

**WRRC**

**Water Resources Research Center  
University Of Minnesota  
Room 107, Hubbard Building  
2675 University Avenue  
St. Paul, Minnesota 55114**

**Bulletin 61**

# **Ninth Annual Report**

# **Water Resources Research Center**

**A Report of Activities Supported  
By the Graduate School and the  
Office of Water Resources Research  
U.S. Department of the Interior  
During the Fiscal Year Ending  
June 30, 1973**

The work upon which this publication is based was supported in part by funds provided by the United States Department of the Interior as authorized under the Water Resources Research Act of 1964, Public Law 88-379

**AUGUST 1973**  
**Minneapolis, Minnesota**

**WATER RESOURCES RESEARCH CENTER  
UNIVERSITY OF MINNESOTA  
GRADUATE SCHOOL**

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## PREFACE

This is the Ninth in a series of annual reports covering the activities of the Water Resources Research Center, University of Minnesota. The report indicates the nature of the program conducted in the twelve months beginning July 1, 1972, and ending June 30, 1973, with funds provided by the Graduate School and the Office of Water Resources Research in connection with the Water Resources Research Act of 1964. It also gives some insight into the potential of the Center for both research and training with Federal and non-Federal support. It is hoped that the academic community will continue to expend its service to the State and Nation by conducting competent research in relation to water resources and by assisting in training additional scientists for work in the field of water resources through research.

This Bulletin is related to the Center Director's Office fiscal year 1973 program and to OWRR Annual Allotment Agreement No.: 14-31-0001-3823.

FCST-COWRR Research Category: 09-D

### Publication Abstract:

The fiscal year 1973 budget of the Center was 413,724. The Center supported 18 research projects involving 19 faculty members. These research projects were concerned with: mathematical watershed system analysis, aquatic plants, eutrophic lakes, groundwater basin information, water resources research planning, soil water movement, Mississippi river ecology, perception of water resources problems, financing of water resources development, water pollution and social factors, forest management, water resources policies, sub-surface irrigation, flood forecasting, water policy decisions, precipitation variations, and floods. About 51 students received employment through the Center's program. During fiscal year 1973, there were 32 reports generated through research projects.

### Publication Descriptors:

\*Research/ \*Water Resources/ \*Minnesota/ Education/ Projects/ Expenditures  
Manpower/ Water Management/ Water Pollution/ Water Resources Research Act

### Publication Identifiers:

\*Researchers/ \*Applied Research/ \*Basic Research/ Physical-Biological-  
Economic-Social Aspects/ Faculty

## WATER RESOURCES RESEARCH CENTER UNIVERSITY OF MINNESOTA GRADUATE SCHOOL

Annual Report to  
Office of Water Resources Research (OWRR)  
for Fiscal Year ending June 30, 1973  
Part I - Narrative Progress Reports

### DIRECTOR'S SECTION

#### INTRODUCTION

The origin, history, organizational structure, functions, goals, objectives and programs of the Water Resources Research Center are described below.

#### Origin and History

One of the most significant recent changes in higher education is the phenomenal growth of offices, bureaus, centers, laboratories and institutes. Developed in response to increased demands for the application of academic research to the social and technical problems of the nation, more than 5,000 institutes and centers are now in operation at universities and colleges.<sup>1/</sup> No easy description of these additions to the academic landscape is possible. They carry out a bewildering variety of purposes, use many different organizational models, are supported at widely disparate levels of investments, are sometimes housed in obscure corners of the campus, and are found at all levels of the organizational hierarchy. Most institutes and centers began their work since World War II.

The growing demands for research and public service, as well as education have undoubtedly contributed to the proliferation of institutes and centers. Recognition that research was not only useful but perhaps essential to progress in this scientifically and technologically advanced age resulted in a dramatic increase in governmental and other support for university-based research. Changing societal needs and the growth of organized research in universities were accompanied by the expectation of sponsors that efforts would be task-oriented rather than discipline-oriented. The task, in turn, frequently required cross-disciplinary collaboration of individuals and a different organizational environment which maximized coordination and offered less professional autonomy than did the typical academic department.

Some degree of support from three sectors - agencies outside the university, the faculty and university administrators - was usually present in the formation of an institute or center. Increased Federal support, in combination with the growing reliance on universities by State governments, private foundation, business and industry, contributed very substantially to a major redefinition of the role of research in the university. The

<sup>1/</sup> Ikenberry, S.O. and R. C. Friedman. 1972. Beyond Academic Departments. Jasssey-Bass Inc., Publishers. San Francisco, Washington and London

emergence of research centers reflects, in part, attempts of universities to accommodate this newly defined mission.

The Water Resources Research Center at the University of Minnesota was established on September 1, 1964 directly as a result of Federal legislation. The Center was created shortly after the Federal Water Resources Research Act of 1964 was approved on July 17, 1964. That Act called for the establishment of one Water Resources Research Center or Institute in each State to be located at the land-grant college or university. Continuing financial support was pledged to the newly established centers under Title I of the Act. It was the purpose of the Act to stimulate, sponsor, provide for, and supplement existing programs for the conduct of research, investigations, experiments, and the training of scientists in the fields of water and of resources which affect water. Emphasis was placed on cross-discipline task or problem-oriented research and training.

Concern about a Water Resources Research Center at the University of Minnesota started on May 31, 1962 as a consequence of a letter from Senator Clinton P. Anderson to University of Minnesota President O. Meredith Wilson requesting information on water related research which could be used to appraise the need for Federal legislature leading to the passage of a Water Resources Research Act. During the period May 31, 1962 through August 3, 1964, numerous meetings were held on the campus involving many university officials and faculty members. The purposes of the meetings were to: formulate purposes, objectives and organizational arrangements for a Center, make preparations for a Center to participate in the programs associated with the Water Resources Research Act of 1964, and to retain a Center Director. On August 4, 1964 a proposal for the establishment of a Water Resources Research Center was agreed upon by various ad hoc committees, the Dean of the Graduate School and the Vice President for Academic Administration. A Director was retained to establish the Center on September 1, 1964. The contents of that proposal are provided below.

Proposal for the establishment of a Water Resources Research Center at the University of Minnesota adopted on August 4, 1964.

The purposes and objectives of the Water Resources Research Center should be as follows:

1. To integrate the diverse water-research activities of the University of Minnesota and to coordinate them with water programs of State and Federal agencies, other academic institutions, and private organizations.
2. To identify and define those areas in which current water research in the University is deficient and to stimulate new research programs in these critical areas.
3. To encourage and integrate the teaching of various aspects of water resources at the University within the appropriate departments, at both graduate and undergraduate levels.

4. To serve as a formal unit to receive and allocate special funds for water resources research to qualified departments and individuals.

5. To serve as an information center on water-resources research in the University.

The Water Resources Research Center should be established in the Graduate School because of the all-University nature of its activities. Management of the Center should be vested in a Director. The Director should be a person with broad experience in water resources and with research experience in one or more areas of water resources. The Director should be selected by the Dean of the Graduate School in consultation with an Advisory Committee for Water Resources and the appropriate teaching department in which the Director would hold his academic tenure. The appointment should be a 12-month academic position with tenure.

The Advisory Committee for water resources should consist of members of the faculty representative of the various areas of water resources research. New appointments should be made by the Dean of the Graduate School from a recommendation list prepared by the Director and the Advisory Committee. The Director should be a member of the Committee ex officio.

Principal duties:

Director

1. The Director should be responsible for the effective operation of the Center.
2. The Director should represent the University of Minnesota in affairs relating to water resources.
3. The Director should inform the Dean of the Graduate School and the Advisory Committee about administrative, budgetary, technical, and scientific matters.
4. The Director should maintain liaison with the State and Federal agencies having research or operational programs in water.

Advisory Committee

- (1) to help identify research needs;
- (2) to help establish priorities among them;
- (3) to help develop the policy of the Center; and
- (4) to provide public liaison pertinent to the goals of the Center.

It is suggested that it meet at least once each quarter.

The Center has functioned during the period September 1, 1964 through June 30, 1973 following, in general, the provisions of the proposal under the supervision of the Director retained on August 4, 1964.

### Organizational Structure

The contract model adopted by the Federal government is largely responsible for the adaptive organizational structure of the Water Resources Research Center. The Center undergoes a continuous process of initiating and terminating projects; it has only a small managerial staff. The professional staff for research projects is drawn from the faculties of the University of Minnesota and State and Private Colleges. The Center has a small office of its own; it does not have a laboratory or library nor does it house any research equipment. Professional staff members do not have any long-term career identification with the Center. The Director, with the assistance of an Advisory Committee, is responsible for the effective operation of the Center. The organizational structure of the Center is designed to maintain flexibility in personnel commitments, space, equipment and other resources sufficient to make major changes in the tasks pursued as well as in the procedures followed. The desire to strengthen graduate education and research programs figures prominently in having the Water Resources Research Center function as a unit of the Graduate School. The Center is effective in generating needed external income for graduate education and research. Some have likened the university to a federation, composed of departments, colleges, schools, institutes, and centers, each going its own way and following its own interests. Much of the strength of the university as well as its own inefficiency and vulnerability result from this conditions. The Center provides one means of preserving the strenghts of this federated diversity among departments and individual faculty members while reducing the negative consequences through increased cross-departmental communication and coordination in the field of water resources.

The Center has functioned with a part-time Director, Assistant Director, Research Accountant, and Property Accounting Officer and a full-time Secretary. The Director has a 12-month academic appointment as a Professor in the Department of Geology and Geophysics. His salary is listed with the Graduate School and his immediate supervisor is the Dean of the Graduate School. The Assistant Director has a 12-month academic appointment as an Associate Professor in the Department of Agricultural and Applied Economics. His salary is listed with that Department and his immediate supervisors are the Head of the Department and the Center Director. The salaries of the Director and Assistant Director are fixed by the Graduate School and the Department of Agricultural and Applied Economics, respectively.

A Research Accountant in the Research Accounting Department of the University's Business Office serves on a part-time (10 percent) basis as the Center's Accountant. A Federal Property Specialist in the Property Accounting Department of the University's Business Office serves on a part-time (5 percent) basis as the Center's Property Accounting Officer. The Vice President for Finance, Planning, and Operations is the officer of the University concerned with the fiscal responsibility and accounting of the Center.

The Center does not have a research personnel nor does it have research facilities. It plans and arranges for faculty members in units of the University of Minnesota and State and Private Colleges to conduct research. Thus, the Center strengthens research activities in existing units of the University of Minnesota and State and Private Colleges and assists in expanding cross-disciplinary, multi-disciplinary and interdisciplinary research. Research equipment is assigned by the Center to units of the University of Minnesota and State and Private Colleges. All research personnel are housed in academic units.

In October 1964, the Water Resources Research Center established an Advisory Committee and a Consulting Council. The Advisory Committee consisted of 15 faculty members from 15 Schools, Departments and Divisions of the University of Minnesota; the Consulting Council was composed of 19 representatives from organizations outside the University. The Advisory Committee counseled with the Center Director, helped identify research needs, assisted in selected research projects the Center sponsored, assisted in determining the activities the Center undertook, and provided public liaison. The Consulting Council counseled with the Center Director, assisted in identifying needed research, assisted in integrating and coordinating University research with water resources projects outside the University, assisted in acquainting the Center with water resources activities in the State, and provided public liaison.

During the period October 1964 through August 1965, the Advisory Committee met once a month. The Advisory Committee met once every three months during fiscal years 1966 and 1967; twice a year during fiscal years 1968, 1969, and 1970; and once a year during fiscal years 1971 and 1972. The Consulting Council always met once a year. Until fiscal year 1971, the Advisory Committee and Consulting Council met separately. During fiscal years 1971 and 1972, joint meetings were held.

Joint meetings of the Advisory Committee and Consulting Council proved to be successful and it was deemed appropriate that the Center consolidate the Committee and Council into a single new Advisory Committee. The membership of the new Advisory Committee, activated in fiscal year 1973, reflects the need for greater representation from the social sciences, State and Private Colleges, Interest Groups, and State Agencies. Changes in the Advisory Committee membership were made to improve coordination between faculty members and Federal, State and Private organizations, and to assure that the Center programs are developed in close coordination and collaboration with leading water resources officials within the State. Advisory Committee members are appointed by the Center Director in consultation with the Dean of the Graduate School. The new Advisory Committee meets at least twice a year; rotation of some members will occur every three years to provide widespread representation. The Advisory Committee reviews the Center's programs and makes recommendations concerning activities and research needs and priorities; assists the Center in coordinating its programs with water resources programs of other organizations within the State; provides public liaison; and assists the Center in information dissemination. The roster of the new Advisory Committee is given below.

