in Montana." For additional results of this evaluation, see USGS, AN EVALUATION OF THE MONTANA UNIVERSITY SYSTEM WATER RESOURCES CENTER (Apr. 1986).

³⁴ The five projects are: Role of Mysis and Zooplankton in Regulating Phytoplankton Populations, Pathways of Metal Contaminant Transport in the Clark Fork River, Groundwater Development Potential of Abandoned Underground Mines, Sediment Reduction by Livestock Grazing Management, and Water Quality Modeling for a River Ecosystem. FISCAL YEAR 1987 PROGRAM REPORT, MONTANA UNIV. SYSTEM WATER RESOURCES CENTER 4-19 (Aug. 1988).

³⁵ *Id.* at 23.

The budget for Montana's Water Research Center was approximately \$320,000 in FY 1989. This amount includes the basic USGS grant of \$105,130 and non-federal funding of \$215,192 (which includes \$88,302 in indirect cost allocation). The staff of the Center is 1.55 FTE's.

Chapter 2:

Characteristics of Water Resources Research Centers

The water resources research institutes or water centers were initially very similar in their organization and programs. The authorizing legislation and subsequent modifications of the federal act have provided the states with general operational objectives, but the programs and organizational structures are almost exclusively a state/university function. To a large extent, the water institutes are a reflection of the financial and political support they have received within their respective states and universities.

This section of the report provides a general summary of important characteristics of the institutes with special reference to some institutes with unique or outstanding characteristics.

A. Organization and Structure

Most institutes are located within the university structure to allow maximum flexibility and operation within a broad range of academic disciplines. Over half of the institutes are directly responsible to the Vice-President of Research or the Dean of the Graduate School of their respective universities. This somewhat neutral position within the university also provides efficiency in responding to program opportunities and facilitating interdisciplinary research. Sixteen universities have placed their institutes within a particular college or academic program; seven institutes are located within an engineering college or department and the others are placed in agriculture and natural sciences, agricultural experiment stations, life sciences and environmental studies.

A number of universities have placed the water research institute within an "umbrella" organization of research institutes. In this arrangement, the water institute may retain its identity as a separate program but it can gain efficiency and strength through its association and sharing of resources with other research programs. Among a number of examples, the programs at Utah, Alaska and Pennsylvania are particularly interesting. The Utah Center for Water Resources Research is joined with the Utah Engineering departments and the Cooperative Fisheries Research Unit. Collectively these programs develop the overall program of the Water Research Laboratory. The resulting program involves a large staff and a total research expenditure of approximately 6 million dollars annually. Alaska has also joined several related interests to form the Institute of Northern Engineering--a research arm of the School of Engineering. The Water Research Center, the Engineering Research Center and Transportation Research Center maintain their

individual identities but gain administrative support as a single institute. Pennsylvania has organized an Environmental Resources Research Institute consisting of five research centers devoted to water, land, air, remote sensing and hazardous and toxic wastes. As in the programs at Utah and Alaska, the five centers gain through shared facilities and resources. The arrangement facilitates interdisciplinary research opportunities and programs. In each of the above examples, the research programs have apparently benefited through their association with the other programs.

B. Staff and Facilities

Most water institutes are staffed by a part-time director and one or more part-time clerical staff. Institute directors are usually full-time faculty who also have teaching and research responsibilities. In many instances the director is assisted by an associate or assistant director who also has other university obligations. However some universities have appointed full-time directors and in some universities the water center staff includes full-time administrative assistants and technical personnel who are involved in research, data management and information transfer activities.

The numbers of staff assigned to or associated with the institutes are shown in Figure 2. In addition to the staff with direct institute employment we asked the institutes to identify the number of researchers involved in their water center programs but not employed by the institute. Although inconsistent in their answers to the question, the institutes indicated a wide range from a few to more than 100 researchers involved on an annual basis.

In addition to research faculty and staff, some institutes employ specialists in the fields of communication, technology transfer, and data management. These individuals play an important role in the water center programs including the production of newsletters and special informational publications, organizing and conducting conferences and workshops, and maintaining library and data management files.

The facilities available for institute activities are also highly variable and dependent on the role of the institute in the state's water resources program. Most institutes are housed in faculty offices or in a special department office that sometimes includes a conference and/or library facilities. Almost one-third of the institutes reported having laboratory facilities associated with their program. Figure 3. provides a general survey of the number of institutes with these various facilities.

FIGURE 2: WATER RESOURCES CENTER STAFFING (Numbers of institutes reporting staff numbers within listed ranges.)				
Staff Type	Number of Full-Time Equivalents			
	.5-1.0	1.1-5.0	5.1-10	>10
Professional & Support Staff	19	16	9	8
Researchers ^a	7	6	7	10
a - Researchers associated with centers whose base salary paid by another department or agency				

FIGURE 3: WATER RESOURCES RESEARCH CENTER FACILITIES (Numbers of institutes reporting these characteristics)				
OfficeSpace (ft2)		Library	Laboratory	Conferences
<500	16	Yes 26	Yes 16	Yes 29
500-1000	10	No 28	No 38	No 25
1000-10,000	17			
>10,000	3			

C. Funding

The Water Resources Research Act of 1964 and subsequent federal legislation has provided each institute an annual funding allotment. Although the legislation has authorized considerably more, the annual allotment appropriated for each institute has increased only slightly from an initial \$75,000 per year to current level of \$105,130 per year. Under current law the institutes are required to match each federal dollar with two non-federal dollars.

Despite the relatively low federal funding most state institute budgets have grown through state appropriations, university funding and extramural contracts and grants. Figure 4 provides a tabulation of the revenues for the 40 institutes that responded to our survey.

In our survey questionnaire we asked the institutes to provide data on their revenues for the most recent fiscal year. The data we received is for variable periods ranging from fiscal year 1987 to fiscal year 1989. In some cases the institutes reported their estimate of an average fiscal year while others provided exact data. Finally, some institutes reported funds used for matching the federal allotment grants including waived indirect costs; others reported only hard dollars. Because of these differences a direct comparison between institutes would be inaccurate. However the data do provide a general indication of the range and sources of funding received by the institutes.

Among the 40 institutes responding to our survey, two reported an annual revenues of greater than two million dollars and six had budgets of \$1 to \$2 million. The majority of institutes (25) reported budgets ranging from \$200,000 to \$500,000 and the remainder (6) reported an annual budget of \$200,000 or less. In several instances the reported budget consists of the \$105,130 federal allotment and the non-federal matching funds.

A median budget of \$523,000 was calculated using the data as provided by the institutes. All institutes in the first quartile reported budgets of \$1 million or more while institutes in the last quartile had budgets of \$315,000 or less. The Montana Water Resources Center ranks in the fourth quartile although its exact position in the ranking cannot be determined because of the inconsistent manner in which institutes responded to our survey. Among the neighboring Rocky Mountain States responding to our survey, Montana's water center budget is among the lowest.

FIGURE 4: WATER RESOURCES RESEARCH CENTER REVENUES

STATE	TOTAL REVENUE	FEDERAL SOURCES	STATE SOURCES	UNIVERSITY SOURCES	OTHER
Alaska	1,000,000	600,000		300,000	
Arkansas	513,643	56,000	76,503	85,622	125,885
California	1,284,130	35,000		1,121,000	23,000
Colorado	542,130	275,000		162,000	
Connecticut	296,898		141,829		49,939
Delaware	297,847			174,717	
Florida	335,000	30,000		25,000	170,000
Hawaii	1,274,000	212,000		695,000	461,000
Illinois	599,170	74,000		130,040	290,000
Indiana	267,009			161,880	
Iowa	814,890		250,000	210,260	249,500
Kansas	332,973			227,843	
Kentucky	139,000			34,000	
Louisiana	150,261	24,435	16,000		4,723
Massachusetts	727,470	16,500		184,284	421,557
Michigan	796,105	110,000		207,185	373,920
Mississippi	701,651	388,552	136,499	58,079	13,391
Missouri	118,256			13,126	
Montana	320,322		15,000	200,192	
N. Hampshire	328,389			111,641	111,618
N. Mexico	1,411,000	561,000	385,000		360,000
New York	700,000	50,000	300,000	150,000	95,000
N. Carolina	905,000	150,000		450,000	200,000
N. Dakota	389,000			184,000	100,000
Oklahoma	772,202	123,410		543,662	
Oregon	164,130			59,000	
Pennsylvania	2,015,130	670,000		650,000	590,000
Puerto Rico	168,388			168,388	
S. Carolina	345,272		59,000	181,142	
S. Dakota	267,000	60,000	56,000		46,000
Tennessee	173,453	29,000		24,323	15,000
Texas	355,637		228,507		22,000
Utah	3,581,834	933,000	1,487,079	45,783	1,010,877
Vermont	537,130	200,000		40,000	192,000
Virgin Isle	204,330			99,200	
Virginia	1,100,000	50,000	450,000	495,000	
Washington	533,326		109,386		318,810
W. Virginia	315,000			210,000	
Wisconsin	1,474,050	1,054,420	193,100	39,000	82,400
Wyoming	1,593,530	463,717	689,566	55,692	279,425

NOTES:

1. Total revenue includes \$105,130 provided by USGS § 104 funds.
2. Federal Sources=federal grants/contracts received in addition to USGS § 104 funds.
3. Other=funds received for grants/contracts from state agencies, local government, and private sources including foundations.
4. Some institutes reported grants/contract revenues that apply to 2 or 3 year periods. Thus, the reported values are not always for a single fiscal year.

The major sources of funds in addition to the federal allotment grant are state appropriations and university funds. Ten institutes reported receiving state appropriations in addition to university funds. These state appropriations ranged from 15,000 in Montana to highs of 690,000 in Wyoming and \$1.5 million in Utah. Most states did not report direct state appropriations but they did report a wide range of university funding. A comparison of university funding levels is probably confounded by the variable responses we received from the institutes. In some instances, the institutes reported matching funds and waived indirect costs as university funds.

Federal grants and contracts make up an important part of the extramural funding received by most institutes. Twenty-three of the 40 responding institutes reported receiving federal dollars in addition to the USGS 104 funds. Thirteen institutes reported federal funding in excess of 100,000 and several larger institutes had federal grants and contracts ranging from \$400,000 to \$900,000. In addition to the federal sources, 24 states reported receiving funds for contracts with state agencies and private firms (listed in the "Other" column in Figure 4). Only Utah and Michigan reported receiving substantial support from private foundations. Although some foundation support may not have been reported to us in this survey, it is apparent that foundations are not presently a major funding source for institutes of water research.

Institute budgets may vary widely from one year to the next. Some institutes reported in one year the revenues from grants and contracts continuing for several years. Thus, the values reported here are only an indication of funding potentials and should not be viewed as an exact comparison of individual institute programs.

D. Expenditures

Another important characteristic of the institutes is how they allocate their total budget for research, administration, information transfer and education. Figure 5 provides a summary of the expenditures reported by the institutes. There were some inconsistencies in the response from various institutes but the data indicates approximate expenditures for the major categories.

Administrative costs range between 6 percent and 55 percent of the institute budgets with an average of 20 percent. Some institutes considered information transfer activities as part of their administrative costs. Research expenditures accounted for an average of 68 percent of the institute budgets with a range of 24 to 94 percent.

FIGURE 5: WATER RESOURCES RESEARCH CENTER EXPENDITURES						
State	Expenditures on Research	% on Research	Expenditures on Admin.	% on Admin.	Expenditures on Info. Transfer	% on Info. Transfer
Alaska	\$880,000	88%	\$100,000	10%	\$20,000	2%
Arkansas	335,478	65%	108,662	21%	5,000	1%
California	739,130	58%	245,000	19%	25,000	2%
Colorado	447,000	82%	31,710	6%	63,420	12%
Connecticut	212,650	72%	80,213	27%	4,035	1.4%
Delaware	203,722	73%	60,325	22%	15,800	5%
Florida	285,000	85%	20,000	6%	30,000	9%
Hawaii	1,217,000	83%	150,000	10%	57,000	4%
Illinois	390,000	65%	40,000	7%	170,000	28%
Indiana	80,129	76%	20,000	19%	5,000	5%
Iowa	764,590	94%	45,300	6%	5,000	6%
Kansas	258,488	78%	74,485	22%	-0-	-0-
Kentucky	67,300	64%	20,000	19%	17,700	17%
Louisiana	56,549	38%	41,318	27%	52,394	35%
Massachusetts	490,087	67%	84,063	12%	53,320	7%
Michigan	188,000	24%	278,105	35%	30,000	4%
Mississippi	574,203	96%	70,126	10%	57,3228%
Missouri	66,229	63%	28,950	28%	9,951	9%
Montana	144,261	45%	78,513	25%	49,448	15%
N. Hampshire	281,585	86%	41,804	13%	-0-	-0-
N. Mexico	876,000	79%	1,115,000	11%	113,000	10%
New York	275,000	39%	150,000	21%	275,000	39%
N. Carolina	650,000	72%	140,000	16%	60,000	7%
N. Dakota	307,153	79%	72,204	19%	-0-	-0-
Oklahoma	519,891	67%	252,311	33%	-0-	-0-
Oregon	80,000	49%	77,130	47%	7,000	4%
Pennsylvania	1,657,130	82%	290,000	14%	68,000	3%
Puerto Rico	79,292	75%	20,000	19%	5,838	6%
S. Carolina	143,836	65%	77,000	34%	2,000	1%
S. Dakota	163,000	67%	35,000	13%	5,000	2%
Tennessee	127,091	73%	46,362	27%	-0-	-0-
Texas	180,706	51%	156,521	44%	18,410	5%
Utah	1,316,324	37%	491,428	14%	58,742	2%
Vermont	92,630	88%	10,000	10%	2,500	2%
Virgin Isles	147,210	72%	39,780	20%	17,340	8%
Virginia	495,000	45%	105,000	10%	430,000	39%
Washington	244,405	55%	129,386	29%	30,000	6%
Wyoming	1,071,756	67%	411,109	26%	110,665	7%

The information transfer category accounted for an average of 9 percent of the total institute budgets although four of the 40 reporting institutes reported zero dollars allocated for this purpose. Several states (Illinois, New Mexico, Virginia) reported information transfer expenditures of greater than \$100,000/year. Montana was considerably above the average in this category with a reported expenditure of 15 percent for information transfer activities.

E. Indirect Costs

Indirect costs or overhead is charged by universities for most research grants and contracts. The indirect costs are necessary to provide the facilities and services required to conduct research. In some instances, however, the universities may waive these charges as their contribution to jointly shared programs.

A U.S. Geological Survey report has reported that 39 universities waived indirect costs on Section 104 grants and that 15 universities required the payment of indirect costs.³⁶ Those universities waiving the indirect costs are permitted to deduct these costs from the required non-federal match. Those universities that charge indirect costs must deduct the costs from the Section 104 allotment, thus reducing the amount of funds available for research.

Our survey asked the universities how indirect costs were used when charged against research grants and contracts. In a majority of universities, the indirect costs are administered by the university administration or divided between the university and the water center. A few universities returned the charges directly to the investigator or to the water center. Three states deposited the funds in the general fund.

There appears to be an advantage to waiving the indirect costs for a cost-sharing program such as the Section 104 grant program. The Montana Water Resources Center reported that indirect costs for this program are waived by the university.

F. Program Emphasis

Each water resources research institute promotes research on water related problems and issues important to their state and region. Five-year plans developed by each institute in conjunction with their statewide advisory committee are used to establish research priorities.

³⁶ USGS, EVALUATION OF WATER WATER RESOURCES RESEARCH INSTITUTES (Open-File Rep. 88-85, 1988).

The water research programs funded by Section 104 grants usually average four or five projects per institute per year. The projects cover a wide range of problems but some issues have clearly received the most attention. According to the recent NAWID report,³⁷ the most common categories for research were: (1) water cycle investigations (precipitation, streamflow and runoff, soil water, ground water, lakes and estuaries) and (2) water quality management (contaminant identification, sources, fate and effect of pollutants, water and wastewater treatment). Groundwater is receiving increasing attention across the nation with special attention given to detection and control of contaminants such as pesticides, industrial wastes, nitrates and heavy metals.

Most institutes do not attempt to focus on single issues but rather maintain wide range of research interests according to their available expertise and state needs. Occasionally, however, several faculty have formed research teams to study a specific issue. These efforts may be started with relatively low funding from the institute but expand and grow with extramural funding. NAWID has provided examples of successful projects of this nature.³⁸

- Texas - Improved Irrigation Systems.

The Institute funded research projects that assisted in the development of the Low Energy Precision Application (LEPA) irrigation system. The institute then provided news reports, publications and demonstrations to encourage adoption by agriculture. The system has proven to be 99% efficient resulting in a 25% saving of water and energy. Research costs over a five-year period were \$63,041 federal and \$112,336 state. .

- Utah - Intermittent Sand Filtration.

Investigators obtained a \$13,000 grant to study the application of intermittent sand filters for use in wastewater and drinking water treatment. From the initial successful beginning, the U.S. Environmental Protection Agency financed more than \$500,000 in research to evaluate the performance of systems in small communities and to further refine their operations. The additional research has improved the methods, resulting in effective low-cost systems for culinary water treatment around the world. The initial seed money for the project was multiplied by 50-fold

³⁷ NAT'L ASS'N WATER INST. DIRECTORS, RESEARCH PROJECTS OF THE WATER RESOURCES RESEARCH INSTITUTES IN FISCAL YEAR 1987 (1988)

³⁸ *Id.*

and saved many times that amount in the cost of water treatment worldwide.

- Iowa - Nitrates and Pesticides in Groundwater.

The Iowa Water Resources Research Institute has funded investigations of nitrate movements in the soil and its incorporation into plant tissues. The work has demonstrated that in many situations as much as 50% of the applied nitrogen is not used by the plant. Much of this excess is leached into groundwater. Leaching can be reduced through modification of the timing of fertilizer application.

Iowa farmers spend \$400 million per year on nitrogen fertilizers. The researchers believe their improved management schemes can reduce leaching by 10% and save farmers an estimated 40 million/year.

Cost of the project: \$17,400 federal funds and \$254,560 state funds.

G. Information Transfer

The dissemination of research results and general water resource information is a major part of the institute mission. The program was initially styled after the land grant university program that has been so successful in making agricultural research results available to the agricultural community. The information transfer program is important also in helping the general public and government officials to learn about and understand the value of the institute program.

As in other parts of the program, some institutes have placed a major emphasis on information transfer activities while some other institutes have invested very little effort or resources. An increasing number of institutes are focusing on the application of research results and documenting the economic value of their programs. All 54 institutes have documented their successful research projects in the 1988 NAWID *Guide to the National Water Research Program*.