Roster of Center's  
Advisory Committee (1973-74)

William C. Walton, Director  
John J. Waelti, Assistant Director  
Elizabeth Hermansen, Secretary

University of Minnesota

A. G. Anderson	St. Anthony Falls Hydraulic Laboratory
V. L. Arnold	School of Public Affairs
W. J. Barrett	Dept. of Geography
R. G. Bond	School of Public Health
A. J. Brook	Dept. of Ecology and Behavioral Biology
L. P. Gerlach	Dept. of Anthropology
W. J. Hueg, Jr.	Agricultural Experiment Station
C. L. Larson	Dept. of Agricultural Engineering
A. C. Mace	School of Forestry
W. J. Maier	Dept. of Civil and Mineral Engineering
W. P. Martin	Dept. of Soil Science
P. K. Sims	Minnesota Geological Survey
T. F. Waters	Dept. of Entomology, Fisheries & Wildlife
H. E. Wright	Limnological Research Center

State and Private Colleges

C. H. Fuchsman	Center of Environmental Studies, Bemidji State College
J. Jack	Dept. of Geography, Mankato State College
R. T. Moline	Dept. of Geography, Gustavus Adolphus College

State, Local and Federal Agencies

R. M. Dennistoun	Minn. Dept. of Agriculture
F. H. Geisenhoff	Minn. Dept. of Economic Development
G. Gere	Minn. Dept. of Natural Resources
C. A. Johannes	Minn. Pollution Control Agency
E. H. Ross	Minn. Dept. of Health
J. E. Sizer	Minn. State Planning Agency
E. M. Weiberg	Minn. Water Resources Board
F. Lamm	Metropolitan Council
L. J. Breimhurst	Environmental Protection Agency
C. R. Collier	U. S. Geological Survey
R. E. Cox	U. S. Army Corps of Engineers
H. M. Jamor	U. S. Soil Conservation Service
R. W. Rilev	U. S. Bureau of Sport Fisheries & Wildlife
J. H. Strub	National Weather Service
C. A. Van Doren	U. S. Agricultural Research Service

Interest Groups and Private Concerns

A. K. Ahmed	Minn. Public Interest Research Group
J. T. Shields	Minn. Association of Commerce and Industry
P. Toren	Izaak Walton League of America
D. W. Barr	Consulting Hydraulic Engineer
R. A. Haik	Attorney
H. Lykken	Sierra Club
M. Watson	League of Women Voters

Functions

Many functions are carried out by the Water Resources Research Center emphasizing the application of knowledge and the solutions of problems. The special ability of the Center to facilitate cross-disciplinary, multi-disciplinary and interdisciplinary research collaboration is regarded as one of the prime justifications for its existence. Several factors have contributed to the growing emphasis on multi-disciplinary research. The so-called knowledge explosion contributed to the fragmentation of disciplines into new and important specialties and to the emergence of new cross-disciplinary relationships. The second major push toward interdisciplinary collaboration has been the increased demand for applied knowledge to solve scientific, technical and social problems. Problem-solving cannot necessarily be restricted to disciplinary boundaries.

The nature of the Center's interdisciplinary involvement and the extent of interdisciplinary collaboration in the Center's programs can be described as follows. The Center involves faculty members from different disciplines; individuals tend to work independently on separate aspects of a larger problem. There is an overall, integrative design to the total enterprise, but substantial autonomy is granted each researcher in the design and direction of separate phases of the effort.

Center resources are distributed among the functions of research, public service, and instruction. Research and public service are the primary or predominant functions. Estimated distribution of resources among functions are: research - 93 percent, public service - 6 percent and instruction - 1 percent.

The Center does not perform research, it administers and facilitates research. The Center is administratively responsible for the research carried out under its sponsorship; the research is actually "produced" in various academic departments. The principal task is to coordinate efforts and ensure accountability to funding agencies. Research programs on the problems of water quantity and quality require competencies from several disciplines, and as problems shift over time, the specific professional talent, equipment and facilities required also change. As a result, the Center supports faculty members from several departments, all of whom maintain their principal identification with their departments. The task of maintaining and coordinating these complex interpersonal and organizational relationships is considerable. The Center facilitates research by referring sponsors of disciplinary research to departments, providing statistical and research design consultation assistance, making available research equipment, and helping move good research ideas into proposal form.

The Center is not involved in the administration of public service, it is involved in the performance and facilitation of public service. The Center publishes and distributes Bulletins, Information Circulars and a Newsletter and sponsors seminars and conferences. The primary purpose of the Center's public service is to disseminate information concerning the Center's programs and the results of its research projects. The Center facilitates public service by offering guidance and technical advice

to agencies which provide direct delivery of public service like the Cooperative Extension Division.

The Center does not perform or administer instruction but it does facilitate instruction. The Center facilitates graduate and undergraduate education programs by providing employment for students.

#### Goals and Objectives

The successes or failures of the Center can be appraised by comparing the Center's goals and objectives and the results of its programs. The Center's goals and objectives as of June 30, 1973 were as follows:

- \* Apply academic water resources research to the social and technical problems of the State and nation.
- \* Stimulate University of Minnesota and State and Private College water resources research through administration of funds associated with the Federal Water Resources Research Act of 1964.
- \* Coordinate Center research programs with programs of local, State and Federal agencies and private organizations throughout the State and nation.
- \* Disseminate information concerning the Center's programs and the results of its research projects.
- \* Facilitate cross-disciplinary, multi-disciplinary and interdisciplinary water resources research collaboration.
- \* Strengthen water resources research programs of academic departments by referring sponsors of disciplinary research to academic departments, providing statistical and research design consultation assistance, making available research equipment, and helping move good research ideas into proposal form.
- \* Facilitate graduate and undergraduate water resources education programs by providing employment for students and stimulating educational offerings.

#### Programs

Funds to support the Center's research, public service, and instruction programs have been obtained from the Office of Water Resources Research (OWRR), U. S. Department of the Interior and the State through the University of Minnesota and State and Private Colleges. With the exception of a small amount of continuing support funds from the Graduate School, all of the funds are associated with the Federal Water Resources Research Act of 1964. The Office of Water Resources Research administers funds connected with that Act.

The purpose of the Act was to stimulate, sponsor, provide for, and supplement present programs for the conduct of research, investigations, experiments, and the training of scientists in the fields of water and of resources which affect water in order to assist in assuring the nation at all times of a supply of water sufficient in quantity and quality to meet the requirements of its expanding population. In part, the Act makes available, on a cost-sharing basis, Federal funds for research programs carried out at universities. The Water Resources Research Center has received funds in connection with Title I of the Act (Annual Allotment and Matching Grant research projects).

The Center's budgets for fiscal years 1965 through 1973 are shown in the table below. The sources of funds are also indicated.

Fiscal Year	<u>Source of Funds</u>					
	Center's Budget \$	Fed. (OWRR) \$	U of M \$	St. Col. \$	Private Col. \$	Grad. School U of M \$
1965	84,564	52,297	7,474	0	0	24,793
1966	195,362	106,980	78,336	0	0	10,046
1967	214,767	113,333	92,567	0	0	8,867
1968	220,525	135,396	78,054	0	6,575	500
1969	262,819	166,508	91,944	0	3,867	500
1970	328,160	180,930	123,055	20,795	0	3,200
1971	338,872	192,846	109,022	29,493	4,011	3,500
1972	432,777	240,856	156,126	27,622	4,473	3,700
1973	413,724	234,584	166,390	4,500	4,550	3,700

#### Research Program

The number of ongoing projects associated with the Center's research program increased from 7 in fiscal year 1965 to 20 in fiscal year 1972 as shown in the table below.

<u>Fiscal Year</u>	<u>Total Number of Ongoing Research Projects</u>
1965	7
1966	14
1967	13
1968	14
1969	14
1970	14
1971	17
1972	20
1973	17

Research conducted through the Center is relevant to water resources problems in Minnesota and the nation. Research efforts in the 10 water resources research categories used by the Committee on Water Resources Research, Federal Council for Science and Technology (FCST) are identified in the table below to provide information on the nature of the Center's research projects.

FCST Category	Fiscal Year								
	1965	1966	1967	1968	1969	1970	1971	1972	1973
I. Nature of Water	0	0	0	0	0	0	0	0	0
II. Water Cycle	2	3	3	4	6	5	4	4	4
III. Water Supply Augmentation and Conservation	0	0	0	0	0	0	0	0	0
IV. Water Quantity Management and Control	2	6	5	4	0	0	0	1	1
V. Water Quality Management and Control	3	5	5	5	6	4	3	3	2
VI. Water Resources Planning	0	0	0	1	2	5	10	11	9
VII. Resources Data	0	0	0	0	0	0	0	1	1
VIII. Engineering Works	0	0	0	0	0	0	0	0	0
IX. Manpower, Grants and Facilities	0	0	0	0	0	0	0	0	0
X. Scientific and Technical Information	0	0	0	0	0	0	0	0	0

Research effort has been consistently high in the following 4 categories: II. Water Cycle, IV. Water Quantity Management and Control, V. Water Quality Management and Protection, and VI. Water Resources Planning. Little effort has been devoted to category VII. Resources Data, and there has been no research in the following 4 categories: I. Nature of Water, III. Water Supply Augmentation and Conservation, VIII. Engineering Works, IX. Manpower, Grants and Facilities, and X. Scientific and Technical Information.

For several years the Center has known that the need for research concerned with the social-economic-political aspects of water resources is great. However, in fiscal year 1967, not a single research project proposal concerned with these aspects was submitted to the Center. In contrast, the Center's fiscal years 1972 and 1973 programs included 7 social-economic-political research projects whose support constituted about 32 percent of the Center's total budget, (see table below).

Broad Aspects	Fiscal Year								
	1965	1966	1967	1968	1969	1970	1971	1972	1973
Physical Sciences	4	11	10	8	7	5	7	8	6
Biological Sciences	3	3	3	4	4	5	4	5	4
Social Sciences	0	0	0	2	3	4	6	7	7

This trend of increased emphasis of the Center's research program on social-economic-political aspects of water resources is expected to continue. Most of the research the Center has supported or will support in the future can be broadly classified as environmental research.

The man-years of effort associated with the Center's research program is summarized in the table below.

Fiscal Year	Estimated Man-Years of Effort			Total
	Professional	Students	Clerks, etc.	
1965	0.83	0.75	0.29	1.87
1966	5.26	7.28	2.98	15.52
1967	4.43	6.00	3.70	14.13
1968	5.59	3.86	4.56	14.01

1969	6.12	7.61	3.49	17.22
1970	7.57	10.64	4.23	22.44
1971	6.90	10.43	2.93	20.26
1972	8.96	12.55	3.22	24.73
1973	5.60	10.50	4.32	20.42

During recent years, about 22 man-years of effort have been associated with the Center's research program involving 7 man-years of professional effort, 11 man-years of student effort, and 4 man-years of clerical and laboratory assistant effort. About 77 percent of man-years of student effort was by graduate students and about 23 percent was by undergraduate students.

Estimated administrative expenses incurred as part of the Center's Director's office budget for the Center's research program are listed below.

Fiscal Year	Center Director's Office Expenses \$	Research Program Administrative Expenses \$	Public Service Administrative Expenses \$	Instruction Administration Expenses \$
1965	14,000	11,000	3,000	0
1966	25,000	13,500	8,000	3,500
1967	30,000	14,000	12,000	4,000
1968	32,000	15,000	14,000	3,000
1969	38,500	20,000	16,000	2,500
1970	41,500	22,500	16,000	3,000
1971	51,500	24,000	24,500	3,000
1972	44,000	25,000	17,000	2,000
1973	45,500	26,000	16,500	3,000

The Center's Director's office expenses have averaged about 10 percent of the total Center's budget; research program administrative expenses have averaged about 6 percent of the total Center's budget.

Typically, expenditures for salaries and wages and associated indirect costs and employee fringe benefits constitute about 86 percent of the total Center's budget. Non-Federal contributions to the Office of Water Resources Research programs consist of the fair value of the services of faculty whose salaries are being paid with non-Federal funds and indirect costs and employee fringe benefits associated with total salaries and wages.

Expenditures through fiscal year 1973 for non-expendable equipment items associated with the Center's research programs total \$115,427. Title to non-expendable equipment purchased with Office of Water Resources Research Funds is vested in the University of Minnesota for the use and benefit of the Center. Upon project completion, equipment is retained by the research project Principal Investigator who gives due credit to the Office of Water Resources Research for continued use of the equipment. Some of the major equipment items purchased with Center funds are: rain gauges, water level recorders, anemometers, evaporation pans, trucks, freezers, centrifuges, balances, boats, trailers, outboard motors, microscopes, mobile limnological laboratory, electronic apparatus, plankton

recorders, hand winches, chain saws, office equipment, calculators, hygro-thermographs, vertical illuminator, depth finders, fluorometer, pumps, samplers, and irrigation systems.

Funding of water resources research projects at the University of Minnesota increased from about \$788,400 in fiscal year 1965 to about \$1,293,200 in fiscal year 1973. The percentage of the total University of Minnesota water resources research supported by the Center has steadily increased from about 9 percent in fiscal year 1965 to about 28 percent in fiscal year 1973. The Center research expenditures in fiscal year 1972 exceeded the water resources research expenditures of all other individual units of the University.

Total funding of water resources research projects conducted in Minnesota has increased from about \$1,226,600 in fiscal year 1965 to about \$3,940,000 in fiscal year 1973. Recent annual Federal and State expenditures for all water resources programs in the State total about \$110,000,000. Thus, expenditures for water resources research constitute only about 3.5 percent of total expenditures for all water resources programs in the State. The Center supported about 10 percent of the total water resources research conducted in Minnesota in fiscal year 1973. On a nationwide basis, the Center has received a high proportion of Title I funds from the Office of Water Resources Research. During recent years, only 5 of the 50 Water Resources Research Centers in each State of the nation received more Title I funds than did the Minnesota Water Resources Research Center.

The Center continuously compiles information on needed and neglected water resources research areas with the assistance of its Advisory Committee. The selection of research projects to be sponsored gives due regard to changing research needs of the State. During the winter months of 1966, about 350 people having an interest in water resources research in Minnesota were solicited by the Center for information concerning needed areas of water resources research. Expansions in research programs were required to solve existing and anticipated problems pertaining to: environmental quality improvement, including pollution control and prevention; provision of additional water-oriented recreation facilities and protection of natural resources; provision of adequate municipal water supplies; flood damage reduction; and soil and water management.

The Center maintains close liaison with the following organizations at the University of Minnesota: All-University Council on Environmental Quality; Environmental Affairs, Institute of Agriculture; Environmental Health Research and Training Center; Limnological Research Center; Minnesota Public Interest Research Group; Center for Population Studies; Center for Studies in Technological Development and Social Change; Center for Studies of the Physical Environment; and Center for Urban and Regional Affairs. The Center maintains close liaison with State agencies through its membership on the Water Resources Coordinating Committee and the Citizens Advisory Committee, Governor's Environmental Quality Council.

To avoid unduly overlapping or duplicating ongoing research, the Center maintains a list of ongoing water resources research projects in Minnesota. In addition, the Center has at its disposal the Water Resources Research Catalog which lists ongoing water resources research projects in the nation and is published by the Office of Water Resources Research. The research projects of the Center are coordinated with research projects of Federal agencies through the Committee on Water Resources Research of the Federal Council for Science and Technology. The Center obtains scientific and technical information concerning the national water resources research community through the Water Resources Scientific Information Center in the Office of Water Resources Research.

Funds to support research projects have been distributed by the Center to various units of the University of Minnesota, St. Mary's College, St. Cloud State College, Bemidji State College, and Gustavus Adolphus College as shown below.

<u>University or College and Unit Performing Research</u>	<u>Cumulative Funds Associated with Center's Research Programs through Fiscal Year 1973</u>
	2,036,025
University of Minnesota	780,706
Institute of Agriculture	259,772
Department of Agricultural Engineering	60,578
School of Forestry	277,190
Department of Soil Science	101,384
Department of Agricultural & Applied Economics	81,782
Department of Horticultural Science	474,982
Institute of Technology	217,461
St. Anthony Falls Hydraulic Laboratory	221,041
Limnological Research Center	9,523
Geological Survey	36,957
Department of Geology and Geophysics	334,105
Health Sciences	265,996
School of Public Health	68,109
Department of Pharmacognosy	216,948
College of Liberal Arts	71,494
Department of Anthropology	145,454
Department of Sociology	42,487
College of Biological Sciences	42,487
Department of Ecology & Behavioral Biology	174,202
Graduate School	203,517
State and Private Colleges	20,597
St. Marys College	20,597
Department of Biology	94,533
St. Cloud State College	94,533
Department of Biology	65,467
Bemidji State College	65,467
Center for Environmental Studies	22,920
Gustavus Adolphus College	22,920
Department of Geography	
Total	2,226,947

In fiscal year 1971, about 20 percent of the Center's funds were distributed to State and Private Colleges.

In response to the need for interdisciplinary-multi-disciplinary State problem-oriented research programs, the Center plans to allocate a part of its Annual Allotment for the support of projects concerning selected topics and involving the team effort of several faculty members and disciplines at the University of Minnesota and State and Private Colleges. The first interdisciplinary project entitled "Indices for Evaluating Water Quality Status and Trends in Minnesota" will start July 1, 1973. The project will involve 7 sub-projects supervised by 7 individual faculty members. Overall coordination of sub-projects will be provided by the Director of the Center. It is anticipated that about 50 percent of interdisciplinary project funds will be allocated to State and Private Colleges. No restrictions will be placed on part of the Annual Allotment research project proposals, Matching Grant Research project proposals. These proposals will not necessarily be limited to selected interdisciplinary topics but will take into consideration research priorities established by the Center and OWRR.

A review of planning documents prepared by Federal-State regional planning organizations and the Minnesota State Planning Agency indicates that the most serious water resources problems in Minnesota are those associated with water quality. Estimated costs, during the period 1971-2020, for potentially feasible water quality programs and projects greatly exceed costs for individual programs and projects associated with other water resources functional areas; water supply; recreation, fish and wildlife; flood control; navigation; and land treatment, drainage, irrigation and forests. Costs of controlling all water pollutants or sources have not been estimated. Benefits of water pollution control have not been assessed. An accounting of direct damage attributable to water pollution is not available. Information concerning impacts of water quality improvement costs on local and State population growth, industries, firms, employment, consumers and taxpayers, trade and incidence of costs of improvement is not documented.

Monitoring the status and trends of water quality is one of the keys to effective management of water resources. Water quality conditions and changes, desirable, natural or man-made, cannot be evaluated without surveys, established base lines, and repeated observations and analyses. Information on the status and trends of water quality is essential for the identification of water quality needs and the establishment of program priorities, as well as for the evaluation of program effectiveness. A review of available publications on water quality in Minnesota revealed only limited quantitative data on status and trends. Measuring the status and trends in water quality is an exceedingly complex problem. Because of the variety of types of requirements as well as the variety of definitions or ways of perceiving water quality, there is no general agreement on the requirements for or nature of water quality indices. Apart from the problem of indices, there are problems with many existing monitoring systems themselves. It is the objective of this research project to identify indices and indicators of water quality status and trends in Minnesota and the data needed to obtain and utilize these indices. Physical, social, political and economic aspects of water quality indices

will be considered. An attempt will be made to quantify past trends and the current status of water quality using available information.

The research project has been subdivided into 7 sub-projects covering the following aspects of water quality indices: 1) Waste loads, treatment and assimilative capacity of streams and lakes; 2) Lake and stream eutrophication and recreation; 3) Agricultural runoff and erosion; 4) Water supply and groundwater pollution; 5) Costs, damages and benefits; 6) Perceptions and attitudes; and 7) Policy, legal and administration. A Principal Investigator will be responsible for each of the 7 sub-projects. The work of Principal Investigators will be coordinated through the Director of the Center. It is anticipated that the Principal Investigators will meet as a group at least once every 3 months. Periodically, the Principal Investigators will meet with the Center's Advisory Committee.

The sub-project entitled "Waste loads, treatment and assimilative capacity of streams and lakes" will be concerned with such matters as: waste treatment facilities, municipal and industrial waste loads before and after treatment, streamflow and lake flow through in relation to the assimilative capacities of waters, adequacy of treatment facilities, and technological advances in treatment. The sub-project entitled "Lake and stream eutrophication and recreation" will be concerned with such matters as: rates of eutrophication-natural and man-made, types of eutrophication problems, factors influencing eutrophication, lake improvement methods, restoration rates, classification of lakes, impairment of recreational use of waters, and impacts on fish and wildlife. The sub-project entitled "Agricultural runoff and erosion" will be concerned with such matters as: sediment carried by erosion, animal wastes, feedlot wastes, fertilizers, pesticides, and animal waste treatment. The sub-project entitled "Water supply and groundwater pollution" will be concerned with such matters as: water supply treatment facilities, health aspects of water supplies, adequacy of water supply treatment facilities, and sources and rates of groundwater pollution. The sub-project entitled "Cost, damages and benefits" will be concerned with such matters as: costs of pollution abatement, damage attributable to water pollution, impacts of water quality improvement costs, and benefits of water quality programs. The sub-project entitled "Perception and attitudes" will be concerned with such matters as: man's perceptions, attitudes and beliefs pertaining to water quality; intensity and motivation behind attitudes; public awareness; publicity knowledge; and education. The sub-project entitled "Policy, legal and administration" will be concerned with such matters as: policies affecting water quality status and trends, legal actions, and administrative arrangements.

A research project (OWRR Project No.: A-028-Minn) entitled "Developing a Water Resources Research Plan for Minnesota" started on July 1, 1972 and is scheduled for completion on June 30, 1974. The Principal Investigator of the research project is the Center Director. The objective of this project is to develop a long-range comprehensive plan for water resources research in Minnesota. Research programs and projects which will assist in solving existing and projected water resources problems will be identified. Guidelines for improving the coordination of research efforts throughout the State will be formulated. Research costs and manpower needs will be estimated and funding opportunities will be reviewed. The capabilities of existing water resources researchers in Minnesota will be eval-

uated and needed future capabilities will be projected. The results of the research should assist the State in increasing the efficiency and relevance of water resources research efforts, improving the timely dissemination of research results, and scheduling expansions in research capabilities in advance of demands. Information concerning future research needs, manpower requirements, and costs should assist the State Legislature in formulating legislation concerning water resources research funding. The results of the research should further assist the Center in administering research funds associated with the Water Resources Research Act of 1964.

Public Service Program

Increase attention is being given to making available to the public, governmental agencies and the research community the information produced by the Center's programs. The Center has published and distributed to 550 people throughout the State 32 quarterly Newsletters and 141 Information Circulars in an effort to disseminate information concerning water resources. Research projects supported by the Center have generated 128 Technical reports and theses. Upon request, the Center has distributed about 140 copies of its publications per month to people throughout the State and Nation. The Center has widely distributed 42,000 copies of 60 Bulletins describing the results of research projects.

Public service administrative expenses have averaged about 5 percent of the total Center's budget.

Instruction Program

One of the purposes of the Center is the stimulation and review of education offerings for students which will prepare them for careers in the field of water resources. The Center assists in recruiting students and in guiding them into appropriate programs of study. The Center has been helpful to the University of Minnesota in developing 53 new courses bearing on water resources, a new graduate option in hydrogeology, and a program of graduate education in water resources.

The number of students receiving part-time employment as research project assistants through the Center's recent research program has averaged 40. Thirty-seven students have graduated with M.S. and Ph.D. degrees in water resources related fields and received Center financial support.

Instruction program administrative expenses have averaged about 1 percent of the total Center's budget.

On a gross basis, the capabilities of Minnesota's water and related land resources exceed demands and needs associated with projected economic and population growths for at least the next 50 years. Past development and management practices in the State, as substantial as they are, have not kept pace with the steadily growing demands placed upon resources. Continuing pressures and demands can be expected to create an ever increasing need for acceleration in resource development. Expansion in resource programs are required to solve existing and anticipated problems pertaining to: environmental quality improvement, including pollution control and prevention; provision of additional water-oriented recreation facilities and protection of natural resources; provision of adequate municipal water supplies; flood damage reduction; and soil and water management.

The Center's program in FY 1973 was directed toward: mathematical simulation of a large watershed using the systems approach to quantity and quality analysis (A-024-Minn.); alleviation of lake pollution by utilization of aquatic plants for nutritional, medicinal or industrial purposes (A-025-Minn.); monitoring the effects of stopping the flow of sewage on the productivity of Lake Minnetonka (A-026-Minn.); determining whether optimum levels of investigations can be set for such groundwater reservoirs as the Twin Cities Artesian basin (A-027-Minn.); developing a water resources research plan for Minnesota (A-028-Minn.); study of the mechanics of soil moisture movement and retention (B-015-Minn.); determination of ecological conditions in the Mississippi River near Monticello, Minnesota before and after operation of a nuclear power plant (B-032-Minn.); spatial variation in the perception of water resources and water problems in South Central Minnesota (B-042-Minn.); area financing of water resource development (B-044-Minn.); social and economic factors in the adoption by industry of water pollution control measures (B-047-Minn.); estimating thermal pollution and increased nitrate and phosphate levels associated with alternative forest management systems (B-053-Minn.); delineating the more immediate and crucial sets of water and related land resources planning policy alternative being considered by the people of Minnesota (B-054-Minn.); determining the feasibility of utilizing irrigation and groundwater recharge as means for disposal of heated water from power plants (B-057-Minn.); the role of scientist-technician in water policy decisions at the community level (B-067-Minn.); spatial and temporal variation of precipitation (B-068-Minn.); and forecasting rainfall and snowmelt floods (B-077-Minn).