Information transfer is a broad category of activities intended to assist other researchers with current information, to provide technology to various water user groups (e.g., irrigators), to guide policy makers and government officials, and to help teachers and the general public to understand new and developing information about water resources.

Some general examples of information transfer activities conducted by the institutes are described below:

- Publication and distribution of research results and the presentation of results at scientific conferences. The greatest value of this activity is for other researchers.
- Conduct conferences and workshops. These activities are usually focused on specific problems or issues with special efforts to organize a body of knowledge or to assist user groups in understanding a new technology.
- Develop special library collections of water resources research publications including computerized data files and bibliographies. The Institutes with these capabilities become a focal point for water resource information within their states and regions. Some institutes are able to access several national and regional water resource data bases.
- Publication and distribution of newsletters, public information brochures, and special educational bulletins pertaining to current water resource issues. Some institutes have also prepared video tapes as a method to assist in the teaching and application of new information.
- Special education programs including short courses for a select group of individuals (e.g., wastewater treatment plant operators), and in-service training programs for government officials.

Information transfer programs can be expensive and often requires the services of specialists in other fields such as communications and data management. Larger institutes have employed staff to conduct information transfer activities while others have often used existing services such as the Cooperative Extension Service to disseminate information.

Several institutes are recognized for their exceptional information transfer activities. Virginia has pioneered the program among the states and continues to place a major emphasis on developing new techniques for disseminating information. The Virginia center's information transfer program includes a data base providing streamflow and weather data, a data base describing current water-related research in the state, an annual conference for exchange of information by researchers, and presentations to citizens' groups interested in groundwater protection, water conservation, or the state's water resources generally. The center has three publications series that are peer-reviewed and a monthly newsletter with a circulation of 6500.

As part of its educational program, the center offers publications, computer games, and slide shows aimed at adult or middle school audiences. The center has conducted a citizens' awareness program in groundwater protection including a groundwater protection handbook for local government officials.

The Wyoming center is a leader in the development of computerized data management including a computerized bibliography of water resource information for the state and the region.

H. Evaluation of Institute Programs

The Water Resources Research Act of 1984 mandated an onsite evaluation of each water resources research institute.³⁹ The evaluations were conducted to determine if the quality and relevance of an institutes water resources research and its effectiveness warranted its continued support in the national interest. The evaluations, which were conducted in 1985-1987 were summarized in a report by the U.S. Geological Survey⁴⁰. The report discussed the following 12 factors that evaluators found to be common among the most effective institutes.

1. State Funds. An appropriation of state funds for discretionary support of research projects in addition to the federal funds received from the Geological Survey. This expansion of the institute resources was found to be a key element in enabling institutes to better mobilize academic expertise in addressing the state water problems. Ten state institutes received such support.

2. Extramural Funds. At least 30 institutes demonstrated a clear capacity for generating research support from various federal agencies, private industry and other sources.. The ability to generate funds was dependent on the institution's administrative policy and the director's ability to pursue the funding. The successful institutes facilitate and coordinate research funding which is conducted by faculty in various disciplines. These water centers are recognized as the focal point for water resources research in their particular state.

3. Director's Position. Adequate time must be allocated for the director to administer the institute. A one-half time appointment, with the remainder of time in closely related matters, was considered to be a productive arrangement. The director's ability to interact effectively within the academic

³⁹ Pub. L. No. 98-242 requires that evaluations be conducted by a team of five specific persons: an employee of the Department of Interior, a director of another water research institute, a university faculty member, a state or local water resources employee, and a private citizen.

⁴⁰ *Supra* note 36.

environment and with the spectrum of water-related interests outside the academic environment was an important key to institute success.

4. Administrative Status. The placement of an institute within the university's organizational structure was not a significant factor if the director had freedom, ability and motivation to act within a broad range of interests within and outside the university.

5. Position Support. Thirty-nine of the universities at which institutes are located pay all of the salary of at least the director and several larger institutes have funded positions for other professionals. Use of the Section 104 funds for the director's salary reduces the research opportunities and handicaps the institute program .

6. Advisory Structure. An external advisory committee made up of agencies and interests external to the university is important in terms of constituency building, information transfer, and potential extramural funding. An internal or academic policy advisory committee is important for peer review and establishing policy.

7. Peer-Review Process. Peer review to assure research quality must be encouraged for research proposals as well as research publications.

8. Statewide Involvement. Institutes must make special efforts to involve all research institutions in its program.

9. Information Transfer. Evaluators encouraged institutes to expand their capabilities and to use existing public information services wherever possible.

10. Graduate Programs. A large number of graduate students are supported by institute programs. Institutes are encouraged to structure their project funding to allow completion and continuity of graduate student projects.

11. Multidisciplinary Research. Interdisciplinary research is encouraged, especially where related projects are supported in different disciplines with benefits to the participants and the overall outcome of their work.

12. Waiver of Indirect Costs. Most institutes are allowed to waive indirect costs and thus have a greater proportion of funds available to support specific projects. Some universities return a portion of indirect costs to their water centers but charging the indirect costs does detract from the program opportunities.

Chapter 3:

Characteristics of Graduate Programs in Water Resources

Research sponsored under the Water Resources Research Act is integrally tied to higher education. The statute contemplates the placement of the water centers at state universities--preferably the state land grant college. The statute also emphasizes the need to provide educational opportunities for university students to participate in water research activities.

Because of the important relationship between water research and education, the authors undertook a survey of colleges and universities in the United States that offer a specific graduate program in water resources management (whether or not the college or university was also the site for the state's graduate center). The authors first identified the 26 colleges and universities that appeared to offer a specific graduate program in water resources. Each of these institutions was contacted for a current graduate catalog and any additional information about the water resources program. When this report was concluded, 20 institutions had provided information about their programs. Seven of these programs are located in the western states, seven are in the Midwest, four are in the South, and two are located in the East.

This chapter presents general, comparative information about the graduate-level, water resource management programs at these 20 institutions. These programs are broken down into major categories according to their emphasis. More detailed abstracts on each of these centers appears as Appendix C.

As Montana decisionmakers determine the future directions concerning the state's water center, the type of educational opportunities afforded graduate students should be a major concern. Of course, a formal educational program in water resources is not necessary to provide educational opportunities for students; such opportunities may also be available in traditional departments such as civil engineering, biology, and others. Formal programs in water resources, however, do allow the integration of the numerous disciplines that are relevant in the management of this resource.

A. General Characteristics of the Water Resource Management Programs

After reviewing information on the water resource educational programs at the 20 universities, we developed a classification system in an effort to understand the similarities and differences among these programs. The development of typologies is always a difficult task, and this was no different. The authors were limited in most cases to printed material about these various programs as the available time and resources did not permit personal or telephone interviews with knowledgeable people at these institutions. Gradations in the programs were often subtle. Still, the following information does indicate the general approaches being taken by some of the nation's major universities to water resources education at the graduate level.

Of the programs we surveyed, there appear to be four general types of graduate-level water resource programs. They are programs that are engineering-oriented, programs that are a part of other professional programs, interdisciplinary programs, and programs with an environmental policy sciences approach. Figure 6 provides information on the general characteristics of these programs. Figure 7 arranges these programs according to our typology.

B. Engineering-Oriented Programs

The most common type of water resources program we found were engineering-oriented and usually housed the university's college or department of civil engineering. Eight of the programs we surveyed fall into this category (University of California, Davis; University of Kansas; University of Kentucky; University of Oklahoma; Utah State University; Vanderbilt University; University of Washington; and Washington State University).

Even these engineering-based programs have their differences. Most of them offer a water resources courses as part of a traditional civil engineering curriculum. At least two of the schools offered an "environmental engineering" emphasis.

The more traditional civil engineering program includes numerous courses in hydrology and hydraulics. The student is encouraged to develop a strong background in quantitative methods and systems analysis. The emphasis is on physical features (*i.e.*, hydrogeology) and on building things whether they be municipal water distribution systems, irrigation systems, or water and wastewater treatment facilities. Utah State University's Civil and Environmental Engineering Department provides one of of the strongest programs in water resources engineering. Other institutions offering similar

FIGURE 6: GENERAL CHARACTERISTICS OF WATER RESOURCES PROGRAMS				
Institution	Location of Program	Degrees Offered	No. Faculty	Tuition (\$)
<i>Western States:</i>				
Univ. of Arizona	Dept of Hydrology & Water Resources	MS, PhD	21	R: 598/sem NR: 2314/sem
Univ. of Calif. (Davis)	Civil Engineering Dept	MS, ME, PhD, DE	31	R: 439/qtr NR: 1801/qtr
Colorado State Univ.	Water Resources Research Institute	MS	Depends on student emphasis	R: 1066/sem NR: 5807/sem
Utah State Univ.	Dept of Civil & Environmental Engineering	ME, MS, CE, PhD	52	R: 286/qtr NR: 784/qtr
Univ. of Washington	Dept of Civil Engineering	MS(CE), MSE, MS, PhD	15	R: 2595/yr NR: 6468/yr
Washington State Univ.	Civil & Environmental Engineering	MS(CE), MS(EE), MS(GE), PhD	15	R: 945/sem NR: 2346/sem
Univ. of Wyoming	Water Center in conjunction with academic dep'ts	MS	Depends on student emphasis	R: 417/sem NR: 1303/sem
<i>Midwestern States:</i>				
Iowa State Univ.	Water Resources Interdepartmental Program	MS, PhD	Depends on student emphasis	R: 2020/yr NR: 5720/yr
Univ. of Kansas	Dept of Civil Engineering	MS	13	R: 705/sem NR: 1660/sem
Univ. of Michigan	Interdepartmental Water Resource Management Program	MS, PhD	5 in core; program	R: 2257/sem NR: 4723/sem
Univ. of Oklahoma	School of Civil Engineering & Environmental Science	MS(CE), MES, PhD, DE	15 (entire school)	R: 50.80/hr. NR: 162.80/hr
Univ. of Wisconsin, Green Bay	Environmental Science & Policy Program	MS	42	R: 1005/sem NR: 2889/sem
Univ. of Wisconsin, Madison	Water Resources Management Program	MS	53	R: 1309/sem NR: 3881/sem
Univ. of Wisconsin, Stevens Point	College of Natural Resources	MS	41 in college	R: 1015/sem NR: 2898/sem
<i>Southern States:</i>				
Duke Univ. (NC)	School of Forestry & Environmental Studies	MEM, MA, MS, PhD	6	4240/sem

Univ of Georgia	School of Forest Resources	MS, MFR, PhD	38 in School; 1 in water	R: 1770/yr NR: 4689/yr
Univ. of Kentucky	Civil Engineering Dept	MS(CE), MCE, PhD	21	R: 750/yr NR: 2250/yr
Vanderbilt Univ. (TN)	Civil Engineering Dept	MS, ME, PhD	13	\$480/sem hr
<i>Eastern States:</i>				
Johns Hopkins Univ. (MD)	School of Hygiene & Public Health	MHS, MS, DPH, DS, PhD	9	3000/qtr 12000/yr
State Univ. of New York, Syracuse	College of Environmental Science & Forestry	MS, PhD	20	R: 90/hr 1075/sem NR: 156/hr 1868/sem

NOTES:

CE	Civil Engineer (2-year professional degree)
DE	Doctor of Engineering
DPH	Doctor of Public Health
DS	Doctor of Science
MCE	Master of Civil Engineering
ME	Master of Engineering
MEM	Master of Environmental Management
MES	Master of Environmental Science
MFR	Master of Forest Resources
MHS	Master of Health Science
MS	Master of Science
MSE	Master of Science in Engineering
MS(EE)	Master of Science in Environmental Engineering
MS(GE)	Master of Science in Geological Engineering
MS(CE)	Master of Science (Civil Engineering)
PhD	Doctor of Philosophy
R	Resident tuition
NR	Nonresident tuition

FIGURE 7: TYPE OF WATER RESOURCES GRADUATE PROGRAM	
Institution	Areas of Concentration
<i>Engineering Emphasis:</i>	
University of California, Davis	Hydrology Hydraulics & fluid mechanics Water resource systems planning & design
University of Kansas	Water resources engineering Water resources science
University of Kentucky	Water resources engineering
Utah State University	Hydrology Water resources engineering
University of Washington	Environmental engineering Hydraulic engineering (hydrology, hydrodynamics, coastal engineering) Applied sciences Environmental engineering
Washington State University	Hydrology Hydraulics Geohydrology Hydropower Water quantity Water quality
<i>Environmental Engineering Emphasis:</i>	
University of Oklahoma	Groundwater quality management Water resources Water quality management
Vanderbilt University	Water quality engineering Water resources engineering Solid & hazardous waste engineering Environmental science
<i>Part of Other Professional Curriculum:</i>	
Duke University (Forestry)	Hydrologic processes Quantitative analysis Decisionmaking and management
University of Georgia (Forestry)	Forest water resources
Johns Hopkins University (Public Health)	Environmental health Wastewater treatment
University of Wisconsin, Stevens Point (Natural Resources)	Watershed management Limnology Fisheries Water chemistry
<i>Interdisciplinary Programs (Decentralized):</i>	
Colorado State University	Water resources planning
University of Wyoming	Technical hydrology Natural resource economics/law Water quality
<i>Interdisciplinary Programs (Centralized):</i>	
Arizona State University	Hydrology Water resources administration

Iowa State University	Water quality Water quantity Water resource economics & institutions
University of Michigan, Ann Arbor	Water resource management Water resource science
University of Wisconsin, Madison	Biological & physical sciences Engineering Law & social sciences
<i>Environmental Policy Sciences Emphasis:</i>	
State University of New York, Syracuse	Institutions Information systems Policy analysis Science
University of Wisconsin, Green Bay	Environmental science Environmental policy & institutions

programs include University of California, Davis; University of Kansas; University of Kentucky; University of Washington; and Washington State University.

The University of Oklahoma and Vanderbilt University are two institutions whose water resource programs appear to place more emphasis on "environmental engineering." Though offering a solid curriculum in some areas, these schools appear to adhere to a "water systems" approach. Thus, courses are offered in "river, lake, and reservoir engineering" and "water resource systems analyses." In the case of the University of Oklahoma, one of the degrees offered is a master of environmental science.

C. Programs Part of Other Professional Curriculum

Several institutions offer water resource programs that are specialized units within other professional schools. Four of the universities surveyed for this report fall into this category. Johns Hopkins' water and wastewater treatment concentration within its School of Hygiene and Public Health is perhaps the best example. The forestry programs offered by Duke University and the University of Georgia offer concentrations in forest water resources. The water resources program at the University of Wisconsin, Stevens Point, is found in the College of Natural Resources. That program has an ecological emphasis with course concentrations in such areas as limnology, fisheries, water chemistry, and watershed management.

D. Interdisciplinary Programs

Six of the surveyed institutions have interdisciplinary water resource programs. Actually, these programs are of two types--what we call "decentralized" and "centralized." While these programs allow a student to broaden his or her background with experiences in other academic fields, they appear to still require a solid grounding in the scientific and technical aspects of water resources.

Colorado State University and the University of Wyoming have interdisciplinary programs that can be described as "decentralized." A wide range of courses in the physical, biological, and social sciences are available to the student; and the program in both institutions is coordinated through the water center. Yet, no "core" courses are offered by the program; and the student (at least in the case of Wyoming) is actually attached to a single academic department. At Wyoming, the student's master's degree is awarded as a speciality option by the department with which he is affiliated. The water resources emphasis is noted on his or her transcript.

Arizona State University, Iowa State University, the University of Michigan, and the University of Wisconsin, Madison, have more centralized interdisciplinary programs. That means that in addition to the availability of courses in other departments, certain "core" courses are offered by the water resources program itself. Thus, for instance, Iowa offered three core interdisciplinary courses entitled "Water Resources I, II & III." These courses cover a range of physical, biological, and social science topics. Arizona offers a dozen courses in water resources administration covering such aspects as economics, quantitative methods, policy, and institutions.

Additionally, these "centralized" programs appear administratively more independent in their institutions with their own core faculty and greater jurisdiction over their students.

E. Environmental Policy Sciences Emphasis

Two of the programs we reviewed seem to be taking an almost fundamentally different approach to water resources education. For lack of a better term, these programs--at the State University of New York (Syracuse) and the University of Wisconsin (Green Bay)--are described as having an environmental policy sciences emphasis. The approach of these programs concerns the formulation and implementation of public policies affecting water and other natural resources. The programs also emphasize a systems approach--both in terms of ecological systems and policy development.

The Wisconsin program, for instance, allows the student to concentrate in such areas as ecosystems studies, quantitative methods and data analysis, institutions and institutional processes, methodology, and management (with an emphasis on organizational processes and decisionmaking).

The SUNY program is equally interesting. Basic core courses are required in environmental institutions, information systems, policy analysis, systems analysis, and the interrelationship of policy and science. The program is one area of concentration within the university's graduate program in environmental science. Other areas of concentration include urban ecosystems, environmental communications, among others.

F. Conclusion

Whether or not the typology we have developed is entirely accurate, it does illustrate the unique and rich variations to water resource education being practiced by colleges and universities around the United States. These programs should suggest different approaches Montana might consider in evaluating graduate educational opportunities in the field of water resources.

Chapter 4:

Recent Trends in Funding of Water Research

A. U.S. Geological Survey

1. Section 104 Program (Funding for Institutes)

As described in earlier discussion, the Section 104 program provides a basic grant of approximately \$105,000 to each of the 54 water centers. Each center must match the basic grant by twice the amount of non-USGS dollars.

Funding patterns taken from recent years allow a determination of how this money is utilized by the centers. All centers use the grant for administrative expenses, for information dissemination, and for research. Some centers use a portion of the USGS grant as "seed" money to attract other funds for research. Some centers use the money to participate to ongoing research supported by other sources.

A survey of research projects supported by Section 104 money in FY 1987 provides information on the research priorities of the nation's water centers.⁴¹ During FY 1987, Section 104 money was used to support 264 research projects. The number of projects supported by an institute ranged from two to eight. The mean number of research projects per institute was five; the mode (most commonly occurring number) was four.

The survey allows provides information on the research research priorities of the water centers using this money. First, the 264 grants were divided into ten research categories that have been developed by the Council on Water Resources Research (COWRR). Research was especially heavy in two categories: water cycle (including precipitation, streamflow and runoff, soil water, groundwater, lakes, estuaries) and water quality management (including contaminant identification, sources, fate and effects of pollutants, water and wastewater treatment). Figures 8 and 9 indicate the distribution of research projects by category, including the distribution of Montana's five research projects for the year.⁴²

⁴¹ *Supra* note 37.

⁴² For the Montana projects, see note 34, *supra*.

FIGURE 8: USE OF SECTION 104 GRANTS BY RESEARCH CATEGORY					
COWRR CATEGORY		US PROJECTS		MT PROJECTS	
01	Nature of Water	0	0%	0	0%
02	Water Cycle	54	21%	0	0%
03	Water Supply Augmentation & Conservation	14	5%	0	0%
04	Water Quantity Management & Control	10	4%	2	40%
05	Water Quality Management & Protection	150	57%	3	60%
06	Water Resources Planning	30	11%	0	0%
07	Resources Data	4	1%	0	0%
08	Engineering Works	2	1%	0	0%
09	Manpower, Grants & Facilities	0	0%	0	0%
10	Scientific & Technical Information	0	0%	0	0%
TOTAL PROJECTS		264	100%	5	100%

Source: NAWID (Sept. 88)(FY 87 grants)

FIGURE 9: USE OF SECTION 104 GRANTS BY SPECIFIC CATEGORY		
SPECIFIC CATEGORY	US PROJECTS	MT PROJECTS
Organic contaminants in groundwater	25	0
Contaminant transport in groundwater/groundwater flow models	15	0
Nitrate contamination of groundwater	9	0
Radon in groundwater	2	0
Trace & heavy metal contamination of water	18	1
Acid precipitation	10	0
Eutrophication & nutrients in surface waters	13	0
Bacteriological quality of natural waters	7	0
Water treatment	12	0
Wastewater treatment	20	0
Flood problems	5	0
Drought & water conservation	16	0
Water policy, law & economics	10	0

Source: NAWID (Sept. 88)(FY 87 grants)

Second, the research projects were divided into more specific categories related to specific water issues and problems of current concern. Some projects pertained to more than one category and, therefore, were listed several times. Figure 9 presents these more specific categories of research undertaken with Section 104 grants. A few grants in other categories are not listed in this figure. It should be noted, however, that Figure 9 does not indicate the amount of money spent on different categories of research--only the number of projects.

As can be seen, the nation's water centers place a heavy emphasis on two categories of research: groundwater [51 projects (19%) listed above] and water quality issues other than groundwater [80 projects (30%) listed above]. Water quantity projects (including drought and water conservation) and water policy projects are underemphasized. These might be areas of research that Montana's water center might wish to emphasize in future years.

2. Section 105 Programs (Competitive Grants)

As previously described, the Section 105 program provides competitive grants for research on water issues of national importance. Public institutions, profit and nonprofit entities, and individuals can apply. The grants have to be matched on a 1:1 basis. In FY 89, \$4.38 million was appropriated for these grants. In FY 88, the range of these federal grants was from \$24,130 to \$174,910. The median grant was approximately \$115,000 to \$119,000.

Over the last five years, 174 grants have been awarded under this program to recipients in 39 states; 35 were awarded in FY 89. Montana State University received three of these grants during the five year period. Figure 10 indicates the number of grants received for each of the 39 recipient states for FY 85 to FY 89. New Mexico, California, and Arizona have been particularly successful in receiving money under this program.

**Figure 10: Distribution of Section 105 Grants by State,
Fiscal Years 1985-89**

<u>State/Institution</u>	<u>FY85</u>	<u>FY86</u>	<u>FY87</u>	<u>FY88</u>	<u>FY89</u>	<u>Total</u>
Alabama.....						2
Auburn Univ.		1			1	
Alaska.....						2
Univ. of Alaska		2				
Arizona.....						12
Univ. of Arizona	1	2	2	3	4	
California.....						17
California Polytechnic State Univ.		1				
California Institute of Technology			1	1		
Orange Co. Water Dist.	1					
Stanford Univ.			1			
Univ. of California (unspecified campus)				3	1	
Univ. of California, Berkeley		1				
Univ. of California, Davis		1	2			
Univ. of California, Los Angeles		1	1			
Univ. of California, San Diego			1			
Univ. of California, Santa Cruz		1				
Colorado.....						9
Colorado State Univ.	1	2		2	1	
Colorado Water Resources Research Inst.			1			
Univ. of Colorado					2	
Delaware.....						3
Univ. of Delaware	1	1		1		
Georgia.....						3
Georgia Institute of Technology		1		1		
Georgia Tech Research Corp.			1			
Hawaii.....						1
University of Hawaii			1			
Illinois.....						5
CBI Industries		1				
Univ. of Illinois	1	1		1	1	
Indiana.....						3
Norte Dame			1			
Purdue Univ.	1					
Univ. of Indiana			1			
Iowa.....						1
Univ. of Iowa		1				
Kentucky.....						1
Univ. of Kentucky Research Foundation	1					
Louisiana.....						1
Louisiana State Univ.					1	
Maryland.....						5
Interstate Comm'n on Potomac River Basin						1
Johns Hopkins Univ.				1		

Univ. of Maryland			2		1	
Massachusetts						9
Massachusetts Institute of Technology	2	1	1		2	
Tufts Univ.		1				
Univ. of Massachusetts		1				
Woods Hole Oceanographic Institute		1				
Michigan						2
Michigan State Univ.		1		1		
Minnesota						3
International Tree Corp.	1					
Univ. of Minnesota				2		
Missouri						2
Univ. of Missouri				1	1	
Montana						3
Montana State Univ.		1	1	1		
Nebraska						5
Univ. of Nebraska	2	1	1	1		
New Hampshire						1
Univ. of New Hampshire				1		
New Jersey						5
New Jersey Institute of Technology					1	
Princeton Univ.	2				1	
Rutgers				1		
New Mexico						14
Calyxes Research & Development Corp.	1	1				
NM Institute of Mining & Technology	1				1	
New Mexico State Univ.		3		5		
NM Water Resources Research Institute			1		1	
New York						8
Cornell Univ.		1	1	1	1	
Eastman Kodak Co.					1	
State Univ. of New York			1	1		
Suffolk Co. Dep't of Health Services		1				
North Carolina						6
North Carolina State Univ.	1		2	2	1	
North Dakota						1
North Dakota State Univ.			1			
Ohio						2
Ohio State Univ. Research Foundation	1			1		
Oklahoma						2
Oklahoma State Univ.					1	
Univ. of Oklahoma		1				
Oregon						7
Oregon Graduate Center	1			1	1	
Oregon State Univ.			2			
Portland State Univ.		1			1	
Pennsylvania						7
Pennsylvania State University	1	1	2	1	1	
Univ. of Pittsburg			1			
South Carolina						1
SC Dep't of Health & Environ. Control					1	
South Dakota						2
South Dakota State Univ.		1				
Univ. of South Dakota					1	

Tennessee							2
Univ. of Tennessee			1				
Vanderbilt Univ.		1					
Texas							6
North Texas State Univ.	1						
Texas A&M Research Foundation						1	
University of Texas, Austin	1	1	2				
Utah							8
Utah State Univ.		3		2	3		
Virginia							5
Univ. of Virginia				1			
Virginia Polytechnic Institute		1	1	1	1		
Washington							2
University of Washington	1	1					
Wisconsin							1
University of Wisconsin, Madison		1					
Wyoming							1
Univ. of Wyoming					1		
TOTAL (39 states represented)	24	43	34*	38	35	174	

* One grant unidentified by state.

Source: U.S. Geological Survey, *Water Resources Research Grant Program Project Descriptions*, Fiscal Year 1985, Open-File Report; Fiscal Year 1986, Open-File Report 86-548; Fiscal Year 1987, Open-File Report 88-179.

FIGURE 11: RESEARCH UNDERTAKEN WITH SECTION 105 FUNDS				
Fiscal Year 1985				
Topic	Projects	Federal funds	Matching funds	Total funds
Groundwater management	8	\$697,324	\$848,130	\$1,545,454
Surface water management	7	736,847	743,544	1,480,391
Systems operation/planning	2	168,445	169,537	337,982
Irrigation management	3	290,518	326,416	616,934
Desalination/reuse	2	292,770	302,379	595,149
Economic/legal/institutional	1	47,881	47,882	95,763
Agricultural drainage	1	139,827	139,827	279,654
Climate variability	0	0	0	0
TOTALS	24	2,373,612	2,577,715	4,951,327
Fiscal Year 1986				
Topic	Projects	Federal funds	Matching funds	Total funds
Groundwater management	14	1,471,284	1,599,783	3,071,067
Surface water management	6	672,074	705,295	1,377,369
Systems operation/planning	2	225,862	225,950	451,812
Irrigation management	3	335,564	354,673	690,237
Desalination/reuse	8	1,020,710	1,039,800	2,060,510
Economic/legal/institutional	6	618,860	694,824	1,313,684
Agricultural drainage	0	0	0	0
Climate variability	4	418,021	430,949	848,970
TOTALS	43	4,762,375	5,051,274	9,813,649
<i>Source: U.S. Geological Survey, Water Resource Research Grant Program Project Descriptions, Fiscal Year 1986, Open-File Report 86-548, at ix.</i>				

Each year, the USGS solicits proposals for Section 105 grants. The solicitation emphasizes the areas of research that are of interest to the Survey (as specified by Congress in the Water Resources Research Act; see discussion at pp. 3-5, *supra*). Figure 11 provides information on the type of research supported by USGS in FY 85 and FY 86.

B. Other Federal Agencies

Besides the U.S. Geological Survey, numerous other federal agencies provide financial assistance for water-related research. While detailed profiles of some of these major funding sources is set forth at Appendix D, the following is a summary of these agencies and their programs:

- Environmental Protection Agency
 - Water Pollution Control Research, Development, and Demonstration Grants
 - Safe Drinking Water Research and Demonstration Grants
 - Freshwater, Marine/Estuarine Waters, Soils, Groundwaters, and Sediments Exploratory Research Grants
 - Environmental Air/Water Chemistry and Physics Exploratory Research Grants
 - Environmental Engineering Drinking Water and Wastewater Treatment and Pollution Control Exploratory Research Grants
 - Environmental Engineering Exploratory Research Grants
 - Environmental Exploratory Research Grants
 - Ecological and Toxicological Effects Exploratory Research Grants
- U.S. Department of Agriculture
 - Cooperative Forestry Research Grants
 - Forestry Research Grants
- U.S. Department of Energy
 - Energy from Municipal Waste Projects Grants
 - Radioactive Waste Geologic Repository Deployment Grants
- U.S. Department of Commerce
 - National Sea Grant College Support Program
- National Heart, Lung, and Blood Institute
 - Epidemiology and Biometrics Grants

National Institute of Environmental Health Sciences
Marine and Freshwater Biomedical Sciences Specialized Centers
of Research Grants
Biometry and Risk Estimation--Health Risks from
Environmental Exposures Research Grants

National Science Foundation
Surficial Processes Research Grants
Environmental Engineering Research Grants

This listing does not include grants or contracts provided by agencies in the areas of marine, coastal, or estuary issues.

C. Other Funding Sources

Appendix D also provides background information on foundations that provide grants in the areas of water research and water policy. The Appendix also lists a few donors who provide graduate fellowships in the water resources field. Foundations that have been active in making water-related grants include the following:

ARCO Foundation
United States-Israel Binational Agricultural Research and
Development Fund
William H. Donner Foundation
General Services Foundation
George Gund Foundation
William and Flora Hewlett Foundation
German Marshall Fund
Jessie Smith Noyes Foundation
W. Alton Jones Foundation
Joyce Foundation
W.K. Kellogg Foundation
Northwest Area Foundation

In recent months, over 30 grants have been made by some of the above foundations to support water-related projects (*see* Appendix E). These grants have ranged from a low of \$25,000 to a high of \$571,000. More than half of these grants were in excess of \$100,000 each.

D. Conclusion

The U.S. Geological Survey's Sections 104 and 105 programs play an important role in the nation's water research. Other federal agencies and nongovernmental donors such as foundations are also active in water research and water education. These sources are potential supporters of expanded research and educational efforts by Montana's water center.

Chapter 5:

Recommendations for Montana Decisionmakers

As mentioned in the Foreword, this report is a presentation of options available to Montana's university system and legislature as they think about the future of Montana's water research program--particularly the purpose and program of the Montana Water Resources Center. An effort has been made to portray the structure, funding and program of other water centers around the country. Profiles of graduate-level, water resource management programs have been presented in the event that the Montana university system desires to offer such a program. Possible funding sources in addition to the basic U.S. Geological Survey grant have been identified in the event more intensive research and educational efforts are undertaken in Montana.

We have only presented possibilities. Ultimately, the decisions about the future of water research and education in Montana must be made by the state's key decisionmakers: the faculty and administration of the university system; the water management agencies of state government; and the legislature.

Yet, the authors of this report have gained many impressions as the result of their research; and these impressions have led to many recommendations that should be shared with Montana decisionmakers. These recommendations are as follows:

General

1. Montana's emphasis on water research and education is probably inadequate given the importance of water to the state. The budget of Montana's Water Center places it in the lowest quartile of the 40 states reporting to our survey. It is also among the lowest in the Rocky Mountain States. Of course, water-related research and education occur outside the Water Center; and some of these programs, such as the research station at Flathead Lake are quite impressive. Yet, they appear to exist independently of the Water Center.

Given the fact that water is Montana's most important natural resource, it appears to us that the Water Center's research and educational program are inadequate to meet the state's short- and long-term needs. We recommend a review of water-related research and education at the state's higher educational institutions to ascertain whether our impressions are correct.

2. Montana's water resources afford ample opportunities for research and education. Montana is a state-wide laboratory of research and educational opportunities. The state's water is found in high mountain streams; in slow-moving, meandering rivers; in large lakes and reservoirs; and in frequently uncharted aquifers. An incredibly wide range of plant and animal species depend on these waters. The water resource problems of the state present some of the most challenging scientific and policy issues of our times: *e.g.*, the impact of global warming and climatic changes on water availability; drought and drought mitigation; eutrophication of lakes; point and nonpoint source pollution; the impact of cities and agricultural, forest, and mining practices on surface and groundwater; water conservation technology; the management of interstate or international waters; the impact of federal and Indian reserved water rights; the economics of water transfers and water development; and many other issues.

Already, some of Montana's faculty and some of the state's water policies have received national (and, in some cases, international) recognition. With planning and additional resources, this is an area in which the state's higher educational institutions could achieve greater distinction. An exceptional Water Center could help attract additional research dollars to the state, help retain and attract quality faculty and students, provide a reason for private-sector firms involved in water resources to locate in the state, and provide advice and assistance to Montana's citizens and water management agencies.

Structure and Organization of Montana's Water Center

3. The Water Center's Charter should be reviewed. With the appointment of the Water Center's policy board and the completion of this report, it is an appropriate time to review and, if needed, revise the Water Center's Charter which was adopted by the Regents in 1985.

We believe the Center's Charter should be more specific as to the Center's purpose, structure, and program. (Wyoming is an example of a water center having a very clear mission.) Representatives of the university administration, faculty, state water management agencies, the legislature, and water users should be involved in this reassessment of the Charter. Perhaps the policy board is the appropriate entity to lead this reassessment.

4. The Water Center should develop a clear, detailed, attainable plan for the future. One result of the review of the Charter, which establishes the purpose of the Montana Water Center, should be the development of a plan for the Center which sets forth mid-range goals and the strategy for achieving those goals. This plan should be more specific than the Center's previous 5-year plan which was found by the USGS to be too general to be meaningful.

5. Efforts should be undertaken to involve more faculty in the Water Center's programs. Based on the experience of other states, such as Indiana, we believe the Water Center should attempt to involve more faculty in its programs. The solicitation of research proposals is not enough. A committee consisting of faculty heavily involved in water research and education at the major campuses should be appointed. This committee should help define major research emphases and help develop major funding proposals. This committee should be a cadre of researchers closely and continuously identified with the Center.

6. The Water Center's program should be better coordinated with other state institutions and agencies. We are fearful that Montana's Water Center is becoming increasingly isolated from other research and data collection efforts in the state such as the University of Montana's Flathead Lake research station, the groundwater information center at Montana College of Mineral Science and Technology, the State Library's Natural Resource Information System (NRIS), the law library at the University of Montana, and the water records of the Department of Natural Resources and Conservation. We believe that frequent, direct communication between the Water Center and these other entities is necessary so that the capacity of the Water Center is enhanced. While California's water archives at UCLA and Berkeley may not be attainable or even desirable in Montana, they represent exceptionally rich, centralized collections of water resources information. The Wyoming Water Center also has a strong role in the collection and management of the state's water information.

7. The current level of Water Center staffing is inadequate. At present, the Montana Water Center is staffed by a 0.4 FTE director, 0.75 FTE support staff, and a 0.1 FTE associate director at each of the other two participating institutions. A 0.4 FTE position for information transfer remains unfilled after the incumbent accepted employment out-of-state.

The USGS's evaluation of water centers discussed earlier in this report indicated that a half-time director is a common staffing pattern with the remainder of the director's time being devoted to research and education.

While this level of staffing (0.4 or 0.5 FTE) may be sufficient simply to maintain the status quo or to run a well-established center with ample support staff, we believe it to be insufficient if a center, such as Montana's, is to be developed. The 0.1 FTE positions at the University of Montana and the Montana College of Mineral Science and Technology allow for nothing more than administrative duties. If Montana desires to build its water research and educational programs, we believe that professional and support staffing must be augmented.

Research Program

8. Montana's Water Center does not appear to be funding research in several important areas. The authors did not complete a longitudinal study of Montana's water research grants; but in a recent year (FY 87), research was not funded in several areas that were considered important by other centers around the country. For instance, no grants were made in the area of "water cycle" (21 percent of the grants nation-wide were in this area) or in the area of "water resources planning" (11 percent nationally). The Water Center made few if any grants in several other areas important to Montana: groundwater protection, hazardous wastes, acid rain, wastewater treatment (although we understand that proposals are frequently submitted in these areas).

We do not suggest that the Water Center is expending its funds on the wrong projects. Funds are very limited and choices be made. We do suggest that the research objectives of the Center must be clear and the proposals receiving funds must further those research objectives.

9. Montana should compete more aggressively for Section 105 funds. Montana has been particularly ineffective in competing for funds available under the Section 105 program. During the last 5 years, Montana has received only three of those grants while other Rocky Mountain States such as New Mexico (14), Colorado (9), and Utah (8) have been much more competitive. Montana's Water Center should make the Section 105 program known to faculty and should be a catalyst for developing proposals to the USGS. Groundwater and surface water management, desalination and reuse, economic-institutional-legal issues, and irrigation management are areas supported by Section 105 grants in recent years.

Educational Programs

10. The Water Center has an opportunity to meet growing educational needs concerning water. As the competition for water increases, water policy issues will be more in the forefront of public debate. There will be the need for education on water issues in our public schools, colleges and universities, civic groups, and legislatures. Also, more students will be searching for undergraduate and graduate programs in water resource fields. Mid-career professionals will be looking for specialized, short-term educational programs to supplement their skills.