The Center's program during the next five years will involve completion of above mentioned projects and it will likely stress indices for evaluating water quality status and trends in Minnesota, environmental considerations in water resources planning and management, restoration of lakes, groundwater basin management, water resource policies, thermal loading problems and urban and metropolitan water resources problems.

Results from projects A-009-Minn. on groundwater contribution to streamflow, A-001-Minn. on effect of pothole drainage upon groundwater resources, and B-002-Minn. on effect of natural sealing of potholes have assisted State and Federal agencies in evaluating groundwater recharge on

a statewide basis. Information from projects A-007-Minn. on the use of planktonic desmids as indicators of pollution of lakes, A-008-Minn. on water quality and organic productivity of lakes, A-011-Minn. on abundance on net plankton as an index of eutrophication in Lake Superior, B-001-Minn. on diatoms and zooplankton in Minnesota, B-101-Minn. on techniques for determining changes in phytoplankton, A-016-Minn. on primary productivity of Minnesota lakes, and B-009-Minn. on phosphorus in lake-bottom deposits is assisting water managers in controlling excessive productivity of polluted lakes. Results from projects A-010-Minn. and A-015-Minn. on recharge from induced streambed infiltration have been used in the U.S. and England to evaluate potential yields of aquifers. The Corps of Engineers has been assisted in their analyses of peak rates of runoff and flood routing by the results of project A-013-Minn on review and analysis of watershed precipitation and runoff data. The Weather Bureau has been assisted in flood forecasting activities by information from project B-001-Minn. on soil moisture and A-001-Minn. on soil freezing in forests. The results of project A-021-Minn. on water resources administration in Minnesota has assisted the Legislature and the Executive Branch in formulating an environmental policy for the State and in reorganizing State agencies.

The Center has been helpful in developing new water resources courses, a graduate option in hydrology, a program of graduate education in water resources, and recruitment of new faculty members with an active interest in water resources. The following State and private colleges have participated in the Center's research program: St. Mary's College, St. Cloud State College, Bemidji State College, Winona State College, and Gustavus Adolphus College.

The Center has an Advisory Committee composed of 39 members from the University of Minnesota; State and Private Colleges; State, Local and Federal Agencies; and Interest Groups and Private Concerns. Members of the Center's Advisory Committee have participated in water and related land resources planning activities of the Minnesota State Planning Agency. The Center Director has served on several important State and national water resources committees.

EXAMPLES OF SELECTED RESEARCH FINDINGS AND THEIR  
ACTUAL OR POTENTIAL APPLICATION TO  
WATER RESOURCES PROBLEMS

First Example

Lake Minnetonka, an intensively developed lake in the Minneapolis-St. Paul suburbs, has been subjected to severe eutrophication due to man's activities. For several years, lakeshore owners, municipalities discharging treated sewage into the lake, and special purpose districts searched for an optimum rehabilitation management program that would improve the recreational use of the lake. Before OWRR Project No.: A-016-Minn. was started on July 1, 1967, available information concerning the productivity of the lake was not sufficient to permit the prediction of the effects of selected management practices.

The lake was studied by the Principal Investigator in cooperation with State agencies, municipalities, special purpose districts and several private engineering firms. It was demonstrated that phosphorus is the nutrient that limits algal growth during the summer, when very dense populations of nitrogen-fixing blue-green algae develop. A model of the photosynthetic system of the phyto-plankton was developed. Computations based on a materials balance indicated that the mean annual phosphorus content of the lake's largest basin should decrease from an existing 13 metric tons to a desirable 4 metric tons within 3 years if the phosphorus influx was reduced by stopping the influx of sewage. Based on the result of the research project, a comprehensive lake watershed management plan was prepared. Sewage effluents will be diverted from the lake within two years. The emphasis of OWRR Project No.: A-026-Minn., which started on July 1, 1971, will be to monitor the effect of stopping the flow of sewage into the lakes and thereby measure the effectiveness of the management plan.

Second Example

During the last 3 Legislative Sessions in Minnesota there have been numerous Committee hearings concerning water resources laws, administration and policies. In addition, two Governors appointed Committees to study the State's water resources statutes and government, and to make recommendations concerning needed changes. Prior to the start of OWRR Project No.: A-015-Minn. on July 1, 1967 and A-021-Minn. on July 1, 1969, the Legislature's and Governor's Committees were greatly hampered in their efforts because of the lack of comprehensive reports on water resources laws, State administration, Legislative process, and policies.

Codified laws, uncodified Legislative enactments, and local laws bearing on water resources in Minnesota were collected, compiled and published. An analysis and interpretation was made of State and Federal statutes and court decisions and recommendations were made concerning ways and means for improving water resources laws. The Principal Investigator inventoried and appraised State water resources administration, Legislative process and policies as of December 1970. Recommendations were made concerning reorganization of State agencies and needed State policies. The information generated by the research has filled large gaps in the understanding of Minnesota's water resources laws and government and the need to improve laws.

In 1970 and 1972, the Principal Investigator served as an adviser to Committees of the Minnesota Senate and House of Representatives and using the results of the research assisted the Committees in preparing reports on needed water resources legislation. The Citizens League, League of Minnesota Municipalities and numerous voluntary environmental organizations have sought the advice of the Principal Investigator in matters pertaining to water resources laws and government. Several recommendations resulting from the research were accepted by legislators and incorporated in bills introduced during the 1973 session of the Minnesota Legislature.

### Third Example

In the United States, only a fraction of one percent of small watersheds 1 to 100 square miles in size have stream gaging stations. Few of these have records of sufficient length for flow frequency analysis. Hundreds of culverts, bridges, channel improvements, stabilizing structures and detention reservoirs are being constructed each year on small watersheds. The hydrologic design for almost all of these structures is by means of some empirical technique or formula of unknown accuracy. Of the thousands of small watersheds, only a few can be gaged because of the limited national streamflow gaging programs. Thus, it is imperative that concerted efforts be made to develop new and better techniques for estimating stream runoff rates and frequencies for small, ungaged watershed.

In planning water control projects, whether large or small, an estimate of peak stream flows in various parts of the watershed with and without the project is essential. The unit hydrograph method and other linear methods are widely used for this purpose. The results of OWRR Project No.: A-017-Minn. and B-007-Minn., based on mathematical model and laboratory experiments, provide evidence that peak discharges estimated by such methods should be adjusted upward by significant amounts in many cases to avoid underdesign.

The results of the research project are being used by the Principal Investigator and other hydrologists throughout the United States to develop new methods for peak streamflow determination for ungaged, small watersheds which will involve consideration of more watershed characteristics and avoid the use of the linearity assumption. The U.S. Soil Conservation Service in Minnesota has expressed great interest in the results of the research; and is revising its planning procedures in light of the new knowledge.

#### COMPLIANCE WITH CONSULTATION AND COLLABORATION PROVISIONS OF SECTION 100(b) P.L. 88-379 AS AMENDED BY P.L. 92-175

On December 2, 1971, the President approved P.L. 92-175 which amended certain sections of P.L. 88-379, the Water Resources Research Act of 1964. Among the amendatory provisions of Section 100(b) is the new requirement that: "The annual programs submitted by the State institutes to the Secretary for approval shall include assurance satisfactory to the Secretary that such programs were developed in close consultation and collaboration with leading water resources officials within the State to promote research, training, and other work meeting the needs of the State."

Information concerning the procedures and actions the Center has established or taken pertaining to compliance with consultation and collaboration provisions of Section 100(b) P.L. 88-379 as amended by P.L. 92-175 is given below.

Changes in the Advisory Committee membership were made to improve coordination between faculty members and Federal, State and Private organizations, and to assure that the annual programs submitted by the Center to OWRR are developed in close coordination and collaboration with leading water resources officials within the State. Thus, the Center is increasingly being responsive to the provisions of the Water Resources Research Act of 1964.

The Center maintains close liaison with the various Schools, Departments and Divisions of the University of Minnesota, State and private research firms and Consultants and voluntary organizations through its Advisory Committee, through its membership on the all-University Council on Environmental Quality at the University of Minnesota. In addition, the Center Director serves on the Citizens Advisory Committee to the Governor's Environmental Quality Council. The Center's activities have been made known to State Legislators through the Center Director's testimony before Senate and House Committees during each of the Legislative Sessions since 1964. The Center director has served as an Advisor to Committees of the Minnesota Senate and House of Representatives. The programs of the Center have been coordinated with the programs associated with Title III of the Water Resources Planning Act of 1965 through the Center's membership on the Water Resources Coordinating Committee. That Committee assists the State Planning Agency in administering Title III funds and programs and it is composed of all State agencies with responsibilities in the water resources field. For several years, the Center Director served as the Chairman of the Water Resources Coordinating Committee.

The Center continuously compiles information on needed and neglected water resources research areas with the assistance of its Advisory Committee. The selection of research projects to be sponsored gives due regard to changing research needs of the State and is approached on an interdisciplinary basis.

In response to the provisions of the amended Water Resources Research Act, the Center Director prepared tentative material for possible submission to the OWRR in regard to the Center's fiscal year 1974 request for funds. This material was distributed to members of the Center's Advisory Committee and Consulting Council on April 28, 1972 and to 550 people throughout Minnesota in June 1972. Members of the Advisory Committee and Consulting Council and readers of the Newsletter and their colleagues were urged to review the Center's tentative fiscal year 1974 request for funds and to send before October 1, 1972 any comments they wished to make concerning the request. The Center's request for fiscal year 1974 Annual Allotment funds was prepared based on the tentative request and recommendations received.

In June of each year, the Center begins recruiting research proposals in the field of water resources for consideration for the next fiscal year support by OWRR. Major subject areas for priority research support are identified during annual meetings of the Center's Advisory Committee each Spring. With the Advisory Committee's assistance, the Center is able to generate priority lists of needed water resources research subject areas which are used in soliciting research proposals.

During an Advisory Committee meeting on March 2, 1973, members identified the following major subject areas for priority research proposal recruitment by the Center:

Criteria, formulae, etc. for implementing the provisions of the Federal Water Pollution Control Act Amendments of 1972.

Stability of groundwater impervious structures.

\* Evaluation of land disposal systems for wastes.

Turnover rates of lakes and other water impoundments.

Methods for hydrogeologic system analysis.

Changes in sediments in lakes.

Affects of thermal pollution on aquatic systems.

Regional movement of groundwater.

Model analysis of nutrient movement.

Effects of zero-discharge waste requirements on rural growth.

Physical, social, economic and political aspects of agricultural irrigation.

Models for lake renovation.

\* Design of statewide water resources information system.

Water quality criteria from user standpoint.

Resolution of water surface use conflicts.

Mathematical simulation models of watersheds.

\* Design of lake management programs.

Modeling of urban storm runoff.

Design of flood plain mapping programs.

\* Sediment control in natural streams and construction projects.

Regional input-output model analysis.

Water quality measurement and monitoring.

Income index-hardship cases involving pollution control policies.

Development of cost and effectiveness for sealing waste stabilization ponds.

Eutrophication indices.

Effects of chlorides in urban runoff on lake stratification.

\* Agricultural drainage in relation to flooding.

Agricultural drainage in relation to wetlands.

Water quality trends in Boundary Waters Canoe area.

Relation between water quality and recreation.

Technology for limiting waste discharges.

Systems for removal of nutrients from agricultural runoff.

Control of accidental emission of hazardous materials to the environment.

Development of legislation for controlling hazardous materials.

Criteria for cooling water intake design.

Airborne epidemiology of waste water treatment plants.

\* Design of groundwater protection systems.

Computer applications of water resources data.

The six subject areas deemed by members to be of highest priority are starred and underlined. All subject areas will be listed on the announcement containing guidelines for submission of research proposals. The Director will recruit FY 1975 matching grant proposals covering as many of the subject areas as possible giving special attention to the six subject areas deemed to be of highest priority.

During fiscal year 1974 starting July 1, 1973, the Water Resources Research Center will place a heavy emphasis on the analysis of important water problems in Minnesota to determine the defensible associated research requirements, i.e., the research necessary to give a reasonable level of assurance

that the problems can be resolved in a cost-effective and timely fashion. A water resources problem-research analysis program will be developed with full consultation and collaboration between the Center; appropriate faculty at the University of Minnesota and State and Private Colleges; leading water resources officials within the State, including appropriate State, Federal and local agency officials; and appropriate members of Interest Groups.

There have been a number of analyses of water resources research requirements during the past two decades. These analyses have been conducted largely by panels of experts, primarily from the research community. For the most part, these panels have worked diligently; they have sought the opinions of others. They have been aware of both the state of disciplinary knowledge and the nature of the problems. Their recommendations have been based on sound judgment reflecting a broad spectrum of experience. Despite this, their recommendations have been largely ignored by researchers and funding agencies alike. Most researchers still consider the most important research requiring attention is either the project they are doing now or the one they just submitted for funding. If the quantity and distribution of research funds is any guide, financial sources have remained pretty much unimpressed. Although the water resources problems and issues requiring research have never been more numerous and more pressing, research funding simply has not responded to these analyses of need.

It is difficult to prove whether the research needs and priorities developed through judgment in this way were right or wrong since the work identified has never been funded at anything close to the levels indicated by the analyses. Thus, one is forced to conclude that the collective judgment of experts taken alone is not a very persuasive basis for budgeting for research in water resources.

A few research programs have been relatively successful in obtaining funds. For the most part, these programs have been related to problems for which the deficiencies in knowledge and understanding are readily identifiable to the extent that one can say "unless these specific R&D tasks are performed there is little chance that the problem can be resolved." This suggests that, from a budget officer's point of view, what is required is a clear-cut showing that the research programs identified are both necessary and sufficient to resolve the problems addressed. The various statements of water resources research needs, while clearly defining work that is relevant and important for resolving problems, appear to have fallen short of demonstrating necessity and sufficiency as well.

Information dissemination should also prove to be a much simpler task with the results of water resources problem-research analyses in hand since they identify the knowledge and understanding needed for each of the various components of the problem, hence also identify the specific potential users. Furthermore, it identifies them while the research is being planned, providing a better opportunity to keep the research on target and to make the users aware of the research as it is being accomplished.

The classical mechanism for funding university research has been the unsolicited proposal. These proposals normally have their genesis when one or more principal investigators recognize a problem and have an idea how research might contribute to its solution. If a granting agency agrees the problem is important, the idea is good, and sufficient funds are available, it would then be financed. The process has resulted in an impressive amount of water resources research that is demonstrably relevant to some important water problem somewhere.

The unsolicited proposal has a lot of merit in that it represents a source of innovative ideas, and innovative ideas are necessary for efficient, effective solutions to problems. If you don't need new ideas you probably don't really have a problem. On the other hand, exclusive reliance on unsolicited proposals while producing research clearly relevant to some problems, may still be so diffused and uncoordinated that few, if any, problems are adequately researched. Furthermore, the mere prospect of unspecified future, unsolicited proposals is not the most effective basis for seeking budgetary support for research. Budget managers and appropriation committees have generally recognized the need for research, but the unsolicited proposal system provides little tangible evidence by which they can judge just how much support should be provided.

Development of research programs based on problem analysis does not mean that so-called basic research will be eliminated. On the contrary, the process may well increase the levels of support for such studies if the analysis is properly structured to include the twin alternatives "do nothing" and "try to find a basis for a better way." Neither of these alternatives imply a maintenance of the status quo. Rather they imply substantial research into the basic behavior of the system.

The objective of the water resources problem-research analysis program is the comprehensive systematic analysis of major problems, in context with statewide settings; the definition of the research necessary for the implementation of sound solutions to the problems; and the provision of a rational basis for making decisions regarding funding levels for the research. The potential alternatives for solving or mitigating problems in the most effective way and the deficiencies in knowledge and understanding which presently prevent or make risky the implementation of these alternatives will be identified. The water resources problem-research analysis will involve those who seek solutions to the problem as well as university scientists.

Water resources problem-research analysis conferences to be sponsored by the Center of the workshop-report-workshop-final report format will serve as the main thrust of the program. The workshop conferences will be directed toward development of analyses which will be summarized by statements as follows: The problem which must be solved within the next x years is \_\_\_\_\_. The suggested alternative ways for solving the problem are \_\_\_\_\_. If we are to be reasonably certain that we can solve the problem we must proceed with those particular alternatives which appear to have better chances of success. In order to evaluate and implement these alternatives the following research studies must be accomplished \_\_\_\_\_. Potential adverse consequences which may result in solving the problem and must be avoided are \_\_\_\_\_. Research studies should be scheduled as follows \_\_\_\_\_. The research costs are \_\_\_\_\_. Targets of information dissemination are \_\_\_\_\_.

The specific system in which the problem is embedded will be characterized and possible ways of modifying or controlling the system will be developed in a preliminary way. These elements of the problem solving process will be used as a mechanism for research identification. Needed research programs may include: identification research, inspirational research, feasibility research, consequences research and monitoring research.

#### INFORMATION DISSEMINATION

On December 2, 1971, the President approved P.L. 92-175 which amended certain sections of P.L. 88-379, the Water Resources Research Act of 1964. Among the amendatory provisions of Section 100(b) is the new requirements that "it shall be the duty of each such institute to plan and conduct and/or arrange for a component or components of the college or university with which it is affiliated to conduct competent research, investigations, and experiments of either a basic or practical nature, or both, in relation to water resources and to provide for the training of scientists through such investigations, and experiments. Such research, investigations, experiments, and training may include, without being limited to, ... scientific information dissemination activities, including identifying, assembling, and interpreting the results of scientific and engineering research deemed potentially significant for solution of water resource problems, providing means for improved communication regarding such research results, including prototype operations, ascertaining the existing and potential effectiveness of such for aiding in the solution of practical problems, and for training qualified persons in the performance of such scientific information dissemination.

Increased attention is being given to making available to the public, governmental agencies and the research community the information produced by the Center's programs. The Center has published and distributed to 550 people throughout the State 32 quarterly Newsletters and 141 Information Circulars in an effort to disseminate information concerning water resources. Research projects supported by the Center have generated 128 Technical reports and theses. Upon request, the Center has distributed about 140 copies of its publications per month to people throughout the State and Nation. The Center has widely distributed 42,000 copies of 60 Bulletins describing the results of research projects.

To provide an opportunity for professional people and students working in the field of water resources to meet and to exchange information, the Center has sponsored 22 interdisciplinary Seminars since 1964. Attendance at the Seminars has averaged 50 people. The Center sponsored a 2 1/2-day Short Course on Ground Water Resource Evaluation in 1965. The course was attended by 50 people from Minnesota, Manitoba, North Dakota, Missouri and Iowa.

Information concerning scientific information dissemination activities during fiscal year 1973 of all personnel (Director, P.I.'s, other researchers, graduate assistants, etc.) associated with the Center's public service program is summarized below.

Item	Number of Events	Average Audience Size
Technical Publications Issued	25	700
Popular Articles Published	15	1,000
News Letters	4	575
Press Releases	10	unknown
Technical Lectures	65	35
Popular Talks	85	50
Sponsorship of Seminars	37	25
Correspondence and Telephone Inquiries (Estimate)	450	1
Costs	Dollars	Source of Funds
Printing and Page Charges	16,500	OWRR, Univ. of Minn.,
Distribution		State and Private Colleges

It is anticipated that, during FY 1974 the Center's scientific information dissemination activities will include: formulation of plans for the improved communication of Center research results; preparation, printing and distribution of a Center Bulletin describing in layman's language the results of completed Center research projects, relevance of research to existing water resources problems and users of the research results; preparation, printing and distribution of 4 quarterly Newsletters; preparation, printing and distribution of 6 Information Circulars; processing, printing and distribution of at least 12 Center Bulletins describing the results of completed Center research projects; and sponsoring one or more Seminars. Some of the technology transfer techniques which will be considered in formulating plans for the improved communication of Center research results are: seminars, conferences, video tape, technical capsule reports, project reviews, publication lists, speaker's bureau, workshops, continuing education, and linking the Center to appropriate libraries.

Arrangements have been made for the Environmental Conservation Library (ECOL) Minneapolis Public Library to serve as the depository for publications received by the Center. ECOL is also assisting the Center in disseminating information on water resources. The 1971 Minnesota Legislature designated ECOL as the State center for environmental information.

During FY 1973, the Center distributed to about 550 people in Minnesota mimeographed Information Circulars covering the following subjects:

Information Circular No.	Title
129	Information Concerning Publications of Water Resources Scientific Information Center
130	Information Concerning National Energy Policy and National Environmental Policy Act
131	Needed: A National Land Use Policy
132	Ecological River Basin Management
133	Information Concerning Groundwater Pollution and Data Programs

134	State Environmental Legislation of 1971
135	Understanding the Water Resources Research Center
136	Water Resources Problem - Research Analysis Problem In Minnesota
137	Water Resources Information Deficiencies in Minnesota
138	Environmental Quality Concerns in Minnesota
139	National Water Commission Recommendations
140	Federal Council for Science and Technology, Committee on Water Resources Research - High Priority Problem Areas
141	Water Resources Problems in Minnesota

The Center receives many requests for copies of its Bulletins, Newsletters and Information Circulars. A few excerpts from letters addressed to the Center Director expressing appreciation for the Center's publications are given below:

With reference to my recent request for details concerning the availability of two reports of your Center, namely, Bulletins 39 and 31; I am extremely grateful to you for sending me copies. These two reports will be very valuable in my research and they have provided stimulating reading.

D.E. Walling B.A. Ph.D.  
Department of Geography  
Queen's Building,  
The Queen's Drive  
Exeter

I wish to thank whomever is responsible for mailing to me a copy of Johnson, et al.'s bulletin on The Potential Productivity of Fresh Water Environments as Determined by an Algal Bioassay Technique. Their critical and exacting technique is a fine example of the type of work that has been long needed. Both myself and my students will find this study very useful in our work on Flathead Lake.

G. W. Prescott  
Univ. Mont. Biol. Sta.  
Bigfork, Montana 59911

I have just received notice of your three reports on Minnesota aquatic plants. These reports appear of great interest to us and I would appreciate copies of each of them, i.e., Bulletins #46, #47, and #48.

Forest W. Stearns  
Department of Botany  
The University of Wisconsin - Milwaukee  
Milwaukee, Wisconsin 53201

I feel greatly indebted to you for sending so quickly the three copies on the Water and Related Land Resources. I hope that I will be able to present some of this material at a workshop of the American Association of University Women this May.

Mrs. Don (Jeanne) David  
TBE, Minn. Division  
R.R. No. 2  
Fairmont, Mn. 56031

I would very much like to receive copies of the following bulletins: #14--J. Fox, T. Odlaug, T. Olson. The Ecology of Periphyton in Western Lake Superior, I. Taxonomy and Distribution. # 17--W. Pearkos, T. Olson, T. Odlaug. Water Quality Studies of the Great Lakes Based on C-14 Measurements of Primary Production. #18--W. Stoks, T. Olson, T. Odlaug. The Photosynthetic Pigments of Lake Superior Periphyton and their Relation to Primary Productivity. # 20--J. Johnson, T. Odlaug, T. Olson, O. Ruschmeyer. The Potential Productivity of Fresh Water Environments as Determined by an Algal Bioassay Technique. # 26--W. Swain, T. Olson, T. Odlaug. The Ecology of the Second Trophic Level in Lake Superior, Michigan and Huron.

These reports are extremely pertinent to our present research work.

John W. Foerster, Ph.D.  
Goucher College  
Towson  
Baltimore, Maryland 21204

Last year you kindly provided me with enough copies of one of your publications for my Environmental Engineering course.

I wonder if it would be possible to obtain 45 copies of your information circular number 130, dated August 1972, discussing national energy policy?

If you can, I would appreciate receiving these by the beginning of the quarter since I plan on talking about the energy problem at the very beginning of the quarter.

K. T. Whitby  
Professor and Chief  
Environmental Division  
Mechanical Engineering  
University of Minnesota

I am currently serving on the Executive Committee of the Sierra Club, North Star Chapter, with responsibility for tracking pollution issues, including water quality. In this capacity, I have had some contact with your WRRC Bulletin series. I have found them most useful and would appreciate being placed on the mailing list, if possible. They should be sent to the following address.

Robert S. Banks,  
Executive Committee  
Sierra Club  
North Star Chapter

If copies of the two papers listed below are still available, I would appreciate receiving a copy of each:

Potential Productivity of Fresh Water Environments as Determined by an Algal Bioassay Technique, by Johnson, Odlaug, Glenn and Ruschmeyer.

Lake Eutrophication--Water Pollution Causes, Effects and Control. Printed in 1970.

These bulletins should prove to be of value in my teaching in courses in phycology and environmental affairs.

Lloyd Ohl  
Associate Professor of Biology  
Wisconsin State University  
Eau Claire, Wisconsin 54701

CENTER'S INVOLVEMENT IN PUBLIC  
AFFAIRS AND ACADEMIC ACTIVITIES

A Conference on "Toward A Statewide Groundwater Quality Information System" was held in the North Star Ballroom, Student Center, University of Minnesota, St. Paul Campus on September 19-20, 1972.