Montana's Water Center and university system have an excellent opportunity to meet these educational needs. Already, the Center spending a greater portion of its budget on information transfer than most other centers in the country; and the Center is planning a major public educational project on water. The Center can also be active in developing curricular materials for public schools, offering summer workshops for school teachers, and offering a

series of professional development programs for governmental employees and other water management professionals.

11. Montana's Water Center and university system should consider establishing a graduate-level, water resource management program. As previously discussed in Chapter 3, there are relatively few (approximately 20) water resource management programs in the United States. While seven of these programs are located in the western states, most of these programs have a strong engineering emphasis.

For a modest investment, the Montana university system probably could begin offering a concentration of water resource management courses or even a master's degree in water resource management. This could be done by developing a speciality within Montana State University's engineering program (such as has been done at the University of California, Davis; University of Kansas; Utah State University; University of Oklahoma; and others) or by developing an interdisciplinary program administered by the Water Center but using courses offered by existing academic departments (such as has been done at Colorado State University and the University of Wyoming).

What could distinguish Montana's interdisciplinary program from those offered by Colorado State and Wyoming would be the potential emphasis on the environmental, economic, policy, legal, and institutional aspects of water. Courses could be selected from the environmental programs, the economic departments, the public administration departments of Montana State and the University of Montana--as well as UM's School of Forestry and School of Law and Montana Tech's mining and environmental engineering courses. Such an interdisciplinary offering--with an emphasis on the policy sciences--would result in a program unique in the Pacific Northwest. In all the western states, only Arizona State's water resource administration program would appear comparable (the University of New Mexico is developing a similar program in natural resource administration).

Such a program would enable the Montana university system to respond to the growing interest in water issues and the growing demand for more integrated educational programs in the field of water. Such a program could also provide a range of educational opportunities (e.g., conferences, short-courses, 1-year concentrated master's programs) for mid-career professionals seeking to broaden their knowledge of water. If the Water Center were involved in creating and managing such a program, it would provide an importance linkage between research and education.

Funding

12. The budget of Montana's Water Center is insufficient to allow the Center to provide meaningful research and educational opportunities. As previously mentioned, the budget of Montana's Water Center is among the lowest quartile in the nation. The state provides minimal support to the Center, and the Center has not been aggressive in attracting other financial support.

If the Center is to play a major role in addressing the state's water needs, it will require greater financial resources. The legislature should provide sufficient additional funds so that the Center's director has the time, support staff, and travel money to develop the Center's program and to attract other financial support. Any additional financial support from the Legislature should be in response to a detailed strategic plan for the development of the Center and with the expectation that the Center's progress will be evaluated after 2 or 3 years.

13. Most, if not all, indirect costs on grants received by the Center should be returned to the Center or to the researchers involved. The return of indirect costs on grants to the Water Center or to the researchers involved in the project provides a valuable financial incentive to search for additional grants or contracts. With recent legislation, Montana has made an important move in this direction. It should continue.

14. The Water Center should aggressively pursue grants and contracts from other sources. Water resource problems are of growing interest with government agencies and foundations. Montana's Water Center has not actively competed for grants or contracts from these sources. As previously mentioned, few Section 105 grants have been awarded to the state. We understand that the Center has not pursued many of the potential funding sources identified in Appendix D to this report (although individual faculty may have done so). Also, this report has not examined contracting possibilities with private firms (the Utah Center has many such contracts).

We believe the Center should take a more active role by working with faculty in developing funding proposals to these sources. These efforts should be pursuant to the strategic plan previously referred to in these recommendations.

Next Steps

Our report is only a modest effort to suggest possibilities for improving Montana's Water Center. Much work remains to be done. If the effort is to continue, we suggest the following next steps:

1. The principal parties must begin the reexamination of the Water Center's Charter and the development of a strategic plan. The university system, the Water Center, and the recently appointed policy board should reexamine the Center's Charter and state specifically what are to be the purposes of the Center. This exercise should be followed by the development of a strategic plan (what the private sector calls a "business plan") setting forth mid-range objectives and the means by which these objectives are to be attained. Both activities should involve university administrators and faculty, state agencies, key legislators, and water users. If necessary, persons with expertise in facilitating such planning processes should be retained.

In the planning process, the question of whether Montana should develop a graduate-level, water resources management program should be specifically addressed.

For the benefit of the legislature, this plan should document the reasons for a greater emphasis on water research and education. This plan should also identify the additional financial support necessary from the state to begin implementation of the plan. The plan should be submitted to the Water Policy Committee and to the 1991 legislature.

2. Additional information should be developed. While this planning process is underway, further information should be gathered which will be useful both in planning and in implementing the plan. Such additional information should include:

a. Survey of faculty research and research interests. A survey should be undertaken of the university system's faculty to determine their water-related interests, what water-related research they have conducted, and the outside sources of funding for their research, if any. This information will be helpful in determining the university system's strengths and the Center's research priorities.

b. Survey of funding sources. Appendix D to this report indicates governmental agencies, foundations, and other entities who appear to provide funding for water-related research and education. Personal contact should be made with these potential funding sources (particularly federal agencies) to learn more about these programs and to determine whether financial support might indeed be available to Montana's Water Center.

3. A proposal for a water resource management program should also be developed. If a tentative decision is made to investigate the possibility of creating a graduate-level, water resource management program, then a specific component of the plan should be addressed to this topic. The following tasks would need to be accomplished:

a. Survey of potential faculty and courses for a water-resources management program. A survey should be undertaken to identify those courses presently offered throughout Montana's higher education system that might be utilized for a interdisciplinary water resources management program. The faculty offering these courses should also be contacted to determine their interest in participating. Also, the faculty offering water resource management programs at other institutions should be contacted for more information about their courses and their experiences.

b. Identification of steps necessary to create such a program. A checklist of the steps necessary to create a graduate-level, water resources management program should also be created. This checklist would identify all the decision points in the process.

c. Estimate the costs and benefits. An analysis of the costs and benefits of such a program should be undertaken. This analysis should include the direct benefits and costs, such as tuition and administrative expenses, as well as indirect costs, such as the benefits that might accrue to the state from such a program. Also, potential student interest should be gauged.

Appendices

- Appendix A: Water Center Survey Form
- Appendix B: Charter for the Montana University System Water Resources Center
- Appendix C: Profiles of Graduate Water Resources Programs
- Appendix D: Potential Funding Sources for Water Resources Research
- Appendix E: Recent Grants for Water Projects

Appendix A:

Water Center Survey Form

Please answer the following questions and return this form in the enclosed envelop:

1. Name and state of Water Center responding to this survey:

2. Name, position, and telephone number of person responding to this survey:

3. We are interested in how your Water Center funds its programs. For your most recent fiscal year, please provide the following information on revenues received by your center:

Fiscal Year 198__		
Revenues	Amount (\$)	% of Total
Basic USGS grant		
Other federal sources (grant/contract)		
State appropriation		
Other state sources (grant/contract)		
University funds		
Foundation sources		
Contracts with private sector firms		
Other: _____		
TOTAL REVENUES		100%

4. We are interested in what type of programs are supported by your Water Center. For the same fiscal year identified in your answer to Question 3, please provide the following information on expenditures by your center:

Fiscal Year 198__		
Expenditures	Amount (\$)	% of Total
Center administration		
Research projects		
Information transfer (e.g., publications, conferences)		
Other: _____		
Other: _____		
TOTAL EXPENDITURES		100%

5. We are interested in how your Water Center is staffed. For the same fiscal year identified in your answer to Question 3, please provide the following information on your staffing:

Core Center staffing (FTE's)	
Professional staff	
Support staff	
Other researchers involved in Center program but not employed directly by Center	

6. What is the disposition of indirect costs resulting from grants or projects that are handled by your Water Center (check as appropriate):

- a. Assigned to the individual researcher _____
- b. Assigned to the Water Center _____
- c. Assigned to the University _____
- d. Assigned to the state general fund _____
- e. Other: _____

7. Unless included in your annual report, which we have requested, please attach a current list of your Water Center's research projects and publications.

Please return this survey to:
 Water Center Survey
 Doney & Thorson
 P.O. Box 1185
 Helena, MT 59624
 (406) 443-7018

Appendix B: Charter for the

~~Appendix B: THE~~ MONTANA UNIVERSITY SYSTEM WATER RESOURCES CENTER

Adopted by the Montana Board of Regents
for Higher Education, September, 1985

FUNCTIONS: The Montana University System Water Resources Center shall carry out a program of research, information transfer and other educational activities to benefit persons and organizations involved in the management, use and/or conservation of water in Montana and as required to participate in the federally funded program. In addition, the Center shall maintain a record of water research projects in progress at all units of the system and shall incorporate the results of such projects in a data base accessible to interested persons.

ORGANIZATION: The Montana University System Water Resources Center shall be a cooperative activity of Montana State University, the University of Montana, and Montana College of Mineral Science and Technology. The Director's office shall be maintained at Montana State University, the state's land grant university, as required by the enabling federal legislation. Qualified faculty at all units of the Montana University System shall be encouraged to participate in the programs of the Center.

COORDINATING COUNCIL: There shall be a Coordinating Council composed of the Director from Montana State University and Associate Directors from the University of Montana and Montana College of Mineral Science and Technology. The Director shall serve as chair of the Coordinating Council. Policies and programs of

the Center shall be formulated and approved by the Coordinating Council. Functions of the Coordinating Council shall include development of criteria for research and information transfer projects and the allocation of funds to approved projects. The Council shall meet at appropriate locations as required to conduct its business; the Council shall meet at the request of any two of its members.

DIRECTOR: The Director of the Center shall be appointed by the President of Montana State University after consultation with the Vice Presidents for Research at Montana State University and the University of Montana, and the Director of Research at Montana College of Mineral Science and Technology. The Director shall be responsible for managing the programs of the Center as approved by the Coordinating Council. The Director shall coordinate and supervise the research, information transfer and educational projects supported by the Center at Montana State University and shall be responsible for preparing program proposals and reports as may be required by funding agencies. The Director shall serve as liaison between the institutions and federal, regional, state and local agencies, and organizations and persons from the private sector engaged in water management, use and/or conservation. The Director shall be responsible to the Vice President for Research at Montana State University.

ASSOCIATE DIRECTORS: One Associate Director shall be appointed by the President of the University of Montana and one by the President of Montana College of Mineral Science and Technology. The Associate Directors shall serve on the Coordinating Council previously described and shall be responsible for coordinating and supervising research, information transfer, and educational projects supported by the Center at their respective institutions. Associate Directors may act on behalf of the Director upon the Director's request. Associate Directors shall be responsible to the Director and to the Vice President for Research at the University of Montana and the Director of Research at Montana College of Mineral Science and Technology.

CONSULTANTS: The Coordinating Council shall select consultants as necessary to insure that its research and information transfer projects are relevant to state and regional needs and that selected projects are based on sound scientific principles.

An Advisory Committee shall be appointed and shall consist of personnel from federal, state and local agencies whose functions include water management or planning, and from private sector organizations and individuals involved in the management, use and/or conservation of water. The Advisory Committee shall identify areas where research and/or information transfer projects are needed and shall review proposed projects for relevancy to state and regional need.

A committee shall be appointed to provide a technical review of projects recommended to the Center by the Advisory Committee. The Peer Review Committee shall consist of faculty from the university system and experts from off campus and shall be selected for their expertise relative to the proposed projects under consideration. Their review and recommendations shall be considered by the Coordinating Council in the final selection of research and information transfer projects.

FUNDING: The Montana Water Resources Center shall receive funds appropriated through section 104 of PL 98-242. The Coordinating Council shall determine the proportion of section 104 funds allotted to research and information transfer projects and to program administration subject to review by the Vice President for Research at MSU. The Center shall also receive funds allocated to projects under sections 105 and 106 of this act when the project proposal was submitted through the Center. In addition, the Center is authorized to receive funds from other federal, state and local sources, and from the private sector when these funds are awarded to proposals submitted through the Water Center. Each unit of the university system shall be responsible for the non-federal match requirements on projects awarded at that unit. The Administrator of the Grants and Contracts office at Montana State University shall receive and account for all of the funds awarded to the Center.

Appendix C:

Profiles of Graduate Water Resources Programs

University of Oklahoma, Norman, OK 73019

- Unit: School of Civil Engineering and Environmental Science
- Degrees Offered: Master of Science (Civil Engineering)(30 hours with thesis; 32 hours without thesis)
Master of Environmental Science (30 hours with thesis; 32 hours without thesis)
Doctor of Philosophy (90 hours with dissertation)
Doctor of Engineering (90 hours with dissertation)
- Areas of Concentration: Groundwater quality management
Water resources
Water quality management
- Representative Courses: Open Channel Flow
Applied Oceanography
Stream Channel Mechanics and River Engineering
Water and Waste Water Treatment Processes
Hydrology
Groundwater and Seepage
Water Quality Management
Subsurface Water Quality Modeling
Sanitary Engineering Design and Water Resources
Water Resources Systems Analyses
Biological and Industrial Wastewater Treatment and Reuse
- Special Features: The Environmental and Ground Water Institute, established in 1982, is the school's focus for nationally known research activities in groundwater.
- The Bureau of Water and Environmental Resources Research is active in environmental engineering and science and in the development of appropriate technology for underdeveloped countries.

The school has a close working relationship with the Environmental Protection Agency's Robert S. Kerr Laboratory in nearby Ada, Oklahoma.

University also has a School of Meteorology granting M.S. and Ph.D. degrees.

Faculty: 15 (entire Engineering School)

Tuition: Resident: \$50.80 per credit hour per semester
Nonresident: \$162.80 per credit hour per semester

University of Kansas, Lawrence, KS 66045

Unit: Department of Civil Engineering

Degree Offered: Master of Science (30 hours with thesis)

Areas of Concentration: Water resources engineering
Water resources science

Representative Courses: *Basic technical core (15 hours) are drawn from following courses:*

Intermediate Fluid Mechanics
Experimental Fluid Mechanics
Water Resources Policy and Administration
Applied Hydrology
Free Surface Flow I
Contaminate Transport
Advanced Fluid Mechanics I
Application of Optimization Techniques in Civil Engineering
Water Resources Literature Seminar
Water Resources Engineering
Quantitative Groundwater Hydrology
Free Surface Flow II
Modeling of Hydrologic Systems
Sediment Transport
Hydrogeology
Advanced Geomorphology: Regimen of Rivers
Energy and Water Balance

Optional and interdisciplinary courses may be taken in the following areas:

Mathematics:

Probability
Statistics
Applied mathematics
Numerical analysis

Computer Science:

Programming
Data structures
Microcomputer systems

Economics:

Public finance
Price and income
Economic growth and development

Microeconomics
Macroeconomics
Geology:
 Geomorphology
 Geophysics
 Geochemistry
 Remote sensing hydrogeology
 Regional geology
Geography:
 Soil science
 Climatology
 Industrial geography
 Physical meteorology
 Urban geography
Political Science/Law:
 Public policy
 Public administration
 Water rights

Special Features:

Program emphasizes that "water resources management requires fundamental knowledge in engineering and physical sciences and demands appreciation of socio-economic, political and legal considerations."

Also, research program is directly related to educational program.

Students must possess a B.S. degree in engineering.

Core curriculum taught by an interdisciplinary committee chaired by the Vice Chancellor of Research and Graduate Studies.

Students have access to the Hydrology and Water Resources Laboratory, the Fluid Mechanics Laboratory, the Environmental Health Laboratory, the Water Resources Institute, and the State Geological Survey.

Faculty:

13 (faculty who offer core curriculum)

Tuition:

Resident: \$705 per semester
Nonresident: \$1660 per semester

State University of New York, Syracuse, NY 13210

Unit: College of Environmental Science and Forestry
(Graduate Program in Environmental Science)

Degree Offered: Master of Science (30 hours plus 6 additional hours for thesis, 12 additional hours including internship, or 12 additional hours of course work with comprehensive examination)
Doctor of Philosophy (15 hours in core courses, preliminary examination, candidacy examination, thesis, and other requirements)

Area of Concentration: Water resources

Representative Courses: *Basic core courses (15 hours) are required in the following:*

Environmental Institutions
Environmental Information Systems
Environmental Policy Analysis
Environmental Systems
Environmental Policy/Science Seminar

Other courses (minimum of 15 hours) are determined by student and Major Professor in the following areas:

Physical sciences:

Civil engineering
Geology
Geomorphology
Hydrology
Meteorology
Sanitary engineering
Soils
Water chemistry

Biological sciences:

Ecology
Entomology
Fishery biology
Forestry
Microbiology
Water quality
Wildlife management
Zoology

Social sciences:
Administration
Economics
Government
History
Law
Policy

Special Features:

The College of Environmental Science and Forestry is a specialized center of the State University of New York. It has a cooperative relationship with the adjacent Syracuse University.

The Water Resources Program is one area of concentration in the Graduate Program of Environmental Science. Other areas of concentration include Urban Ecosystems, Environmental Communications, Waste Management, Land Resources, Energy, and Environmental Chemistry and Toxicology (experimental offering).

The mission of the Graduate Program in Environmental Science is "to provide interdisciplinary education, research, and public service to foster the wise use of natural resources and to prepare students to comprehensively address environmental concerns and problems." Central to the program is education in environmental management, "the act of organizing, utilizing, and directing technical, social, human, and economic resources" to protect our natural resources and to provide for public needs. The program emphasizes a multidisciplinary approach, holistic perspective, topical grounding, and realistic experience.

The Water Resources concentration emphasizes "an understanding of both the technical information and transdisciplinary relationships of various water-related issues. Scientific aspects include the basic physical, chemical, and biological interactions occurring under natural conditions a[nd] under modified conditions that result from changes in water quantity or quality. The social aspects are concerned with planning, regulation, and management of water resources.

Dual degree programs are offered with Syracuse University's Maxwell School of Citizenship and Public Affairs, S.I. Newhouse School of Public Communications, School of Management, and College of Law.

Faculty: 20 (Water Resources concentration only)

Tuition: Resident: \$90 per hour per semester or \$1075 per semester
Nonresident: \$156 per hour per semester or \$1868 per semester

Duke University, Durham, NC 27706

Unit: School of Forestry and Environmental Studies
(Water and Air Resources Program)

Degrees Offered: Master of Environmental Management (M.E.M.)
(48 hours; 30 hour program available to exceptional students having bachelor's degree in environmental sciences or engineering; 30-hour, part-time program also available for qualified professionals)
Master of Arts (30 hours with thesis optional; offered through Graduate School with bulk of instruction in School of Forestry and Environmental Studies; student could emphasize water resources)
Master of Science (30 hours with thesis mandatory; offered through Graduate School with bulk of instruction in School of Forestry and Environmental Studies; student could emphasize water resources)
Doctor of Philosophy (60 hours plus preliminary examination, final examination, and dissertation; offered through Graduate School with bulk of instruction in School of Forestry and Environmental Studies; student could emphasize water resources)

Areas of Concentration: Water resources
Combination of water and air resources

Representative Courses: *Basic hydrologic processes:*
Watershed hydrology
Water quality
General meteorology and climatology
Limnology
Environmental chemistry
Ecology
Ecotoxicology

Quantitative analysis techniques:
Statistics
Probabilistic and deterministic modeling
Optimization and simulation

Decisionmaking and management:
Water resource management
Economics
Risk analysis

Special Features:

The objective of the M.E.M., a professional degree, "is to develop expertise in planning and administering the management of the natural environment for maximum human benefits with minimum deterioration of ecosystem stability."

School emphasizes integrated cases study method in instruction. The case studies result from cooperative efforts of a multidisciplinary team of investigators. The team approach is also emphasized as "resolution of the nation's complex resource and environmental problems requires a holistic perspective."

Master of Science and Doctor of Philosophy degrees can also be earned in water resources policy through the University's Center for Resource and Environmental Policy Research. The Center "is committed to objective and timely analyses of critical natural resource and environmental issues, both national and international.

Joint Master of Environmental Management/Master of Business Administration degree programs offered in cooperation with Duke's Fuqua School of Business (3 year program). Joint Master of Environmental Management/Master of Arts in Public Policy Sciences also offered in cooperation with Duke's Institute of Policy Sciences and Public Affairs.

School also offers M.E.M. and Ph.D. degrees through the Integrated Toxicology Program. The program seeks to develop holistic and innovative approaches to toxicology training and to provide training in three areas: (1) general toxicology, with training in the principles and concepts of toxicology; (2) specialized toxicology, emphasizing such areas as pulmonary toxicology or biochemical toxicology; and (3) ecotoxicology.

Faculty: 6 (Water and Air Resources Program)

Tuition: \$4,240 per semester

Johns Hopkins University, Baltimore, MD 21205

Unit: School of Hygiene and Public Health (Division of Environmental Health Engineering)

Degrees Offered: Master of Health Science (M.H.S.)(64 quarter units plus master's essay; can be completed in 9 months)
Master of Science (Sc.M.) plus thesis; can be completed in 2 years)
Doctor of Public Health (Dr.P.H.)(4 quarters of residence, 18 credit units outside primary department, comprehensive examination, thesis)
Doctor of Science (Sc.D.)(4 quarters of residence, 18 credit units outside primary department, preliminary examination, thesis)
Doctor of Philosophy (Ph.D.)(4 quarters of residence, 18 credit units outside primary department, preliminary examination, thesis)

Areas of Concentration: Water and wastewater treatment

Representative Courses: *Required:*
Biostatistics
Epidemiology

Optional courses:
Municipal Sanitation
Research Methods in Environmental Microbiology
Environmental Law
Environmental Health Administration and Policy
Tropical Environmental Health
Instrumental Analysis in Environmental Engineering

Special Features: Water and wastewater program provides "instruction and research opportunities in the engineering and scientific disciplines that have direct or indirect impacts on the prevention of human disease and the promotion of human health through the control of the environment."

Areas of instruction include technical supervision, monitoring, and development of performance standards for (1) public drinking water systems,

sanitary and storm water drainage systems, and disposal of liquid and solid wastes; (2) for maintenance of safe drinking, recreational or shellfish water uses; and (3) for achieving freedom from hazards of human habitation from vectors or animal reservoirs of disease.

Faculty: 9 in Environmental Health Engineering Division

Tuition: \$3,000 per quarter; \$12,000 for full-time enrollment for a 4-quarter, 9-month academic year

Utah State University, Logan, UT 84322-4110

Unit: Department of Civil and Environmental Engineering

Degrees Offered: Master of Engineering (M.E.)(45 quarter credits; no thesis)
Master of Science (M.S.)(45 quarter credits with thesis or 51 credits without thesis but with oral examination)
Civil Engineer (C.E.)(2-year professional degree; 90 quarter credits)
Doctor of Philosophy (Ph.D.)(45 quarter credits beyond M.S. degree plus dissertation)

Areas of Concentration: Hydrology
Water Resources Engineering

Representative Courses: *Typical M.S. program in groundwater hydrology:*
Engineering Statistics
Hydrologic Instrumentation
Engineering Hydrology
Groundwater Hydrology
Porous Media Flow
Hydrologic Processes and Operational Hydrology
Statistical Hydrology
Advanced Groundwater Hydrology
Numerical Methods in Engineering
Groundwater Modeling
Drainage Engineering
Groundwater and Engineering Geology
Groundwater Quality Modeling

Typical M.S. program in water resources engineering:
Engineering Statistics
Hydrologic Instrumentation
Water Systems Analysis I & II
Water Systems Evaluation
Hydrologic Processes and Operational Hydrology
Statistical Hydrology
Water Management
Sedimentation Engineering
Water Resources Planning and Institutions
Parametric Hydrology

Special Features:

Core offering in Department of Civil and Environmental Engineering may be supplemented by choosing from more than 200 courses in Departments of Mathematics, Applied Statistics and Computer Science, Economics, Political Science, Geology, Bacteriology and Public Health, Business Administration, Sociology, Agricultural Economics, Agricultural and Irrigation Engineering, Electrical Engineering, Botany, Forest Science, Range Science, Wildlife Resources, Chemistry, and Soil Science and Biometeorology.

In addition to instructional laboratories, program utilizes facilities of Utah Water Research Laboratory which contains a variety of flumes, channels, and measuring systems for research in hydraulics and fluid mechanics; chemical and biological laboratories for water quality studies; electronic laboratories for development of telemetry and remote sensing systems; and computer systems.

Faculty:

52 engineering and other staff members primarily responsible for instruction and research in water resources.

Tuition:

Resident: \$286 per quarter (12 credits); \$334 per quarter (15 credits)
Nonresident: \$784 per quarter (12 credits); \$940 per quarter (15 credits)

University of Wisconsin, Stevens Point, WI 54481

Unit: College of Natural Resources (Water Resources Program)

Degrees Offered: Master of Science (M.S.)(30 semester credits; both thesis and non-thesis options are available)

Areas of Concentration: Limnology
Fisheries
Water chemistry
Watershed management

Representative Courses: [Detailed catalog never received]

Special Features: The College of Natural Resources, with over 1500 students, is largest college of natural resources in North America. Only 65, however, are in graduate program.

Specialized facilities available to water resources students include (1) the Environmental Task Force Laboratory, which offers experience in water analysis; (2) the Wetlands Laboratory; (3) the Wisconsin Cooperative Fisheries Unit; (4) the Central Wisconsin Environmental Station, located on Sunset Lake; (5) the Schmeckle Reserve, a 200-acre areas with man-made lake and wetlands; and (6) Treehaven, a 960-acre area of lakes, wetlands, and streams.

Faculty: 41 in College

Tuition: Resident: \$1015 per semester
Nonresident: \$2898 per semester

University of Wyoming, Laramie, WY 82071

Unit: Water Center in conjunction with academic departments

Degree Offered: Master of Science (26 hours with thesis)

Areas of Concentration: Technical hydrology
Natural resource economics and/or law
Water quality

Representative Courses: Required 1-credit seminar on water resources organized through Water Center.
Six credit hours must be taken in technical water resources offerings from outside student's department.

Special Features: This interdisciplinary program is conducted by the Water Center in cooperation with other academic departments. The master's degree is awarded as speciality option by the department with which the student is affiliated. The water resources emphasis is noted on the student's transcript.

The program is coordinated by the Water Center Academic Committee.

The student is admitted to both an academic department and the interdisciplinary water resources program. Once admitted, one member of his or her guidance committee is from the Water Center Academic Committee.

Faculty: Depends on student's departmental affiliation

Tuition: Resident: \$416.50 per semester
Nonresident: \$1302.50 per semester

Colorado State University, Fort Collins, CO 80523

Unit: Colorado Water Resources Research Institute

Degree Offered: Master of Science

Areas of Concentration: Water resources planning

Representative Courses: Institute arranges "generalist" program with offerings in several disciplines

Special Features: This interdisciplinary program is conducted by the Water Center in cooperation with other academic departments.

Program suitable for student with several years of professional experience and whose career objectives are in water resources planning.

Advisory committee comprised of senior faculty with experience in water resource planning assists student in designing curriculum.

Faculty: Depends on curriculum designed by student in cooperation with advisory committee.

Tuition: Resident: \$1065.65/semester
Nonresident: \$5807.30/semester

University of Washington, Seattle, WA 98195

- Unit: Environmental Engineering and Science Program
Department of Civil Engineering
- Degrees Offered: Master of Science in Civil Engineering (for students with a bachelors degree in civil engineering)(36 quarter credits plus 9 credit thesis)
Master of Science in Engineering (for students with bachelor's degree in engineering)(36 quarter credits plus 9 credit thesis)
Master of Science (for nonengineering students)(36 quarter credits plus 9 credit thesis)
Doctor of Philosophy (75 credits beyond bachelor's degree)
- Areas of Concentration: Environmental engineering
Hydraulic engineering
Hydrodynamics
Hydrology
Coastal engineering
Applied sciences (water resources)
Environmental engineering systems
- Representative Courses: Environmental engineering
Biological waste treatment
Sanitary engineering unit operations
Design of water and waste treatment processes
Industrial waste treatment
Environmental health engineering
Hydraulic engineering
Computational hydraulics
Open channel engineering
Advanced computational hydraulics
Hydrodynamics
Analysis techniques for groundwater flow
Hydrodynamics
Hydrodynamics in water quality
Hydrology
Physical hydrology
Coastal engineering
Coastal engineering

Coastal hydraulics
Applied sciences (water resources)
Ecological effects of waste water
Aquatic chemistry
Water quality analysis
Environmental engineering systems
Water resources management
Water quality management
Water resources system management

Special Features: Program offers strong background in engineering plus opportunity to develop interdisciplinary perspective with work in other departments.

Faculty: 15 in Environmental Engineering and Science Program

Tuition: Resident: \$2595 per year
Nonresident: \$6468 per year

University of Georgia, Athens, GA 30602

Unit:	School of Forest Resources
Degrees Offered:	Master of Science (40 quarter credits plus thesis) Master of Forest Resources (55 quarter credits; no thesis) Doctor of Philosophy
Areas of Concentration:	Forest water resources
Representative Courses:	<i>Basic requirements:</i> Physics Calculus Biological sciences Inorganic chemistry Economics <i>Program requirements:</i> Principles of soils Forest ecology Forest hydrology Forest resource management decisions Statistical methods I Statistical methods II
Special Features:	Forest water resources is one component of moderate-sized forestry school. Other program areas in the school include forest biology, silviculture and soils; forest biometrics and timber management; forest economics, policy and administration; wildlife and fisheries; wood science and technology; and forest business management.
Faculty:	38 graduate faculty in School; 1 faculty member in forest water resources
Tuition:	Resident: \$1770 per year (3 quarters) Nonresident: \$4689 per year (3 quarters)

Vanderbilt University, Nashville, TN 37240

- Unit: Environmental & Water Resources Engineering
Department of Civil Engineering
- Degrees Offered: Master of Science (24 semester hours plus thesis
or 30 semester hours plus seminar report)
Doctor of Philosophy (48 semester hours)
Master of Engineering
- Area of Concentration: Water quality engineering
Water resources engineering
Solid and hazardous waste engineering
Environmental science
- Representative Courses: *Civil and environmental engineering:*
Fluid mechanics
Principles of water treatment and wastewater
disposal
Solid waste management
Radiological aspects of environmental engineering
Environmental chemistry
Microbiology of water, wastewater and air
Environmental engineering laboratory
Groundwater hydrology
Open-channel hydraulics
Economics and law of air and water resources
- Environmental & water resources engineering:*
Water quality management
Flow and transport in environmental systems
Water treatment theory and practice
Biological waste treatment theory and practice
Industrial waste treatment
Advanced environmental engineering laboratory
Biology and biochemistry of polluted
environments
River, lake and reservoir engineering
Water resources engineering
Advanced industrial waste treatment process
design
Advanced physical/chemical waste treatment
Hazardous waste engineering

Special Features:

Minor work can be selected in any of the above areas of concentration or in any one of the following departments: biology, chemistry, chemical engineering, geology, mathematics, economics, physics, public health, or radiological health.

Program has emphasis on solid and hazardous wastes and their impact on water.

Faculty:

13

Tuition:

\$480 per semester hour

University of Kentucky, Lexington, KY 40506

- Unit: Department of Civil Engineering
- Degrees Offered: Master of Science in Civil Engineering (MSCE)(24 hours plus thesis or 30 hours without thesis)
Master of Civil Engineering (MCE)(30 hours)
Doctor of Philosophy (PhD)
- Area of Concentration: Water resources engineering
- Representative Courses: Hydrology
The engineer, the law and the environment
Hydraulic structures
Applied fluid mechanics
Engineering Hydraulics
Water quality control laboratory I & II
Solid & hazardous waste management
Water quality control facilities design
Urban hydrology
Water resources system design
Mechanics of liquid flow in pipes
Open channel flow
Fundamentals of water quality control I & II
Water quality in surface waters
Advanced hydrology
Applied statistical methods in water resources
Water resources planning
Water resources systems
Stormwater modeling
Groundwater & seepage
Fluid dynamics of multiphase systems
- Special Features: Students are encouraged to take advance of interdepartmental offering--*i.e.*, engineering mechanics, mechanical engineering, chemical engineering, agricultural engineering, mining engineering, mathematics, computer science, geology, biology, and chemistry.
- Faculty: 21 in civil engineering department
- Tuition: Resident: \$750 per year (2 semesters)
Nonresident: \$2250 per year (2 semesters)

Iowa State University, Ames, IO 50011

- Unit: Water Resources Interdepartmental Program
Attached to Department of Civil & Construction
Engineering
- Degrees Offered: Master of Science (30 semester hours with thesis)
Doctor of Philosophy (72 semester hours)
- Areas of Concentration: Water quantity
Water quality
Water resources economics and institutions
- Representative Courses: *Core interdisciplinary courses:*
Water resources I (planning, hydrology, beneficial
use groups, demand, hydraulics, water
control facilities)(offered by civil
engineering department in cooperation with
agriculture engineering, agronomy, earth
sciences, forestry)
Water resources II (planning, water quality,
wastewater treatment)(offered by civil
engineering department in cooperation with
agricultural engineering, animal ecology,
botany, food technology)
Water resources III (planning; beneficial use
groups; demand; legal, economic,
sociological, governmental, technical
aspects; allocation conflicts)(offered by
economics department in cooperation with
sociology, political science)
- Water quantity emphasis:*
Agricultural engineering (6 courses available)
Agronomy (9 courses available)
Chemical engineering (4 courses available)
Civil engineering (9 courses available)
Mechanical engineering (4 courses available)
Family environment (2 courses available)
Forestry (2 courses available)
Geology (5 courses available)
Industrial engineering (7 courses available)
Meteorology (8 courses available)

Water quality emphasis:

Agricultural engineering (1 course available)
Agronomy (2 courses available)
Agricultural economics (10 courses available)
Botany (7 courses available)
Civil engineering (9 courses available)
Chemical engineering (1 course available)
Nuclear engineering (1 course available)
Food & nutrition (3 courses available)
Forestry (1 course available)
Food technology (1 course available)
Horticulture (2 courses available)

Water resources, economics & institutions emphasis:

Civil engineering (1 course available)
Economics (5 courses available)
Environmental studies (2 courses available)
Family environment (2 courses available)
Food & nutrition (1 course available)
Food technology (2 courses available)
Forestry (6 courses available)
Political science (10 courses available)
Sociology (10 courses available)
Technology & social change (1 course available)

Special Features:

Program is offered cooperatively by various departments including agricultural engineering, agronomy, animal ecology, botany, chemical engineering, civil engineering, earth sciences, economics, family environment, food technology, forestry, horticulture, microbiology, political science, sociology, and anthropology.

Student is assigned to department of major professor.

Program is coordinated by Interdepartmental Program Supervisory Committee.

Iowa's Water Resources Research Institute is located at Iowa State and its research activities are available to students in this program.

7 students enrolled in program in 1987-88.

Authors have on file detailed "procedures guide" for administering this interdisciplinary program.

Faculty: Number in total program is unknown. There are 8 in civil engineering department alone.

Tuition: Resident: \$2020 per year (2 semesters)
Nonresident: \$5720 per year (2 semesters)

University of Wisconsin, Green Bay, WI 54311

- Unit: Environmental Science and Policy
- Degree Offered: Master of Science (24-30 semester hours plus 6-credit thesis)
- Areas of Concentration: Environmental science
Ecosystem studies
Resource management
Waste management and resource recovery
Quantitative methods and data analysis
Environmental policy and administration
Institutions and processes
Management
Methodology
Public policy
- Representative Courses: *Core requirements:*
Seminar in environmental science and policy (both programs)
Perspectives in environmental science (science program)
Natural sciences seminar (science program)
Environmental policy and administration (policy program)
Public policy analysis (policy program)
- Ecosystems studies specialization:*
Ecological dynamics
Statistical design and analysis of experiments
Multivariate analysis
Frontiers in ecology and evolution
Aquatic systems (5 courses available)
Terrestrial systems (6 courses available)
- Resource management specialization:*
Resource utilization and management (10 courses available)
Methods and techniques (9 courses available)
- Waste management and resource recovery specialization:*
Waste management and pollution (5 courses available)
Quantitative methods (3 courses available)

Basic science and techniques (11 courses available)

Quantitative methods and data analysis specialization:

Mathematics of operations research and management

Multivariate statistical analysis

Statistical analysis (6 courses available)

Mathematical modeling and mathematics (6 courses available)

Computer science and information processing (11 courses available)

Other natural science courses (6 courses available)

Institutions and processes specialization:

Management of complex organizations

Politics and power in organizations

Intergovernmental relations

American legislative process

Administrative law

Administration of local government

Management specialization:

Executive decisionmaking

Administrative theory and behavior

Organizational analysis

Organizational change and development

Management of nonprofit organizations

Public and nonprofit budgeting

Methodology specialization:

Social research methods

Mathematics of operations research and management

Statistical design and analysis of experiments

Multivariate statistical analysis

Survey and field research methods

Evaluating social programs

Techniques and methods of regional planning

Urban planning

Decision theory and methods

Planning theory and methods

Public policy specialization:

Science, technology, and public policy

Energy, natural resources, and public policy
Environmental law
Regulatory policy and administration

Special Features:

Students who study environmental policy and administration typically enter governmental agencies at the national, state or local level, or nonprofit organizations where their work involves policy analysis, planning, or administration. Some take positions in legislative bodies, environmental organizations, or industry where administrative or analytic work is combined with politics, public relations, education, or advocacy.