The objectives of the Conference were: to document, publicize, and promote the need for a statewide ground water quality-information system; to consider possible institutional arrangements for designing the system; and to review the factors to be considered in designing the system. The Conference was sponsored by: Citizens Advisory Committee to Governor's Environmental Quality Council; Minnesota Department of Agriculture; Minnesota Geological Survey; Minnesota Department of Natural Resources; Minnesota Department of Health; Minnesota Pollution Control Agency; Minnesota State Planning Agency; U.S. Geological Survey; University of Minnesota.

The Program of the Conference is given below:

- September 19
- 8:00 a.m. Registration, 2nd floor, Student Center
- 9:00 a.m. Introductory remarks . . . Gerald Christensen, Chairman, Governor's Council on Environmental Quality
- Session I
- 9:10 a.m. Ground Water, A Resource to be Protected  
Presiding . . . Robert Herbst Commissioner, Minnesota Dept. of Natural Resources
- 9:30 a.m. Occurrence and natural quality of ground water . . . T. C. Winter, U.S. Geological Survey
- 10:10 a.m. Coffee

10:30 a.m. Review of information programs . . . Paul Johnson, Minnesota Department of Health

11:00 a.m. The Use of Groundwater in Minnesota . . . Ronald Harnack, Minnesota Department of Natural Resources

11:30 a.m. Lunch

Session 2

1:00 p.m. Man's Impact on Ground Water Quality  
 Presiding . . . Grant Merritt Executive Director, Minnesota Pollution Control Agency

1:10 p.m. Hydrogeologic framework for deterioration in ground water quality . . . Olaf H. Pfannkuch, Department of Geology and Geophysics, University of Minnesota

1:40 p.m. Ground water pollution in Minnesota . . . Dale Wikre, Pollution Control Agency

2:10 p.m. Establishing the impact of agriculture practices on ground water quality . . . Robert Gast and Philip R. Goodrich, Department of Soil Science and Agricultural Engineering, University of Minnesota

2:40 p.m. Coffee

3:00 p.m. Impacts of land disposals on ground water quality  
 Spray disposal of sewage . . . Earl A. Meyers, Pennsylvania State University  
 Solid Waste disposal . . . George Hughes, Illinois State Geological Survey

4:20 p.m. Announcements

4:30 p.m. Adjournment

September 20

9:00 a.m. Introductory remarks . . . Dan Magraw, Assistant Commissioner, Department of Administration

Session 3

9:10 a.m. Needs and Uses for Ground Water Quality Information System  
 Presiding . . . Shirley Hunt, Nine Mile Creek Citizens Association & Board Member, Mecca, Water Resources Board

9:20 a.m. Future uses of ground water information system . . . Lowell Hanson, Agricultural Extension Service & Department of Soil Science, University of Minnesota

9:40 a.m. Water well records and information system needs . . . Edwin H. Ross, Minnesota Department of Health

10:00 a.m. Subsurface geologic information system in Minnesota . . . G. B. Morey, Minnesota Geological Survey

10:20 a.m. Coffee

Session 4

10:30 a.m. Ground Water Quality Information System Design  
 Presiding . . . Joseph Sizer, Director of Environmental Planning, State Planning Agency

10:40 a.m. Ground water quality standards . . . Robert R. Aitken, Environmental Protection Agency

11:10 a.m. Information system experiences in other states . . . Conrad Straub, School of Public Health, University of Minnesota

11:30 a.m. Utah's Ground Water Quality Information System . . . Lynn M. Thatcher, Utah State Division of Health

11:55 a.m. Sherwood Berg, Dean, Institute of Agriculture, University of Minn.

12:00 noon Lunch

1:15 p.m. Hydrogeologic considerations in information system design . . . James R. Rollo, U.S. Geological Survey

1:45 p.m. The Federal water information system . . . William Doyel, Hydrologist, Office of Water Data Coordination, U.S. Geological Survey.

2:25 p.m. Relation of ground water quality information system and other systems in Minnesota . . . David Hamernick, State Planning Agency.

2:45 p.m. Coffee

3:05 p.m. Summary and recommendations of task force . . . William Walton, University of Minnesota, Water Resources Research Center

3:35 p.m. Questions and Discussion

Two hundred and three people attended the Conference. The publication of the 238 page proceedings of the Conference was part of the fiscal year 1973 program of the Center Director's office.

A Conference on "Toward a Water Resources Research Plan for Minnesota" was held on May 9-10, 1973 at Camp Courage which is located on Cedar Lake between the communities of Maple Lake and Annandale - about 50 miles northwest of the Twin Cities of Minneapolis and St. Paul.

The Water Resources Research Center is developing a long-range comprehensive plan for water resources research in Minnesota involving Federal, State and local agencies, private organizations, University of Minnesota, State and private Colleges, and others. An attempt is being made to formulate broad research guidelines and programs for coordinating research efforts.

During fiscal year 1974, the Water Resources Research Center will place a heavy emphasis on the analysis of important water problems in Minnesota to determine defensible associated research requirements, i.e., the research necessary to give a reasonable level of assurance that the problems can be resolved in a cost-effective and timely fashion. A water resources problem-research analysis workshop conference program will be developed with full consultation and collaboration between the Center; appropriate faculty at the University of Minnesota and State and Private Colleges; leading water resources officials within the State, including appropriate State, Federal and local agency officials, and appropriate members of Interest Groups.

The objective of this Conference was to discuss matters associated with developing the water resources research plan, and to devise ways and means for completing the plan.

The Program of the Conference is given below:

Wednesday, May 9

11:30 - 12:00 a.m.	Registration
12:00 - 1:00 p.m.	Lunch
1:00 - 1:15	Opening Remarks - W.C. Walton, Director, Water Resources Research Center, University of Minnesota
1:15 - 2:00	Background Paper on Water Resources Research Community in Minnesota - J. P. Ludwig, Consulting Ecologist, Bemidji
2:00 - 2:45	Background Paper on Water Resources Problems in Minnesota and Associated Research Needs - W.C. Walton
2:45 - 3:00	Coffee
3:00 - 5:30	Workshop Session I - Discuss and rank severity of water resources problems and need for research leading to solutions of problems
5:30 - 7:00	Dinner
7:00 - 8:00	Workshop Session II - Workshop Session I continued
8:00 - 9:30	Reports of Workshop Chairmen - Develop a comprehensive list of Water Resources Problem areas and a Water Resources Problem-Research Analysis Workshop Conference Program

Thursday, May 10

8:00 - 8:30 a.m.	Breakfast
8:30 - 9:30	Background Paper on Federal Water Pollution Control Act Amendments and Associated Research Opportunities - Frank G. Wilkes, EPA
9:30 - 9:45	Coffee
9:45 - 11:30	Workshop Session III - Discuss need for coordination of Water Resources Research Activities on a State-wide basis
11:30 - 12:00	Report of Workshop Chairmen - Develop arrangements to pursue ways and means of coordinating Water Resources Research Activities through a Workshop Conference
12:00 - 1:00 p.m.	Lunch
1:00	Adjourn

Sixty-five people attended the Conference.

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12:00 - 1:00 p.m.	Lunch
1:00	Adjourn

Sixty-five people attended the Conference.

An ad hoc Task Force on Statewide Ground Water Quality Information System was activated as a result of an informal meeting of 17 people held on the University of St. Paul Campus on December 22, 1971. The subject of concern of the Task Force is a statewide ground water quality-data system (total statewide activity to acquire, process, store, and disseminate ground water quality data). The objectives of the Task Force are: to document, publicize, and promote the need for a statewide groundwater quality-data system; to recommend institutional arrangements for designing the system; and to enumerate the factors to be considered in designing the system. Members of the Task Force who also served as the Planning Committee for the Conference on Toward a Statewide Groundwater Quality Information System are:

Robert Gast, Dept. of Soil Science, University of Minnesota  
Ron Harnack, Minnesota Department of Natural Resources, Division of Waters, Soils and Minerals  
Paul Johnson, Minnesota Department of Health  
Dave Hamernick, Minnesota State Planning Agency  
Lowell Hanson, Agricultural Extension Service, University of Minnesota  
Edward Ross, Minnesota Department of Health  
Conrad Straub, School of Public Health, University of Minnesota  
Dale Wikre, Minnesota Pollution Control Agency  
Tom Winter, U. S. Geological Survey  
William Walton, Water Resources Research Center, University of Minnesota (Chairman)

At Governor Rolvaag's request, the Center Director served on a 19-member Minnesota Water Resources Review Committee in 1966. The Center Director also attended the Special Midwestern Governor's Conference on Water Resources and Pollution at Lexington, Kentucky in 1966. At Governor LeVander's request, the Center Director from 1967 to 1969 served part time as Water Resources Planning Director, Minnesota State Planning Agency; Minnesota's representative on the Souris-Red-Rainy Rivers Basin Commission, Great Lake Basin Commission and Upper Mississippi River Coordinating Committee; and Minnesota's alternate representative on the Missouri Basin Inter-Agency Committee. The Center Director also served as Vice Chairman of the Souris-Red-Rainy Rivers Basin Commission. With the assistance of the Center, the Minnesota State Planning Agency has made considerable progress in preparing a statewide framework water and related land resources plan and in participating in Federal-State planning activities. Several documents have been completed with the assistance of the Center Director: "Background Information for Framework Statewide Water and Related Land Resources Planning in Minnesota," "Minnesota Water and Related Land Resources - First Assessment", "Alternate Programs and Projects for Managing Minnesota's Water and Related Land Resources Through the Year 2020," "Reaction to Water and Related Land Resources Planning Policy Questions During the Period November 1970 through June 1971", "A Statewide Water and Related Land Resources-Data System", and "Digest of Planning Information for the Southern Minnesota Rivers Basin".

On April 12, 1972 Governor Anderson appointed the Center Director to serve on the Citizens Advisory Committee of his Environmental Quality Council. The Council is composed of the Governor and the Heads of the State Planning Agency, Department of Natural Resources, Pollution Control Agency and Department of Highways. There are 24 members on the Committee. The

Committee's responsibilities are to: recommend possible agenda items for the Council, assist in establishing Council Task Forces, hold public meetings to sample opinions concerning environmental issues, assess the operation of the Council, assess Federal environmental Legislation, and make recommendations concerning institutional arrangements for environmental affairs. One of the first matters considered by the Committee was power plant siting.

The Center Director has served as an advisor to the Minnesota House Natural Resources Committee, Subcommittee on Waters and Drainage; Senate Agriculture Committee, Subcommittee on Drainage; and Senate Natural Resources and Environmental Committee, Subcommittee on Water Permits. He assisted these Subcommittees in preparing joint reports concerning needed legislation in the water and related land resources field.

During fiscal year 1972, the Center Director served on the following Committees: Advisory Committee on Water Data for Public Use, U.S. Geological Survey; Delegate - University Council on Water Resources; All-University Environmental Council, University of Minnesota; Water Resources Coordinating Committee, State Planning Agency; Citizens Advisory Committee to the Governor's Environmental Quality Council.

The Center Director presented several lectures and talks on water resources and environmental factors. Excerpts from a few letters expressing appreciation for the Director's efforts are given below:

Thanks again for participating in our Workshop last Saturday. I received numerous compliments on the program which, of course, should be passed on to you and the other speakers. The presentations really brought home to us the breadth and importance of the problems we face in the months and years ahead. I hope that the Minnesota Division IWLA can contribute in some way to solving some of these problems.

Paul Toren, Workshop Chairman  
Minnesota Division  
Izaak Walton League of America, Inc.

Allow me to express the appreciation of the Labor Education Service for your participation in the recent conference at Arrowwood Lodge. We were particularly grateful to you for coming up on such short notice and for your insights into the problem of the environment. We shall become more deeply involved with this subject and will be certainly interested in working you into our programs with much more lead time.

In closing, Bill, let me again thank you for your valuable assistance.

Emil Starr  
Assoc. Prof. of Industrial Relations &  
Director of Labor & Urban Affairs  
Labor Education Service  
University of Minnesota

On behalf of Representative (now Senator) Robert Dunn, Chairman of the House Subcommittee, I wish to thank you for taking the time to appear before the Joint Subcommittee.

Enclosed is a copy of the House Subcommittee's Final Report. You should have been sent - sometime last Fall - copies of the Topical Summary Outline of Testimony and the Recommendations dated August 16, 1972. If, however, you didn't receive a copy of the above, please let us know (296-6753); House Research Department, B46 State Capitol, St. Paul, Minnesota 55155.

John Helland, House Research Assistant  
State of Minnesota  
House of Representatives

#### CENTER DIRECTOR'S ACTIVITIES

July 17, 1972 - Attended meeting of Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; July 24-26 - Attended Annual Meeting of Universities Council on Water Resources, Amherst, Mass.; August 14 - attended meeting of Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; August 16-18 - Presented a paper entitled "From Theory to Practice in Groundwater Modeling" during American Society of Civil Engineers, Hydraulics Division Speciality Meeting, Ithaca, New York; September 14 - Chaired meeting of Subcommittee on State Environmental Policy, Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; September 16 - Presented a paper on Water Resources Policy to Annual Meeting of Izaak Walton League, Aitkin; September 19-20 - Chaired Conference on Toward a Statewide Groundwater Quality Information System, St. Paul; September 21 - Attended meeting of Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; September 28 - Chaired meeting of Subcommittee on State Environmental Policy, Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; October 10 - Attended meeting of Ground Water Quality Subcommittee, Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; October 12 - Chaired meeting of State Environmental Policy Subcommittee, Citizens Advisory Committee, Governor's Environmental Quality Council - St. Paul; October 17 - Presented a paper entitled "Protecting the Worker and His Family in the Human Environment" during the Ninth Annual Labor & World Affairs Conference - Alexandria; October 24 - Attended meeting of Ground Water Quality Subcommittee, Citizens Advisory Committee, Governor's Environmental Quality Council - St. Paul; October 26 - Chaired meeting of State Environmental Policy Subcommittee, Citizen Advisory Committee, Governor's Environmental Quality Council - St. Paul; October 27 - Attended meeting of Citizens Advisory Committee, Governor's Environmental Quality Council - St. Paul; November 13 - Chaired a Groundwater Session of the Geological Society of America Annual Meeting - Minneapolis; November 14 - Presented a paper on Environmental Concerns to members of the World Institute at Macalester College - St. Paul; November 16, 27 and 30 - Chaired meetings of State Environmental Policy Subcommittee, Citizens Advisory Committee, Governor's Environmental Quality Council - St. Paul; December 12 - Attended a meeting of Midwestern Water Resources Research Center Directors, Detroit, Michigan; December 21 - Attended a meeting of the

Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; December 27 - Attended a meeting of the Governor's Environmental Quality Council, St. Paul; January 4, 1973 - Attended a meeting of the Governor's Environmental Quality Council, St. Paul; January 10 - Presented a paper on Environmental Concerns to meeting of Deans and Departmental Chairmen of the Institute of Agriculture, St. Paul; January 16 - Attended a meeting of the Citizen's Advisory Committee, Governor's Environmental Quality Council, St. Paul; January 17-18 - Attended a meeting of Midwest Center Directors sponsored by the Office of Water Resources Research, Madison, Wisconsin; January 22 - Attended a meeting of the Governor's Environmental Quality Council - St. Paul; February 7-8 - Attended a meeting of Midwestern Water Resources Research Center Directors, Madison, Wisc.; February 20 - Attended a meeting of All-University Environmental Quality Council, Minneapolis; February 22 - Attended a meeting of the Citizens Advisory Committee, Governor's Environmental Quality Council; St. Paul; February 28 - Presented a paper on Water Resources Administration in Minnesota to meeting of Citizens League; March 2 - Chaired a meeting of the Center's Advisory Committee, St. Paul; March 13 - Attended a meeting of the Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; March 20 - Presented a paper on Environmental Quality in Minnesota at League of Women Voters meeting, St. Paul; April 10-12 - Attended Annual Conference sponsored by Office of Water Resources Research, Washington, D.C.; April 17 - Attended a meeting of the Citizens Advisory Committee, Governor's Environmental Quality Council, St. Paul; April 19 - Presented a lecture on Water Resources to those attending Growth Seminar at University of Minnesota, Minneapolis; May 3 - Attended Seminar on State Land Use Criteria, Minneapolis; May 4 - Presented a lecture on Water Resources Planning to participants in CE 5-420 at University of Minnesota, Minneapolis; May 9-10 - Chaired Conference on Toward A Water Resources Research Plan for Minnesota, Camp Courage; May 29 - Presented a talk during hearing on Copper Nickel Development, Bemidji; May 30 - Attended meeting of All University Council on Environmental Quality, Minneapolis; June 5-7 - Attended a meeting of the Advisory Committee on Water Data for Public Use, U.S. Geological Survey, Portland, Oregon; June 11 - Attended meeting of Water Resources Coordinating Committee, St. Paul.

INFORMATION CONCERNING RESEARCH PROJECT  
PROPOSALS SUBMITTED TO OWRR BY CENTER, FY 1974

Lists of FY 1974 Annual Allotment, Matching Grant and Title II research project proposals submitted to OWRR by the Center are given below. A table summarizing the number of Center proposals funded or rejected by OWRR FY 1965-74 is also provided.

About 30 percent of Matching Grant proposals have been funded and 100 percent of Annual Allotment proposals have been funded. No Title II proposals have been funded.

List of Annual Allotment Research Project Proposals Submitted to OWRR by Center, Fiscal Year 1974

\*(Proposals Funded)

\* Water Quality Status and Trends in Minnesota - Indices for Water Supply and Groundwater Pollution

\* Analysis of Organic Carbon as a Pollution Index

List of Matching Grant Research Proposals Submitted to OWRR by Center, Fiscal Year 1974

\*(Proposals Funded)

Assessment of the Efficacy and Feasibility of Abating Pollution of Eagle Lake in Minnesota  
Thermal Pollution and Lake Superior Periphvton  
\* Geochemical Studies on Minnesota Lakes, With Special Reference to Historical Aspects of Lake Eutrophication, Landscape Erosion, and Soil Weathering  
Effects of Present and Future Water Quality on Growth, Development and Reproduction of Aquatic Vascular Plants  
Effects of Soil Minerals and Microbial Activity on the Degradation of Agridultural Pesticides in Surface and Ground Waters under Freezing and Near-Freezing Conditions  
Ecology Movement, System Response, and Socio-cultural Change: A Study of Interactions, Explorations and Adaptations to Improve Water Resources Environment

An Attitudinal Study of Western Minnesota Lake Residents Toward Water Conservation and Water Pollution

Factors Leading to Outbreaks of Swimmer's Itch in Minnesota Waters

\* Bio-manipulation of Lakes for Elimination of Blue-Green Algae

A Study of the Effect of Agricultural Practices on Priage Lakes in Southwestern Minnesota

\* Techniques for Determining the Pollutational History of Minnesota Lakes  
Analysis of Organic Carbon as a Pollution Index

Systems Analysis of Land Disposal of Waste Water by Irrigation, and Comparison of Performance to other Waste Water Renovation Systems

Application of Water Quality Models to Minnesota Lakes

Developing Reaction Gas Chromatographic Procedures for Determination of Aqueous Anions

System Simulation Studies of a Large Watershed to Evaluate Water Quality and Quantity

Subsurface Injection of Thermally Enriched Water, A Means of Artificial Ground Water Recharge and Soil Warming

Prediction Surface and Subsurface Runoff for Shallow or Two-Layered Soils

\* Thermal Pollution and Second Trophic Level Fauna in Lake Superior

Quality of Ground Water Recharge Water in Selected Agricultural and Forested Land Use Areas

List of Title II Research Proposal Submitted to OWRR by Center, Fiscal Year 1974

\*(Proposals Funded)

Nitrogen Losses from Soils by Denitrification and Tile Line Drainage in Minnesota

Feasibility of Using Overburden Material as a Media for Disposal of Secondary Sewage Effluent in Northwestern Minnesota

Computer Programs and Simulation Models in Water Resources: Scope and Availability

Number of Research Project Proposals Submitted to OWRR by Center and Funded or Rejected, Fiscal Years 1965 through 1974

<u>Fiscal Year</u>	<u>Allotment</u>			<u>Matching Grant</u>		
	<u>Funded</u>	<u>Rejected</u>	<u>Total</u>	<u>Funded</u>	<u>Rejected</u>	<u>Total</u>
1965	7	0	7	0	0	0
1966	2	0	2	5	2	7
1967	1	0	1	0	3	3
1968	4	0	4	2	1	3
1969	2	0	2	3	2	5
1970	2	0	2	3	15	18
1971	3	0	3	4	15	19
1972	2	0	2	4	8	12
1973	1	0	1	3	11	14
1974	2	0	2	4	16	20
Total	26	0	26	48	73	101

Title II

<u>Fiscal Year</u>	<u>Funded</u>	<u>Rejected</u>	<u>Total</u>
1968	0	2	2
1969	0	6	6
1970	0	9	9
1971	0	2	2
1972	0	1	1
1973	0	1	1
1974	0	3	3
Total	0	24	24

The Center Director assisted private Principal Investigators in preparing the following 3 FY 1974 OWRR Title II research proposals.

Title of Project: Developing a Model to Identify, Interpret and Disseminate Water Resources Information to the General Public

Principal Investigators: Ervin J. Gaines, Director, Minneapolis Public Library, Julia W. Copeland, Head, Environmental Conservation Library

Period of Operation: October 1, 1973 through March 31, 1976

Project Description:

The objective of this project is to develop a method by which water and related land resources information can be distributed widely to the general public, to enable the citizen to make wise decisions in the use and protection of these resources. Research plans will include: (1) identifying and contacting government agencies and other sources of water resources information, (2) acquiring and organizing documents, (3) digesting and abstracting information for use by the non-scientific citizen, (4) reviewing abstracted information by an advisory committee, (5) indexing the materials and disseminating a printed index (6) developing methods for effective delivery of all project information and printed materials to the general public in the State of Minnesota.

Financial Plan:

<u>Year</u>	<u>Fed. \$</u>	<u>Non-Fed. \$</u>	<u>Total \$</u>
1	31,971	2,544	34,515
2	39,676	3,044	42,720
3	19,838	1,522	21,360
Total	91,485	7,110	98,595

Title Of Project: Development of Water Quality Indices for Improved Water Resources Planning and Management

Principal Investigator: Roy E. Peterson, President Creative Research Services, Inc., Minneapolis, Minnesota

Period of Operation: July 1, 1973 through June 30, 1975

Project Description:

The proposed research plan involves a two-phase study to develop practical, useful water quality indices for improved water resources planning and management. During Phase I, a thorough review and systematic classification will be made of all relevant water quality data bases in Minnesota. A critical evaluation will be made of previous work in developing water quality indices. A set of general requirements will then be established for developing improved indices. These requirements include data availability, scientific and technical feasibility, and utility for water resources planning, decision-making and operational implementation. The Phase II research involves the identification and development of specific water quality indices for near-term (1975-1980) and longer term (1980-1990) applications. Input data requirements and statistical methods for trend and time series analysis will be considered. A recommended program will be outlined for final development and operational usage of selected water quality indices.

Financial Plan:

Funding: \$33,150 Federal  
5,850 Creative Research Services, Inc.

Title Of Project: Planning Water Resources Management for the Upper Mississippi and Tangent River Basins

Principal Investigator: James P. Ludwig, Consulting Ecologist, Bemidji, Minnesota

Period of Operation: July 1, 1973 through September 30, 1975

Project Description:

The specific objective of this research is to assess the level of research capability within these drainage basins in order to lay a sound foundation for the development of a complete plan for the development of a one or more River Basin Study Centers pursuant to provisions of the Water Pollution Control Act of 1972. This preliminary work is needed if a vigorous interstate and interagency coordination attempt is to underlie the development of a River Basin Study Center(s). Such a broad attempt at coordination is essential if attempts to fulfill the spirit and intention of the new legislation are to be legitimate. A second objective is to establish a mechanism to link together the several river basin commissions in terms of their research needs as well as assisting these formal organizations in their effort to identify the personnel and institutions who can provide the technical assistance to each commission to gather the research data on problems as these are identified. A third objective is

to encourage both the researchers and their support institutions to identify the problems and problem areas that they can provide research effort toward; with existing conditions of chaos in funding of many agencies and programs which sustain reserach personnel, such an effort may be crucial to the success of any multi-agency-institution attempt to develop a River Basin Study Center. Liason between the various interested groups and institutions in even more essential today than previously when it has been critical. A fourth objective is to assist the responsible Federal officials and agencies to recognize the vigor and potential of the responsible agencies and institutions of this region to search for a viable new institutional arrangement designed to provide the best approach to gathering the needed research information.