Students who study environmental science are prepared for positions of responsibility dealing with environmental problems in industry, consulting, laboratory/engineering firms, or governmental agencies. Students are also prepared for further graduate work. Emphasis is on developing skills appropriate for designing and conducting scientific investigations, interpreting data, making responsible decisions, and communicating the results of environmental studies to other scientists, decisionmakers, and the general public.

Faculty:

42

Tuition:

Resident: \$1005.40 per semester
Nonresident: \$2888.90 per semester

University of Wisconsin, Madison, WI 53705

- Unit: Water Resources Management Program
Institute for Environmental Studies
- Degree Offered: Master of Science (45 semester hours; up to 15 hours may be waived for students with professional experience or other graduate degrees; no thesis is required)
- Areas of Concentration: Biological and physical sciences
Engineering
Law and social sciences
- Representative Courses: Core curriculum (30 hours; must be distributed in three of following categories):
Natural science and technology courses
Small watershed engineering
Sanitary engineering
Algae
Aquatic plants/resources
Ecology
Hydroscience
Hydrology
Pollution control
Water resources engineering
Water analysis
Hydrogeology
Soil science
Entomology
Environmental health
Environmental toxicology
Forestry/ecosystems management
Limnology/zoology
Wildlife ecology
Water resources institutions and public decisionmaking processes
Environmental/resource economics
Environmental impact analysis
Land use controls
Water rights/environmental law
Land/water policy
Resource policy
Environmental education/communication

Environmental decisionmaking
 Regional planning
 Analytical and design tools in water resources
 Computer programming
 Statistics for bioscience
 Remote sensing
 Cartography/surveying
 Modeling techniques
 Technical writing/journalism
 Economic analysis
 Statistical methods
 Synthesis and integration (5-credit
 interdisciplinary workshop required of all
 students)
 Area specialities (15 hours; students select one)
 Agricultural economics
 Aquatic biology
 Botany
 Civil and environmental engineering
 Economics
 Education
 Forestry
 Geography
 Geology and geophysics
 Industrial engineering
 Journalism
 Landscape architecture
 Law
 Limnology
 Political science
 Rural sociology
 Soils
 Urban and regional planning
 Water chemistry
 Water quality
 Zoology

Special Features:

Program is designed to offer terminal degree for
 students who wish to be resource management
 professionals. Students do not conduct
 independent research; instead, they participate in a
 summer practicum workshop that has a water
 resource management focus.

The Institute for Environmental Studies was established in 1970 as an interdisciplinary unit that combines environmental instruction with a comprehensive research program.

Approximately 30 students were in the program during the 1988-89 academic year.

Three Helena-area water resource professionals are graduates of this program.

Faculty: 53 faculty are directly involved in the water resources management program.

70 faculty with ties to 25 academic departments are associated with the Institute for Environmental Studies.

Tuition: Resident: \$1308.50 per semester
Nonresident: \$3881.00 per semester

University of Michigan, Ann Arbor, MI 48104

Unit: Interdepartmental Water Resource Management Program

Degrees Offered: Master of Science
Water resource management emphasis (48 semester hours; no thesis)
Water resource science emphasis (36 semester hours plus thesis)
Doctor of Philosophy (water resource science only)

Areas of Concentration: Water resource management
Water resource science

Representative Courses: *Water resource management emphasis:*
Specific courses not listed in catalog; program designed to provide integrated training in technical, economic, social, and institutional aspects involved in public water management enterprises.

Water resources science emphasis:
Courses offered in water chemistry, civil engineering, environmental and industrial health, aquatic biology, natural resources, biology, and others.

Special Features: The Water Resources Program coordinates four basic graduate programs: Environmental and Water Resources Engineering (through the Department of Civil Engineering; offers MSE and PhD); Health Aspects of Water Quality (through the Department of Environmental and Industrial Health; offers MPH, MS, PhD); Water Resources Management (*supra*); and Water Resources Science (*supra*).

Also, the School of Natural Resources offers related areas of concentration leading to MS and PhD degrees. In addition, it is associated with the Department of Economics in offering an interdepartmental program leading to a PhD in natural resource economics which permits specialization in water resources.

Faculty: 5 involved in core program; supplemented by faculty in other university departments

Tuition:

Resident: \$2257 per semester (term)

Nonresident: \$4723 per semester (term)

University of California, Davis, CA 95616

Unit: Civil Engineering Department
College of Engineering

Degrees Offered: Master of Science (36 quarter credits with thesis;
36 quarter credits with comprehensive
examination)
Master of Engineering (36 credits plus project)
Doctor of Philosophy (minimum of 40 graduate
credits)
Doctor of Engineering (minimum of 40 graduate
credits)

Areas of Concentration: Hydrology
Hydraulics and fluid mechanics
Water resources systems planning and design

Representative Courses: Finite elements: application to fluid problems
Water quality
Water and waste treatment I&II
Noncohesive sediment transportation
Water resources management I&II
Water supply and hydroelectric power planning
Water resources planning laboratory
Groundwater hydrology
Water resources systems engineering
Hydraulics of pipe lines
Hydrologic time-series analysis
Watershed hydrology
Hydrodynamics
Mechanics of fluids

Faculty: 31 in Civil Engineering Department

Tuition: \$439 per quarter (fees)
\$1801 per quarter (tuition and fees)

Washington State University, Pullman, WA 99163

Unit: Department of Civil and Environmental Engineering

Degrees Offered: Master of Science (with or without thesis)
Doctor of Philosophy

Areas of Concentration: Master of Science (Civil Engineering):
Hydrology
Hydraulics
Water resources
Hydropower
Master of Science (Environmental Engineering):
Water supply
Water pollution control
Master of Science (Geological Engineering):
Geohydrology
Doctor of Philosophy:
Hydraulic and water water resources engineering

Representative Courses: Hydraulic engineering laboratory
Hydraulic design
Open channel flow
Intermediate hydrology
Groundwater hydrology
Design and construction of water wells
Seepage and earth dams
Unsteady open channel flow
Wastewater treatment system design
Industrial waste problems
Water quality management
Advanced topics in water quality engineering systems
Solid waste management and design
Intermediate fluid mechanics
Advanced topics in hydraulic engineering
River engineering
Hydraulic design
Natural channel flow
Numerical modeling in fluid mechanics
Topics in fisheries engineering
Fluid mechanics of porous materials
Stochastic hydrology
Advanced hydrology

Water resources systems
Water resources planning
Hydropower planning
Advanced groundwater hydrology
Engineering aspects of aquatic chemistry
Engineering aspects of aquatic biology
Applied stream sanitation
Remote sensing and geologic applications

Special Features: Department has Albrook Hydraulics Laboratory which provides equipment and space for large-scale physical models.

Faculty: 15 in Civil and Environmental Engineering Department

Tuition: Resident: \$945 per semester
Nonresident: \$2346 per semester

University of Arizona, Tucson, AZ 85721

Unit: Department of Hydrology and Water Resources
College of Engineering and Mines

Degrees Offered: Master of Science (thesis required)
Doctor of Philosophy

Areas of Concentration: Hydrology
Hydrogeology
Hydrogeochemistry
Groundwater hydrology
Surface water hydrology
Mathematical and statistical methods
Water resources administration
Water policy and planning
Water resource systems
Water quality management

Representative Courses: *Courses in hydrology:*
Hydrology of unsaturated media
Field hydrology
General hydrology
Hydrogeology
Statistical hydrology
Watershed hydrology
Hydrochemistry
Water quality control
Hydrologic systems
Physical oceanology and limnology for hydrologists
Environmental tracers
Well hydraulics and pumping test analysis
Subsurface fluid dynamics
Snow hydrology
Soil water dynamics
Water quality dynamics
Aquifer mechanics and well hydraulics
Development of groundwater resources
Advanced topics in hydrology
Deterministic methods in hydrology
Stochastic methods in hydrology
Isotope hydrology
Numerical methods in subsurface hydrology
Analysis of hydrologic systems

Courses in water resources administration:

Water resource management
Natural resource economics
Operations research in water resources
Population and resources
Environmental policy
Finite state methods in water resource management
Forest and range policy
Water resource policy and administration
Advanced natural resource economics
Coupled economic-physical systems
Water resources systems analysis
Water quality management

Courses may also be taken in these other fields:

Agriculture
Biology
Economics
Engineering
Geography and regional development
Law
Mathematics
Planning
Political science
Statistics

Special Features: Department stresses its expertise and emphasis on groundwater

Departmental faculty has conducted \$3.8 million in research over the last 3 years

Faculty: 21

Tuition: Resident: \$598 per semester
Nonresident: \$2314 per semester

Appendix D:

Potential Funding Sources for Water Resources Research

The water resources research program of the USGS is not the only source of money for water-related research. This appendix provides a summary of some of the sources of funding for water resource research. These sources are governmental, nonprofit, and private-sector. The source for information contained in this appendix is the *Directory of Research Grants* published by Oryx Press (1989).

A. Federal Agencies

1. Environmental Protection Agency

Water Pollution Control Research, Development, and Demonstration Grants.⁴³ The cooperative agreements and project grants support and promote the coordination and acceleration of research, development, and demonstration projects related to the causes, effects, extent, prevention, reduction, and elimination of water pollution. Funds are available for allowable direct expenditures incident to research performance plus allocable portions of allowable indirect costs of the institution. Applications are accepted at any time.

Requirements: Project grants are available to each state, territory, and possession of the U.S., including the District of Columbia; for public, private, state, and community agencies; universities and colleges; hospitals; laboratories; state water pollution control agencies; interstate agencies; state and local governments; and other public or private nonprofit agencies, institutions, and organizations. Grants may also be awarded to individuals who have demonstrated unusually high scientific ability. Grants may be awarded to profit-making organizations under certain conditions.

Amount of Grant: Average grant \$110,722.

Program No.: 66.505

Sponsor: Director, Research Grants Staff, RD-675
U.S. Environmental Protection Agency
401 M St., S.W.
Washington, DC 20460
(202) 381-7473

Safe Drinking Water Research and Demonstration Grants.⁴⁴ The cooperative agreements and project grants are intended to be used to conduct research relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and other impairments of humans resulting

⁴³ DIRECTORY OF RESEARCH GRANTS at 983 (1989).

⁴⁴ *Id.* at 848.

directly or indirectly from contaminants in water or to the provision of a dependably safe supply of drinking water. They may also be used for development and demonstration of any project which will offer a new or improved method, approach, or technology for providing a dependable safe supply of drinking water to the public or which will investigate and demonstrate health implications involved in the reclamation, recycling, and reuse of wastewater for drinking and/or the preparation of safe and acceptable drinking water. Applications are accepted at any time.

Restrictions: Profit-making organizations are not eligible.

Requirements: Project grants are available to each state, territory, and possession of the U.S., including the District of Columbia; for public or private state colleges and universities; public agencies; state and local governments; other organizations; and individuals.

Amount of Grant: \$11,811-\$240,000; average grant \$120,000.

Program No.: 66.506

Sponsor: Director, Research Grants Staff, RD-675
U.S. Environmental Protection Agency
401 M St., S.W.
Washington, DC 20460
(202) 381-7473

Freshwater, Marine/Estuarine Waters, Soils, Groundwaters, and Sediments Exploratory Research Grants.⁴⁵ Under this category of the Environmental Air/Water Chemistry and Physics Research Programs, the EPA's areas of research interest include but are not limited to studies of transport and transformation processes in the surface and subsurface environment in order to predict the impact of surface conditions on groundwater systems and for use in the design, control, or cleanup of hazardous waste disposal sites, landfills, waste lagoons, land treatment operations, and other sources of groundwater contamination; studies of transport and fate of toxic chemicals in lakes, rivers, and estuarine waters with emphasis on providing information required for use in predictive models; development of predictive water quality models and techniques of varying complexity for application to toxic substances, nutrients, anoxic conditions, and resuspension of dredged materials after aquatic disposal; research in chemistry and physics to develop new measurement and monitoring techniques including instrumentation, for increasing sample through-put, sensitivity, and selectivity, and for field use. Application/information kit should be obtained from the address listed prior to submitting a proposal.

Requirements: Nonprofit institutions and state or local governments are eligible; profit-making firms are eligible only under certain laws and under restrictive conditions including the absence of any profit from the project.

Date(s) Application is Due: Feb. 15, Aug. 15.

Program No.: 66.500 to 66.507 inclusive.

⁴⁵ *Id.* at 374.

Sponsor: Louis G. Swaby, Ph.D.
Science Review Administrator (RD-875)
Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
(202) 382-7445

Environmental Air/Water Chemistry and Physics Exploratory Research Grants.⁴⁶ The objectives of this program are to develop, improve, and test the theories and concepts on which the methods, tools, and models required for environmental protection decisions are based. Of primary concern are new or improved concepts of extracting, concentrating, identifying, and quantifying trace amounts of organic and inorganic chemicals in complex environmental samples; the scientific understanding of the basic processes by which pollutants are transported, transformed, degraded, or otherwise distributed in (air, water, soil) environmental media; new or simplified concepts for quantitatively characterizing natural environments so that model representations preserve the structure and functional relationships essential in predicting the fate and impact of toxic and hazardous chemicals; and new concepts for predicting the fate and effects of chemicals based on molecular structure. The program is divided into research on air pollution and research on freshwater, marine/estuarine waters, groundwaters, soils, and sediments. Application/information kit should be obtained prior to submitting a proposal.

Requirements: Nonprofit institutions and state or local governments are eligible; profit-making firms are eligible only under certain laws and under restrictive conditions including the absence of any profit from the project. The proposed project must be for research, must directly pertain to EPA's mission, and must be of a long-term nature addressing the fundamental aspects of problems which do not necessarily lend themselves to quick solutions.

Date(s) Application is Due: Feb. 15, Aug. 15.

Program No.: 66.500 to 66.507 inclusive.

Sponsor: Louis G. Swaby, Ph.D.
Science Review Administrator (RD-675)
Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
(202) 382-7445

⁴⁶ *Id.* at 338.

Environmental Engineering Drinking Water and Wastewater Treatment and Pollution Control Exploratory Research Grants.⁴⁷ Under this category of the environmental research program, EPA's areas of research interest include reaction kinetics and by-products identification of alternatives to chlorine; improvements in sludge digestion and gas production; sludge stabilization, dewatering, and thermal processing including disposal in the marine environment; in-plant process operations minimizing or eliminating toxics generation and release to the environment; groundwater decontamination; production of genetically engineered organisms for degradation of toxic and/or hazardous wastes in contaminated water, groundwater, and sediments and for improving biological treatment; development of predictive techniques for the treatment and release of and exposure to toxic chemicals and asbestos; and development of rapid, cost-effective biomonitoring techniques for water supply and wastewater treatment systems. Innovative residual controls research includes municipal water and wastewater sludge volume reduction and final disposal practices which lower concentrations of pathogens, parasites, heavy metals, and synthetic organics; recovery techniques for metals from industrial sludges; handling and disposal of hazardous solid wastes including detoxification, solidification, and otherwise fixing organic waste before disposal in secure landfills; improving landfill construction methods and materials and improving monitoring methods; cleanup techniques (e.g., in-situ treatment) for contaminated soils, structures, surface and groundwater, and asbestos; and improved thermal destruction (incineration) or other treatment techniques (e.g., biological or chemical) for the final disposition of hazardous materials. Application/information kit must be obtained from the address listed prior to submitting a proposal.

Requirements: Nonprofit institutions and state and local governments are eligible. Profit-making firms are eligible only under restrictive conditions including the absence of any profit from the project.

Date(s) Application is Due: Feb. 15, Aug. 15.

Program No.: 66.500 to 66.507 inclusive

Sponsor: Louis Swaby, Ph.D.
Science Review Administrator (RD-675)
Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
(202) 382-7445

Environmental Engineering Exploratory Research Grants. This program reflects EPA's research activities in multimedia (solid, liquid, gaseous) pollution control approaches including emissions reduction/control processes associated with hazardous material and energy production and conservation, increased efficiencies, recycling, and reuse. Areas of interest

⁴⁷ *Id.*

include, but are not limited to, fundamental mechanisms in drinking water and municipal and/or industrial wastewater treatment and pollution control; development of innovative new technology in drinking water and municipal and/or industrial wastewater treatment and pollution control; development of predictive techniques for the treatability, release of, and exposure to toxic chemicals and asbestos; development of rapid, cost-effective biomonitoring techniques for water supply and wastewater treatment systems; innovative residuals control; air pollution control technology exploratory research; and fundamental thermal destruction/combustion research leading to less pollutant production and to better incineration of hazardous wastes. Application/information kit should be obtained from the EPA prior to submitting proposal.

Requirements: Eligible to apply are nonprofit institutions and state or local governments; profit-making firms are eligible only under certain laws and under restrictive conditions including the absence of any profit from the project. To be considered, a proposed project must be for research, must directly pertain to EPA's mission, and must be of a long-term nature which addresses fundamental aspects of problems which do not necessarily lend themselves to quick solutions.

Amount of Grant: \$20,000-\$453,000; average \$135,000.

Date(s) Application is Due: Feb. 15, Aug. 15.

Program No.: 66.501-66.506 inclusive.

Sponsor: Director, Research Grants Staff, RD-675
Environmental Protection Agency
401 M St., S.W.
Washington, DC 20460
(202) 382-7473

Environmental Exploratory Research Grants.⁴⁸ A primary goal of EPA's Office of Research and Development (ORD) is to develop new knowledge and principles which can be used to address and resolve environmental problems. To this end ORD solicits research grants through their Office of Exploratory Research. The principal areas of interest and specific research needs fall under the categories of environmental biology, environmental health, environmental engineering, and *environmental air/water chemistry and physics*. These categories are by no means all inclusive. Every scientifically meritorious proposal will be accorded full and fair consideration, although they must be germane to EPA's mission. Application forms, instructions, and other pertinent information are available in the EPA Research Grant Application/Information Kit. It is recommended that interested investigators review the material in this kit before preparing an application for assistance. The kits are available from either of the two offices listed.

Requirements: Nonprofit institutions and state or local governments are eligible; profit-making firms are eligible only under certain restrictive

⁴⁸ *Id.* at 339.

conditions including the absence of any profit from the project. Investigators at minority institutions and those who have not previously received support are encouraged to submit applications. While applications are accepted at any time, proposals will be evaluated at semi-annual peer review panel meetings. *Date(s) Application is Due:* Feb. 15, Aug. 15. Receipt of application satisfies deadline date requirements.

Program No.: 66.500 to 66.507 inclusive.

Sponsor: Grants Operation Branch
Grants Administration Division, PM-216
or
Research Grants Staff
Office of Exploratory Research, RD-675
Environmental Protection Agency
401 M St., S.W.
Washington, DC 20460
(202) 382-7445

Ecological and Toxicological Effects Exploratory Research Grants.⁴⁹ Under this areas of the environmental biology research program, EPA's research interests include studies delineating the effects of gaseous and particulate air pollution (e.g., acid rain) on forests, crops, and *receiving waters and their biota*; studies to examine the mechanisms by which major pollutants combine to alter plant growth and produce pathological symptoms in plants; studies on the sublethal effects of toxic chemicals and their biodegraded products on the behavior of animals; effects of chemicals on wildlife including effects on populations and individuals; ecological significance of the loss, due to exposure to toxic chemicals, of a portion of a natural population; modes by which organisms (i.e., fish, algae, and plants) are exposed to *chemicals in freshwater* and marine sediments; and studies defining the role of bacteria in the movement, transfer, and *destruction of pollutants in soil and water*. Application/information kit is available from the address listed and should be obtained before submitting a proposal.

Requirements: Nonprofit institutions and state or local governments are eligible to apply. Profit-making firms are eligible only under restrictive conditions including the absence of any profit from the project.

Date(s) Application is Due: Feb. 15, Aug. 15. Receipt of application satisfies deadline date requirements.

Program No.: 66.500 to 66.507 inclusive.

Sponsor: Louis G. Swaby, Ph.D.
Science Review Administrator (RD-675)
Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
(202) 382-7445

⁴⁹ *Id.* at 327.

2. U.S. Department of Agriculture

Cooperative Forestry Research Grants.⁵⁰ The grants encourage and assist states in carrying on a program of forestry research at forestry schools and to develop a trained pool of forest scientists capable of conducting needed forestry research. Categories of forestry research supported include reforestation and management of lands for the production of crops of timber and other related products of the forest; management of forest and related watershed lands to improve conditions of waterflow and to protect resources against flood and erosion; management of forest and related rangeland for production of forage for domestic livestock and game and improvement of food and habitat for wildlife; management of forest lands for outdoor recreation; protection of forest resources against fire, insects, diseases, or other destructive agents; utilization of wood and other forest products; development of sound policies for the management of forest lands and the harvesting and marketing of forest products; and other studies necessary to obtain the fullest and most effective use of forest resources. Applications are accepted at any time.

Requirements: Applicants must be state institutions certified as eligible by the governor of each state.

Amount of Grant: \$27,406-\$602,642; average grant \$274,800.

Program No.: 10.202

Sponsor: Administrator
Cooperative State Research Service
Department of Agriculture
Washington, DC 20250
(202) 447-4423

Forestry Research Grants.⁵¹ The program extends the research activities of the Forest Service by awarding grants to nonprofit institutions of higher education and organizations engaged in scientific research. Grants will be used for research in the fields of timber management, *watershed management*, forest range management, wildlife habitat management, forest recreation, forest fire protection, forest insect and disease protection and control, forest products utilization, forest engineering, forest production economics, forest products marketing, and forest survey. Grants are limited to 5-years duration. Contact the regional experiment stations for deadlines.

Amount of Grant: \$2000-\$100,000; average grant \$25,000.

Program No.: 10.652

⁵⁰ *Id.* at 261.

⁵¹ *Id.* at 368.

Sponsor: Peter J. Roussopoulos
Deputy Chief for Research
Forest Service
Department of Agriculture
P.O. Box 96090
Washington, DC 20090-6090
(202) 447-7075

3. Department of Energy

DOE Energy from Municipal Waste Projects Grants.⁵² Grants support research to provide a database on liquids and gas production and to provide a basis for environmental and feedstock preparation. Potential areas for new research initiatives include thermochemical studies to provide a generic technology base for systems producing liquid and gaseous fuels; combustion tasks concerned with kinetics, efficiency, and products formation for corrosion and pollution control; pyrolysis tasks concerned with base data development on effects of various feedstock components and of time, temperature, pressure, and so forth; biochemical studies to provide data on biochemistry and life support systems of anaerobes; *water and wastewater studies to provide information to improve energy efficiency in treatment systems*; mechanical studies to provide generic data on processing generic data on systems design; and improved densification techniques and binders. Proposals are accepted at any time.

Program No.: 81.086

Sponsor: Donald K. Walker
Energy from Municipal Waste
Energy Conservation R&D Program
Office of Conservation & Renewable Energy
Department of Energy
Forrestal Bldg.
1000 Independence Ave., S.W.
Washington, DC 20585
(202) 586-6104

DOE Radioactive Waste Geologic Repository Deployment Grants.⁵³ Grants support research to locate, design, construct, operate, and decommission radioactive waste disposal facilities. The program is responsible for screening and characterizing potential geologic repository sites; recommending sites; conducting in-situ tests within exploratory shafts; designing a test and evaluation facility; and managing the R&D of disposal technology for repositories. Potential areas for new research initiatives include absorption of

⁵² *Id.* at 301.

⁵³ *Id.* at 310.

radionuclides on geologic media; leaching of waste forms in groundwaters; interactions among the materials of the waste package, host rocks, and groundwaters; fracture flow in geologic media; radiation effects on repository containment; solubility of radionuclides in groundwaters; flow and transport in unsaturated media; measurement of hydrologic parameters in rocks with low permeability radiation effects on deep-sea organisms; development of deep ocean monitoring techniques; and identification and characterization of the life cycle of mid-water organisms.

Program No.: 81.065

Sponsor: J. William Bennett
Geologic Repository Deployment
Office of Civilian Radioactive Waste Management
Department of Energy
Germantown, MD 20545
(301) 353-4286

4. Department of Commerce Programs

National Sea Grant College Support Program.⁵⁴ The Sea Grant program supports research, education, and marine extension services based upon competitive proposals and their vigorous review. The mission of the program is to increase the understanding, assessment, development, utilization, and conservation of the nation's ocean and coastal resources by providing assistance to promote a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques. Currently, 29 sea grant colleges and institutions serve as the core to the program which operates through a network of over 200 participating universities and marine research institutions throughout the nation, marshalling the intellectual talents and skills of over 3000 scientists, engineers, educators, extension service agents, and students working together to advance knowledge in the marine economic sector. The program supports projects in a wide array of marine-related subjects through its 5 divisions: living resources, nonliving resources, technology and commercial development, environmental studies, and human resources. In addition, a grants management division handles the processing of grants and managing of the sea grant network's computerized information system. Research support is divided into subject areas under each division. Under living resources division, subject areas include: plant and animal aquaculture, fisheries, seafood science and technology, marine biotechnology, and microbiology and DNA technology. Under nonliving resources division, subject areas include: marine mineral resources, coastal processes, energy related projects, and diving physiology and safety. Under technology and commercial development, subject areas include: marine transportation, ocean engineering, marine economics, and marine recreation and tourism.

⁵⁴ *Id.* at 647.

Under the environmental studies division, subjects include: environmental quality and estuarine studies. The human resources' subjects include: communication, education and training, marine advisory services, marine policy and social sciences, and ocean law. A booklet outlining the extent of the current program is available to interested persons upon request.

Restrictions: Grant money may not be used to purchase or construct ships or facilities.

Requirements: Universities, colleges, junior colleges, technical schools, institutes, laboratories, and any public or private corporation, partnership, or other association or entity may apply for grants under this program. Also, any individual, state, political subdivision of a state or agency or officer thereof are eligible to apply.

Amount of Grant: \$45,000-\$2,250,000; average grant \$775,000; 1/3 of funds must be matched.

Program No.: 11.417

Sponsor: Ned A. Ostenso, (301) 443-8923
Director, National Sea Grant College Program
or
William Graham, (301) 443-8926
Assistant Director, Grants Management Division
National Oceanic & Atmospheric Administration
6101 Executive Blvd.
Rockville, MD 20852

B. Federal Institutes (does not include marine, coastal, estuary programs)

1. National Heart, Lung, and Blood Institute (NHLBI)

NHLBI Epidemiology and Biometrics Grants.⁵⁵ Epidemiological studies of heart and vascular, pulmonary, and blood diseases, as well as biometrical and statistical analyses of research relating to the NHLBI programs, are supported in populations within the U.S. and in other countries, such as studies in Puerto Rico, Japan, Hawaii, Israel, and Yugoslavia. Other activities include genetic studies of twins and *possible relationships of trace elements in drinking water to heart disease*. Grant-supported research into hypertension in the young is underway.

Date(s) Application is Due: Feb. 1, Jun. 1, Oct. 1. Receipt of application satisfies deadline date requirements.

Renewal Dates: Mar. 1, Jul. 1, Nov. 1.

Program No.: 13.837-13.838-13.839.

Sponsor: Associate Director for Epidemiology and Biometry
National Heart, Lung, and Blood Institute
Bethesda, MD 20892-4200
(301) 496-2327

⁵⁵ *Id.* at 683.

2. National Institute of Environmental Health Sciences

Marine and Freshwater Biomedical Sciences Specialized Centers of Research Grants.⁵⁶ Grants provide core support for multidisciplinary research on environmental health problems. These centers foster research using marine organisms as models in studies on air, water, and food pollution; occupational and industrial neighborhood health and safety; heavy metal toxicity; agricultural chemical hazards; the relationships of the environment to cancer, birth defects, behavior anomalies, respiratory and cardiovascular diseases; and disease of other body defense mechanisms. The centers also support research on the influence of aging, nutrition, and other factors in chemically-induced injury and disease.

Amount of Grant: \$267,000-\$2,884,000; average grant \$1,057,000

Date(s) Application is Due: Feb. 1, Jun. 1, Oct. 1. Receipt of application satisfies deadline date requirements.

Renewal Dates: Feb. 1, Jun. 1, Oct. 1.

Program No.: 13.894

Sponsor: Director, Division of Extramural Research and Training
National Institute of Environmental Health Sciences
P.O. Box 12233
Research Triangle Park, NC 27709
(919) 541-7723

Biometry and Risk Estimation--Health Risks from Environmental Exposures Research Grants.⁵⁷ The grants and contracts support research in statistics, biomathematics, epidemiology, and risk assessment directed at estimating the probable risks of cancer, reproductive effects, and other adverse effects from various environmental factors. Major emphases are on refining existing methods for estimating human risks from data derived from studies on laboratory animals and on examining the quantitative aspects of designing short-term tests and interpreting the data from these tests. Current research focuses on the relationships between exposure to a variety of harmful substances and human disease. Field studies are supported to assess the effects of air pollutants, drinking water contamination, breast milk, contamination by substances such as polychlorinated biphenyls (PCB's) and DDE, indoor air pollution, effects of lead on children, and many others.

Requirements: A university, college, hospital, state or local government, nonprofit research institution, or for-profit organization may submit an application.

Amount of Grant: \$41,000-\$2,024,000; average grant \$588,000

Date(s) Application is Due: Feb. 1, Jun. 1, Oct. 1. Receipt of application satisfies deadline date requirements.

⁵⁶ *Id.* at 555.

⁵⁷ *Id.* at 158.

Renewal Dates: Mar. 1, Jul. 1, Nov. 1.

Program No.: 13.115

Sponsor: Director, Division of Extramural Research and Training
National Institute of Environmental Health Sciences
P.O. Box 12233
Research Triangle Park, NC 27709
(919) 541-7723

3. National Science Foundation

Surficial Processes Research Grants.⁵⁸ Research supported covers physical and chemical processes active at or near the earth's surface. Research includes geomorphology and quaternary geology, low-temperature geochemistry, *surface waters and groundwaters*, glaciology, soil genesis and classification, fossil-fuel generation, and study of geologic hazards. This program is part of the Research Grants Section, which deals primarily with proposals from individuals and small groups of investigators.

Date(s) Application is Due: Jun. 1, Dec. 1. Receipt of application satisfies deadline date requirements. Allow 6-9 months for review and processing.

Program No.: 47.050.

Sponsor: Dr. John Maccini
Surficial Processes
Division of Earth Sciences
Directorate for Geosciences
National Science Foundation
1800 G St., N.W.
Washington, DC 20550
(202) 357-7866

Environmental Engineering Research Grants. Research activities supported deal with impact of human activities that adversely affect water, air, and land. The problems of environmental quality and water-borne pollutants are addressed by research activities in the hydrodynamics of mixing, diffusion, dispersion, and sedimentation; the chemical reactions in water, on land, and in the air; and the biological activity of plants and animals on land and in water. Other research activities are directed toward investigating alternative chemical manufacturing processes that would produce less hazardous wastes; converting hazardous wastes into useful by-products; and using recombinant DNA techniques to produce organisms for enhancing the treatment of hazardous wastes. Proposals may be submitted at any time; allow at least 6 months for processing.

⁵⁸ *Id.* at 915.

Sponsor: Dr. Edward Bryan (202) 357-7737
Dr. Tapan Mukherjee (202) 357-9545
Environmental Engineering
Critical Systems
Directorate for Engineering
National Science Foundation
1800 G St., N.W.
Washington, DC 20550

C. Foundation Funding (does not include marine, coastal, estuary programs)

ARCO Foundation Environmental Program Grants.⁵⁹ The foundation allocates a small share of its grant funds to selected programs and organizations devoted to the natural environment. Environmental efforts that will be considered include: organizations that address natural resource and land use issues and that have a proven record of balanced analysis and judgment on these issues; programs that promote environmental education and natural history activities; programs for the preservation of ecologically unique land or recreational land for public access; programs for wildlife conservation and protection of endangered species; and balanced policy studies and action programs on risk assessment and risk management of hazardous wastes, toxicology, and *groundwater contamination* and reclamation. Applications are accepted at any time; guidelines should be obtained prior to submitting a proposal.

Restrictions: The foundation will not support consistently adversarial environmental organizations; organizations that promote only quid pro quo positions; political or business lobbying organizations; or land preservation activities with parochial or self-serving aims rather than concern for increasing public access.

Amount of Grant: Total of approximately \$1 million in environmental programs.

Sponsor: E.R. Wilson, President
ARCO Foundation
515 S. Flower St.
Los Angeles, CA 90071
(213) 486-3342

⁵⁹ *Id.* at 90.

BARD Research Grants.⁶⁰ The United States-Israel Binational Agricultural Research and Development Fund (BARD) was established by the governments of the U.S. and Israel for the purpose of promoting and supporting cooperative research and development projects in agriculture for the mutual benefit of both countries. Proposals may be unidisciplinary or interdisciplinary and may cover any or all phases of research and development. BARD will consider financing research and development projects, exploratory or basic research studies, and small initial feasibility studies and other closely related activities in the areas of soil and *water conservation management and utilization*; crop production including new technology; crop production; animal production including aquaculture; veterinary medicine; crop and animal genetic improvement; recycling of wastes; post-harvest sciences covering operations from production through processing; agricultural engineering; agricultural economics; and cellular and molecular biology in agriculture. Investigators of either country may, at their convenience, request further information or mail proposals to Ben Kopacz, USDA-ARS-IA-BARD at the address listed or Yair Guron, BARD Executive Director, Volcani Center, P.O. Box 6, GBet Dagan, Israel 50250, 03-980230.

Requirements: BARD will accept research proposals from institutions of higher learning as well as government institutions and nonprofit organizations whose primary activity is research. Scientists who wish to apply for grants should submit their proposals through such legally constituted institutions or agencies. The research proposal should be prepared jointly by all investigators and should describe the areas of anticipated cooperative endeavor between them. BARD will assist scientists who are unable to find cooperators; the BARD office in Israel or its liaison office in the U.S. should be contacted if such assistance is necessary.

Date(s) Application is Due: Sep. 1. Receipt of application satisfies deadline date requirements.

Sponsor: Lynn Gipe
Administrative Officer
BARD, c/o Department of Agriculture
United States-Israel Binational Agricultural Research
& Development Fund
Bldg. 5, Rm. 107, BARC-West
Beltsville, MD 20705
(301) 344-2605

⁶⁰ *Id.* at 139.

William H. Donner Foundation Grants.⁶¹ The foundation offers grant support in 3 areas: U.S.-Canadian relations; coastal and *inland water resources*; and nutrition education. A brief letter describing the project proposed for support should be submitted prior to a formal proposal. Applications are accepted at any time.

Restrictions: The foundation does not support construction or renovation of buildings, capital campaigns, annual charitable drives, research and travel, operating deficits or loans, or individuals not affiliated with nonprofit organizations.

Sponsor: President
William H. Donner Foundation
630 5th Ave.
New York, NY 10111
(212) 719-9290

General Services Foundation Natural Resource Grants.⁶² The foundation supports programs and projects for improving the use, management, and quality of *water* in the U.S., particularly west of the Mississippi River, and developing food, water, fuel, forage, forests, and/or fertilizer on a sustainable basis in developing countries, and particularly tied in with family-planning education and services. The foundation will make occasional contributions to exceptional proposals in an area not coming strictly within the approved guidelines, and is interested in initiatives at any level of the educational system which promise to develop integrative thinking and an international perspective.

Restrictions: In general, contributions are not made to operating budgets or to annual campaigns of established organizations. Nor does the foundation ordinarily contribute to capital (physical plant, equipment, endowment), to individuals, or for relief.

Requirements: Grants are made to organizations that are tax-exempt under U.S. laws. The foundation prefers projects and/or programs which give promise of significant contribution and which are new, innovative, demonstrational, and/or research in nature.

Sponsor: Robert W. and Marcie J. Musser
General Services Foundation
P.O. Box 4012
Boulder, CO 80306
(303) 447-9541

⁶¹ *Id.* at 314.

⁶² *Id.* at 389.

German Marshall Fund Comparative Domestic Program--Environmental Grants. The objective of the program is to support the exchange of experience, practices, and policy approaches between Europe and the U.S. in defined issue areas and to encourage productive cooperation among environmental experts and policymakers. The fund currently takes a special interest in consensus building and regulatory processes that are directed toward protection of critical soil, air, and water resources from acid deposition and nonpoint pollution; better management of toxic wastes; and conservation of non renewable energy resources. While the principal focus is on policymaking and implementation, the program also supports a small amount of policy-relevant research in order to consolidate its fellowships and exchanges and to broaden the impact of all activities. Applications for grants are considered throughout the year.

Sponsor: Marianne L. Ginsburg
Environmental Program Officer
German Marshall Fund Fund of the United States
11 Dupont Circle, N.W.
Washington, DC 20036
(202) 745-3950

Jessie Smith Noyes Foundation Grants.⁶³ The Jessie Smith Noyes Foundation provides support only to tax-exempt organizations with 501(c)(3) classification from the Internal Revenue Service. Normally, the foundation will not consider requests for endowment grants, loans, or scholarships to individuals, capital construction funds or general fund-raising drives. The foundation's program areas are exclusively environment and population. Specifically, the environment program consists of tropical ecology in the Western Hemisphere and sustainable agriculture in North and Latin America, which include preservation of genetic diversity, and *groundwater in the U.S.* The population program is limited to family-planning programs in Third World countries. Projects that address the connections among these problems and their global implications, and especially those that have a widespread impact or applicability, are of particular interest. Letters of inquiry are due June 1 for November board meeting and December 1 for May meeting. Proposals will be requested from foundation after review.

Date(s) Application is Due: Jun. 1, Dec. 1. Receipt of application satisfies deadline date requirements.

Sponsor: Stephen Viederman, President
Jessie Smith Noyes Foundation
16 E. 34th St.
New York, NY 10016
(212) 684-6577

⁶³ *Id.* at 717.

W. Alton Jones Foundation. Grants are awarded in the areas of conservation of biological diversity; protection of air, land, and water from pollution and toxic contamination; and nuclear arms policy and control. Applications are accepted at any time. Board meets the first of January, April, July, and October at which times accumulated proposals will be reviewed.

Requirements: Applying organizations must be tax-exempt under the IRS Code.

Amount of Grant: \$1000-\$2,500,500.

Sponsor: Charles H.W. Foster, President
W. Alton Jones Foundation
614 E. High St., Ste. 1
Charlottesville, VA 22901
(804) 295-2134

Joyce Foundation Grants.⁶⁴ The foundation awards grants primarily in the fields of conservation, culture, economic development, education, government, and health. In conservation, groundwater protection, soil conservation, the Great Lakes, and reducing air pollution are of basic concern to the foundation. The foundation strives to improve educational opportunities offered to low-income students in primary, secondary, and collegiate institutions.

Requirements: Applications should be made only by organizations that can demonstrate their tax-exempt status and that can supply complete financial information and permit the results of a grant to be audited. Preference is given to nonprofit organizations having a base or program in the Midwest.

Amount of Grants: Approximately \$10 million per year.

Date(s) Application is Due: May 15 for conservation proposals. Receipt of application satisfies deadline date requirement.

Sponsor: Craig Kennedy, President
Joyce Foundation
135 S. LaSalle St., Ste. 4010
Chicago, IL 60603
(312) 782-2464

W.K. Kellogg Foundation Grants.⁶⁵ Grants focus on current areas of activity and are limited to the fields of agriculture, education, community leadership, and health with emphasis on the following areas: a wholesome food supply; broadening leadership capacity of individuals; adult continuing education; community-based, problem-focused health services; opportunities for youth; and economic development in Michigan. The following areas of interest are seen by the foundation as sufficiently promising to warrant exploration and limited grantmaking: development of rural America; *water resources*;

⁶⁴ *Id.* at 503.

⁶⁵ *Id.* at 510.

information management systems in America; and science education. Decisions will be made subsequently as to whether these themes, or variations of them, may become major parts of foundation programming. A new grant program strengthens public policy education in agriculture. Applications are accepted at any time.

Restrictions: The foundation does not provide loans nor does it provide grants for operational phases of established programs; capital facilities, equipment, conferences, publications, films, television, or radio programs unless they are an integral phase of a project already being funded; endowments or developmental campaigns; religious purposes; or individuals (except for fellowships in specific areas of foundation programming).

Amount of Grants: Total of \$122 million.

Sponsor: Executive Assistant, Programming
W.K. Kellogg Foundation
400 North Ave.
Battle Creek, MI 49017-3398
(616) 968-1611

Northwest Area Foundation.⁶⁶ The foundation's grants support organizations involved in regional economic vitality--community development, economic development, macro-capital mechanisms, and macroeconomics/public policy; responsibly meeting basic human needs--economic self-sufficiency for vulnerable populations, housing, primary health care for low-income and rural and underserved populations, and teen pregnancy prevention; enhancing and *conserving natural resources--agriculture, air, land, water*; and providing access to the arts--artistic excellence and organizational development/management. Grants are awarded for research and public education on the effects of economic development strategies and other policies on rural economics. Applications are accepted throughout the year.

Restrictions: Grants are not awarded for building, renovation, or equipment; general operating; to individuals or for scholarship or travel; publication, film, video; workshop, conferences, symposium; duplication or expansion or existing effort; propaganda or lobbying; leadership development; scientific research; higher education; youth education; legally mandated programs; or voter registration. Organizations supported must be operating in Minnesota, Iowa, North and South Dakota, Montana, Idaho, Washington, and Oregon.

Requirements: Applicants must be nonprofit organizations.

Amount of Grant: Average grants \$40,000-\$60,000 with a total of approximately \$9 million annually.

⁶⁶ *Id.* at 715.

Sponsor: Terry T. Saario, President
Northwest Area Foundation
W-975 First National Bank Bldg.
St. Paul, MN 55101-1373
(612) 224-9635

D. Corporate Funding

Chevron Contributions Program. Chevron's primary interest is in programs that address critical issues where support can make a discernible difference. Education continues to be the highest priority. Higher education receives support for programs designed to upgrade curriculum and to increase the participation of women and minorities in important technical areas. The environment, its protection, and conservation is a high priority for the company and nonprofit organizations are assisted in projects dealing with water and air quality, land preservation, and the protection of endangered species. Applications are reviewed on an ongoing basis; it usually takes 90 days to complete evaluation.

Requirements: Grants are made to tax-exempt organizations.

Amount of Grant: \$1000-\$1.4 million.

Sponsor: Skip Rhodes
Manager of Corporate Contributions
Chevron Corporation
P.O. Box 7753
San Francisco, CA 94120-7753
(415) 894-5464

Sohio Corporate Contributions Program.⁶⁷ The three issues the company has chosen on which to focus its giving are energy and natural resources, education, and urban planning and economic redevelopment. Topics of interest under the energy and natural resources category include the impact of energy costs on the poor, the disabled, and the elderly; as well as on nonprofits and governmental agencies; development of new energy resources; and environmental preservation and land and *water use*. Education is the highest priority. Grants support graduate programs and research in technology and the geological sciences; programs promoting advancement of minorities, particularly in the sciences; and efforts to improve management of secondary education.

Restrictions: No grants are made to individuals or for religious purposes.

Requirements: Organizations presenting a proposal must have tax exempt status.

Amount of Grant: \$2000-300,000.

⁶⁷ *Id.* at 890.

Sponsor: Charles E. Taylor
Director, Corporate Contributions
Standard Oil Company of Ohio (SOHIO)
Midland Bldg.
Cleveland, OH 44115
(216) 575-8621

E. Fellowships

Abel Wolman Doctoral Fellowships.⁶⁸ The fellowships are designed to encourage promising students to pursue advanced training and research in the field of water supply and treatment.

Requirements: Applicants must be citizens of Canada, Mexico, or the U.S., and anticipate the completion of the requirements for a Ph.D degree within the next 2 years.

Amount of Grant: \$10,000 stipend distributed over 12 months, \$1000 for research supplies and equipment, and a maximum of \$4000 for tuition and other fees.

Date Application is Due: April 1. Receipt of application satisfies deadline date requirements.

Sponsor: James L. Hardman
American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
(303) 794-7711

American Water Works Association Academic Achievement Awards.⁶⁹ The awards recognize outstanding academic achievement on a graduate level through the selection of excellent master's theses and doctoral dissertations that relate to the field of *potable water*. First and second place awards are given for master's theses and also for doctoral dissertations. An announcement and form must be obtained from the training programs manager prior to submitting an application.

Requirements: Applicants must have completed their theses or dissertations within the specified year.

Amount of Grant: \$1000 each, doctoral dissertation and master's thesis; \$500 for second place in each category.

Date(s) Application is Due: Oct. 1. Postmark satisfies deadline date requirements.

⁶⁸ *Id.* at 996.

⁶⁹ *Id.* at 77.

Sponsor: Kathy Chamberlain
Training Programs Manager
American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
(303) 794-7711 ext. 78

Asian Institute of Technology Scholarships.⁷⁰ Approximately 350 scholarships are awarded for study toward a graduate diploma, master's or doctoral degree in engineering--agricultural, environmental, structural, transportation geotechnical, industrial, water resources, human settlements development; computer applications and energy technology. Studies will be held for the duration of the project in the U.S. for Asian candidates and in Asia (eastward from Afghanistan through Japan) for U.S. candidates. The scholarship is paid directly to the institute for the recipient to use to cover tuition and fees, travel, and maintenance expenses. Fellows are expected to return to their own countries at the conclusion of the fellowship period.

Requirements: Suitably qualified Asians and Americans are eligible to apply. They must be engaged in cultural and artistic studies or activities.

Amount of Grant: \$2700 per term.

Date(s) Application is Due: January 15, May 15, September 15. Receipt of application satisfies deadline date requirements.

Sponsor: Head of Registry
Asian Institute of Technology
P.O. Box 2754
Bangkok 10501
Thailand

German Marshall Fund Comparative Domestic Program--Environmental Fellowships.⁷¹ Up to 12 fellowships are given annually to enable professional American and European environmentalists to spend up to 2 months on the opposite side of the Atlantic gaining firsthand knowledge of selected environmental policies and institutions. The American fellows pursue their inquiries under the guidance of the Institute for European Environmental Policy, based in Bonn, London, Paris, and Brussels. European fellows are chosen from France, Germany, and another European country (probably Spain in 1989). Application deadline varies.

⁷⁰ *Id.* at 123.

⁷¹ *Id.* at 394.

Sponsor: Marianne L. Ginsburg
Environmental Program Officer
German Marshall Fund Fund of the United States
11 Dupont Circle, N.W.
Washington, DC 20036
(202) 745-3950

Environmental Law Institute Fellowships.⁷² Internships are available for various period of time for attorneys, law students, and graduate students to serve at the Environmental Law Institute to provide access to facets of environmental law and policy, improve level of practice, and raise quality of debate on key legal/policy questions. Visiting scholars are also invited to work with the staff of the *Environmental Law Reporter*. Deadline date and further information may be requested from the president of the institute.

Sponsor: J. William Futrell, President
Environmental Law Institute
1616 P Street, N.W., Ste. 200
Washington, DC 20036
(202) 328-5150

Horton Research Grant in Hydrology and Water Resources.⁷³ One or more grants are awarded annually in support of a research project in hydrology and water resources, with the objective of fostering graduate student research leading to the completion of doctoral dissertations. Appropriate topics may be in *hydrology* including its physical, chemical, or biological aspects, or in *water resources policy* sciences including economic systems analysis, sociology, and law. A proposal must be signed by the student and by the faculty supervisor; formal application form must accompany the proposal.

Requirements: Applicant must be a Ph.D. candidate who is a member or student member of AGU.

Amount of Grant: \$4500-\$7500 plus travel allowance to attend the awards luncheon.

Date(s) Application is Due: Mar. 1. Receipt of application satisfies deadline date requirements.

Sponsor: Horton Research Grant
American Geophysical Union
2000 Florida Ave., N.W.
Washington, DC 20009
(202) 462-6903

⁷² *Id.* at 341.

⁷³ *Id.* at 440.

LARS Scholarships.⁷⁴ These scholarships, given in honor of Dr. Thurston E. Larson, are intended to provide encouragement to outstanding graduate students in the fields of *water treatment*, aquatic, analytic, and environmental chemistry; and corrosion control.

Requirements: Applicants must be pursuing a degree (M.S. or Ph.D.) at an institution of higher learning in the U.S., Canada, Guam, Puerto Rico, or Mexico, and will complete the degree requirements after August 31 of the year of deadline date.

Amount of Grant: \$3000 for M.S. candidates, \$5000 for Ph.D. candidates.

Date(s) Application is Due: Feb. 1. Receipt of application satisfies deadline date requirements.

Sponsor: Jon G. DeBoer
Director, Technical & Professional Dep't
American Water Works Ass'n
6666 W. Quincy Ave.
Denver, CO 80235
(303) 794-7711

⁷⁴ *Id.* at 525.

Appendix E:

Recent Grants for Water Projects

This appendix lists some of the water-related grants that have been announced since January 1, 1989. This list does not include grants in the following categories: faculty development and other higher educational grants, health, chemistry, science education, public policy, or wildlife projects.

Pew Charitable Trusts, Philadelphia, PA, \$250,000 grant over 2 years to Kenyon College, Gambier, OH, for equipment for biology, chemistry, and physics departments (reported Apr. 18, 1989).

William & Flora Hewlett Foundation, Menlo Park, CA, \$300,000 grant over 2 years to Clean Sites, Alexandria, VA, for general support (hazardous wastes program)(reported Apr. 4, 1989).

William & Flora Hewlett Foundation, Menlo Park, CA, \$100,000 grant over 3 years to Western Network, Santa Fe, NM, for general support (conflict resolution in natural resource field)(reported Apr. 4, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$128,600 grant to the University of Arizona, Tucson, AZ, to develop an educational model to get the average Arizonian involved in natural resource decisionmaking (reported Apr. 18, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$484,281 grant to Michigan State University for program to train community residents in proper handling of environmentally hazardous waste products (reported Apr. 4, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$34,150 grant to Au Sable Institute of Environmental Studies, Mancelona, MI, for program to increase public awareness of groundwater resource protection strategies (reported Apr. 4, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$570,975 grant over 3 years to Institute for Water Sciences, Western Michigan University, Kalamazoo, MI, for regional center for Groundwater Education in Michigan (reported Apr. 4, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, grants to heighten public awareness of groundwater resource and protection strategies made to: East Michigan Environmental Action Council, Birmingham, MI (\$202,400); Tri-County Regional Planning Commission, Lansing, MI (\$187,000); Kalamazoo

County Board of Commissioners, Kalamazoo, MI (\$123,825)(reported Jun. 13, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$185,210 grant to Ecology Center of Ann Arbor, Ann Arbor, MI), to heighten public awareness of strategies for protection of groundwater resources (reported May 2, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$570,975 grant to Western Michigan University to establish center for education on groundwater issues (reported May 2, 1989).

W.K. Kellogg Foundation, Battle Creek, MI, \$185,210 grant to Ecology Center of Ann Arbor, Ann Arbor, MI), for its Groundwater Education on Wheels program (reported May 30, 1989).

Northwest Area Foundation, St. Paul, MN, \$75,000 grant to Clark Fork Coalition, Missoula, MT, to support model project to involve the public in the Superfund toxic-waste cleanup process (reported Mar. 21, 1989).

Northwest Area Foundation, St. Paul, MN, \$150,000 to Greater Yellowstone Coalition, Bozeman, MT, to implement a comprehensive management plan for the Greater Yellowstone ecosystem (reported Mar. 21, 1989).

Northwest Area Foundation, St. Paul, MN, \$108,000 to Idaho Conservation League, Boise, ID, to support participation in Idaho's Anti-degradation Agreement (reported Mar. 21, 1989).

Northwest Area Foundation, St. Paul, MN, \$173,142 grant to the Minnesota Project, Minneapolis, MN, to improve hazardous waste collection (reported Mar. 21, 1989).

Northwest Area Foundation, St. Paul, MN, \$160,400 grant to 49th Parallel Institute, Bozeman, MT, to establish the Western Border Waters Forum (reported Mar. 21, 1989).

Northwest Area Foundation, St. Paul, MN, \$76,425 to the Northern Lights Institute, Missoula, MT, to test cooperative approach between landowners and water users in the development and implementation of management policies for the Clark Fork River Basin (reported Mar. 21, 1989).

Marin Community Foundation, Larkspur, CA, \$39,000 to Bay Institute of San Francisco, Sausalito, CA, for coordinated technical- and policy-development work of San Francisco Bay area environmental organizations in addressing Phases II and III of the State Water Board's Bay-Delta hearings (reported Mar. 21, 1989).

Marin Community Foundation, Larkspur, CA, \$33,000 to San Francisco Bay Delta Preservation Association, Sausalito, CA, to establish Baykeeper for San Francisco Bay to document law violations and act as a deterrent to activities that are harmful to the bay (reported Mar. 21, 1989).

Marin Community Foundation, Larkspur, CA, \$28,000 to Department of Geography, University of California, Berkeley, to complete an interdisciplinary applied research project to establish scientific guidelines for the restoration and conservation of tidal wetlands (reported Mar. 21, 1989).

Jessie Smith Noyes Foundation, New York, NY, \$30,000 grant to National Coalition Against the Misuse of Pesticides, Washington, DC, for adequate assessments of pesticides risks and benefits to farmers, consumers, and communities dependent on groundwater (reported May 2, 1989).

Jessie Smith Noyes Foundation, New York, NY, \$25,000 grant to Southern Environmental Law Center, Charlottesville, VA, to increase legal and technical assistance capacity in areas of toxics and surface and groundwater quality concerns (reported May 2, 1989).

Jessie Smith Noyes Foundation, New York, NY, \$25,000 grant to Tulane University School of Law, New Orleans, LA, to increase environmental legal capacity and training in groundwater protection (reported May 2, 1989).

Joyce Foundation, Chicago, IL, \$50,000 grant to the Council of Great Lakes Governors, Chicago, IL, for Great Lakes protection programs (reported May 30, 1989).

W. Alton Jones Foundation, Charlottesville, VA, \$228,000 3-year grant to Jacob Blaustein Institute for Desert Research, Ben-Gurion University, Israel, for a project to investigate the feasibility of planting trees in rocky and sand-dune terrain in the Negev Desert using "wasted" surface and subsurface water (reported May 30, 1989).

W. Alton Jones Foundation, Charlottesville, VA, \$120,000 grant to Chesapeake Bay Foundation, Annapolis, MD, for expanded research, advocacy, and litigation designed to reduce toxic contamination of the Chesapeake Bay (reported May 30, 1989).

W. Alton Jones Foundation, Charlottesville, VA, \$25,000 grant to the Ohio Environmental Council, Columbus, OH, for its Groundwater Quality Project (reported May 30, 1989).

George Gund Foundation, Cleveland, OH, \$51,398 grant to the National Wildlife Foundation, Washington, DC, for Great Lakes Model Water Quality Standards Project (reported May 16, 1989).

George Gund Foundation, Cleveland, OH, \$25,000 grant to Public Broadcasting Foundation of Northwest Ohio, Toledo, OH, for television documentary, "The Great Lakes: A Clear and Present Danger" (reported May 16, 1989).

George Gund Foundation, Cleveland, OH, \$30,000 grant to Wood, Seneca, Ottawa, and Sandusky Counties Community Action Commission, Fremont, OH, for a project seeking stronger safety regulations for underground storage tanks for petroleum products (reported May 16, 1989).

Honeywell Foundation, Minneapolis, MN, \$25,000 grant to Freshwater Foundation, Navarre, MN, to support a drought-education project (reported May 16, 1989).

Waste Management Inc., Oak Brook, IL, \$50,000 grant to National Audubon Society, New York, NY, to support EPA regulations on unregulated hazardous wastes (reported May 16, 1989).

Mary Reynolds Babcock Foundation, Winston-Salem, NC, \$25,000 grant to Piedmont Environmental Council, Warrenton, VA, for the Rappahannock River Basin Water Quality Project (reported July 11, 1989).