Financial Plan:

Year	Funding		
	Fed. \$	Non-Fed. \$	Total \$
1	18,633	2,500	21,133
2	19,040	2,500	21,540
3	2,851	300	3,151
Total	40,524	5,300	45,824

FISCAL YEAR 1973 OWRR BUDGET

Annual Allotment Program

Project Title, Principal Investigator and OWRR Project No.	Federal Funds \$
Center Director's Office	29,300
Mathematical Simulation of a Large Watershed Using the System Approach to Quantity and Quality Analysis- Charles C. S. Song and C. Edward Bowers, St. Anthony Falls Hydraulic Laboratory (A-024-Minn)	13,906
Alleviation of Lake Pollution by Utilization of Aquatic Plants for Nutritional, Medicinal, or Industrial Purposes - E. John Staba, Department of Pharmacognosy (A-025-Minn)	14,000
Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes - Robert O. Megard, Department of Ecology and Behavioral Biology (A-026-Minn)	14,000
Study of Criteria and Models for Establishing Optimum Level of Hydrogeologic Information for Groundwater Basis Management - Hans Olaf Pfannkuch, Department of Geology and Geophysics (A-027-Minn)	13,584
Developing a Water Resources Research Plan for Minnesota - William C. Walton, Graduate School (A-028-Minn)	15,210
Total	100,000

Annual Allotment Non-Federal Contribution

\$ 43,197

Matching Grant Program

	Federal Funds \$	Non. Fed. Funds \$	Total Funds \$
Characteristics of the Soil Matrix That Affect Water Storage and Movement - G. R. Blake, Department of Soil Science (B-015-Minn)	12,083	20,819	32,902
Mississippi River Ecology Associated with Heated Power - A. J. Hopwood, Biology Department, St. Cloud State College (B-032-Minn)	6,500	4,500	11,000
Spatial Variation in the Perception of Water Resources and Water Problems in South Central Minnesota - R.T. Moline, Department of Geography, Gustavus Adolphus College (B-042-Minn)	7,157	4,550	11,707
Area Financing of Water Resources Development - W.R. Maki, Department of Agricultural & Applied Economics, University of Minnesota (B-044-Minn)	15,167	11,780	26,947
Social and Economic Factors in the Adoption by Industry of Water Pollution Control Measures - R.E. Rickson, Department of Sociology (B-047-Minn)	11,365	10,471	21,836
A Hydronomic Analysis of Forest Management Alternatives For Environmental Quality - A.C. Mace & J.M. Hughes, School of Forestry (B-053-Minn)	15,306	12,458	27,764
Socio-Economic Implications of Alternative Water Resources Policies In Minnesota - John J. Waelti, Department of Agricultural and Applied Economics (B-054-Minn)	11,440	9,568	21,008
Suhsurface Irrigation With Heated Water, Its Management, and Application Toward Reduction of Thermal Pollution Problems - Evan R. Allred, Department of Agricultural Engineering (B-057-Minn)	11,685	12,301	23,986
Role of the Scientist-Technician in Water Policy Decisions at the Community Level: A Study in Purposive Communication - R.E. Rickson, P.J. Tichenor and G.A. Donohue, Department of Sociology and School of Journalism (B-067-Minn)	15,580	15,300	31,150

Spatial and Temporal Variation of Precipitation of a Concentrated Net- work in Both Urban and Rural Environ- ment - Donald G. Baker, Department of Soil Science (B-068-Minn)	11,100	9,938	21,038
Forecasting Rainfall and Snowmelt Floods on Upper Midwestern Water- sheds - C. Edward Bowers, St. Anthony Falls Hydraulic Laboratory (B-077-Minn)	16,931	16,515	33,446
Total	134,584	128,200	262,784

FACULTY RESEARCH AT UNIVERSITY OF MINNESOTA  
BEARING ON WATER RESOURCES, 1971-1972,  
IN ADDITION TO THE CENTER'S PROGRAM

Office of the Vice President  
for Academic Administration

Center for Urban and Regional Affairs

Borchert, J.R.  
Minnesota Land Use Study and Development of Land Management Infor-  
mation System - Dept. of Administration, State of Minnesota; Plan-  
ning Agency, State of Minnesota; The Rockefeller Foundation

College of Biological Sciences

James Ford Bell Museum of Natural History

Bright, R.C.  
Diatoms of Lake Superior  
Ethnobotany of Prairie Island - Northern States Power Company  
Geology of North Lake Bonneville  
Late Quaternary Mollusca of Southeast Idaho  
Paleoecology of Lake Thatcher  
Paleoecology of Whimpy Lake - Graduate School, University of Minnesota  
Planktonic Diatoms of Minnesota

Huver, C.W.  
Age and Growth in the Yellow Perch Population of Gull Lake, Michigan  
Biological Effects of Low Level Radiation  
Effect of the Degree of Parasitism on the Coefficient of Condition  
of Gull Lake Fishes  
Etiology of Malignant Melanomas in Teleosts - American Cancer Society, Inc.  
Histological and Physiological Study of the Teleost Parathyroid Gland  
Histological and Ultrastructural Study of the Teleost Axillary Gland  
Sex Differentiation in the American Eel - Society of the Sigma Xi

Kuechle, V. B.  
Cooperative Radio Telemetry on Waterfowl - United States Fish and  
Wildlife Service

Botany

Burke, M.E.  
Distribution of Photosynthetic Bacteria in Minnesota Bogs -  
Limnological Research Center, University of Minnesota

Gorham, Eville  
Chemical Classification of Minnesota Lake Waters and Sediments  
Geochemical Studies on the History and Evaluation of Minnesota Lakes -  
National Science Foundation  
Distribution of Photosynthetic Bacteria Along Moisture and Acidity  
Gradients - Limnological Research Center, University of Minnesota

Koukkari, W. L.  
Physiology of Aquatic Plants

Ecology and Behavioral Biology

Brook, A. J.  
Aspects of the Biology of River Algae  
Ecological Studies on Dynamics of Planktonic Blue-Green Algae with  
Special Reference to their Microstratification - Atomic Energy Commission

McColl, J. G.  
Effects of Fire on Lakes in a Natural Forest Ecosystem - Graduate  
School, University of Minnesota

Siniff, D. B.  
Mink-Waterfowl Relations on Prairie Wetlands - U.S. Department of  
the Interior  
Movement of Rainbow Trout on Lake Superior - U.S. Department of the  
Interior

Zoology

Barnwell, F. H.  
Activity Rhythms in Bivalve Molluscs Biochemical Taxonomy of the  
North  
American Fiddler Crabs  
Characterization of New Species of Fiddler Crab from the Gulf of  
Mexico  
Ecological Relations of Activity Rhythms in Central American Fiddler  
Crabs

Law School

Bryden, D.P.  
Shoreland Regulation in Minnesota

College of Liberal Arts

Anthropology

Gerlach, L. P.  
Land Use and Social Change - Environmental Quality Laboratory,  
California Institute of Technology

Geography

Skaggs, R. H.  
Drought Climatology of the United States

Health Sciences

School of Public Health

Singer, R. D.  
Consortium for the Study of Solid Waste Management/Recycling-  
Minnesota Pollution Control Agency  
Water Well Construction Technology: a Review of Current Principles

Straub, C. P.  
Accumulation of Trace Substances in Recycled Water Treatment Plant  
Sludges - Water Works, City of Minneapolis  
Hospital Water Supplies - National Institutes of Health, United  
States Public Health Service  
Leaching of Hazardous and Chemical Wastes through Granular Soil -  
Minnesota Pollution Control Agency  
Removal of Trace Substances by Water Treatment Plants - Water  
Works, City of Minneapolis

Institute of Agriculture

Department of Agricultural and Applied Economics

Blank, O. Uel  
Economics of the tourism/recreation industry - University of  
Minnesota Agricultural Experiment Station

Jensen, Harald R.  
Impact of metropolitan growth on regional resource use (with  
W. Maki and W. Bryant) - University of Minnesota Agricultural  
Experiment Station

Maki, Wilbur R.  
Impact of metropolitan growth on regional resource use (with  
H. Jensen and W. Bryant) - University of Minnesota Agricultural  
Experiment Station

Raup, Philip M.  
Analysis of public investments in natural resources within  
Minnesota (with L. Martin) - University of Minnesota Agricultural  
Experiment Station  
Economic problems in the use, allocation, and pricing of water -  
University of Minnesota Agricultural Experiment Station

Snyder, Robert W.  
Local government and policy implications of seasonal home owner-  
ship in rural areas - University of Minnesota Agricultural  
Experiment Station

Stam, Jerome M.  
Economic analysis of the Lake of the Woods/Rainy Lakes region  
of Minnesota - University of Minnesota Agricultural Experiment  
Station

Department of Agricultural Engineering

Allred, Evan R.  
Supplemental irrigation in Minnesota (with J. Gilley) - Univer-  
sity of Minnesota Agricultural Experiment Station

Goodrich, Phillip R.  
Hydrology of small watersheds (with C. Larson) - University of  
Minnesota Agricultural Experiment Station

Larson, Curtis, L.  
Hydrology of small watersheds (with P. Goodrich) - University of  
Minnesota Agricultural Experiment Station

Department of Entomology, Fisheries, and Wildlife

Beer, James R.  
Upland game bird population dynamics and habitat requirements -  
University of Minnesota Agricultural Experiment Station

Cook, Edwin, F.  
Biological and systematic studies on aquatic arthropods - Univer-  
sity of Minnesota Agricultural Experiment Station and National  
Institutes of Health

Heyerdahl, Eugene G.  
Lake of the Woods commercial and sport fishing investigations  
(with L. Smith) - University of Minnesota Agricultural Experiment  
Station and State of Minnesota Department of Natural Resources

Marshall, William H.  
Productivity of artificial duck ponds - State of Wisconsin Depart-  
ment of Conservation

Smith, Lloyd L., Jr.  
Causes of population changes in Red Lake commercial fish species -  
University of Minnesota Agricultural Experiment Station and United  
States Department of the Interior  
Dynamics of separate intralake fish populations - University of  
Minnesota Agricultural Experiment Station  
Influence of water pollutants and water quality on early life  
history and population dynamics of Minnesota fishes - University  
of Minnesota Agricultural Experiment Station and Environmental  
Protection Agency  
Lake of the Woods commercial and sport fishing investigations (with  
E. Heyerdahl) - University of Minnesota Agricultural Experiment  
Station and State of Minnesota Department of Natural Resources

Waters, Thomas F.  
Production Ecology in Streams and Rivers - University of Minnesota  
Agricultural Experiment Station  
Secondary Production in Running-Water Ecosystems - National Science  
Foundation

Department of Horticultural Science

Kuska, James  
Development of design and utilization criteria for Minnesota  
natural resources - University of Minnesota Agricultural Experi-  
ment Station

Department of Soil Science

Arneman, Harold F.  
Minnesota soil survey and soil characterization (with R. Rust and  
R. Farnham) - University of Minnesota Agricultural Experiment Station

Baker, Donald G.  
Soil heat and moisture characteristics related to evaporation from  
cropped land - University of Minnesota Agricultural Experiment Station  
Urban Climatology - University of Minnesota Agricultural Experiment  
Station  
Weather Information for agriculture - University of Minnesota Agricul-  
ture Experiment Station

Blake, George R.  
Soil structure and crop growth - University of Minnesota Agricultural  
Experiment Station

Farnham, Rouse S.  
Minnesota soil survey and soil characterization (with R. Rust and  
H. Arneman) - University of Minnesota Agricultural Experiment Station

Rust, Richard H.  
Minnesota soil survey and soil characterization (with H. Arneman  
and R. Farnham) - University of Minnesota Agricultural Experiment  
Station

College of Forestry

Gregersen, Hans M.  
Determinants of forest resource, supply, benefits, and management  
levels in Minnesota forests (with J. Hughes and R. Skok) - Univ-  
ersity of Minnesota Agricultural Experiment Station

Hansen, Henry L.  
Ecomanagement of forest vegetation on parks and wilderness areas -  
University of Minnesota Agricultural Experiment Station

Mace, Arnett C., Jr.  
Watershed values as affected by forest management - University of  
Minnesota Agricultural Experiment Station

Merriam, Lawrence C., Jr.  
Relationships between recreation land management and user satis-  
faction - University of Minnesota Agricultural Experiment Station  
and College of Forestry

Meyer, Merle P.  
Remote sensing in resources management - University of Minnesota  
Agricultural Experiment Station and College of Forestry

Institute of Technology

Civil and Mineral Engineering

Johnson, W. K.  
Denitrification Kinetics  
Filamentous Sludge Bulking  
Sludge Disposal Studies - Metropolitan Sewer Board

Maier, W. J.  
Assessment of Solid Waste Management and Recycle Technology -  
Minnesota Pollution Control Agency  
Computer Application for Preliminary Design of Waste Water Treat-  
ment Systems Phenomenology of Water-Air Interfaces Removal of  
Colloidal Materials by Biological Processes - Environmental Prot-  
ection Agency  
Use of Soluable Carbon as a Measure of Pollution

Schroepfer, G. J.  
Water Pollution in Minneapolis-St. Paul Metropolitan Area

St. Anthony Falls Hydraulic Laboratory

Anderson, A. G.  
Erosion Control in Highway Drainage Channels - National Academy  
of Sciences  
Flow in Long Vertical Drop Shafts - Environmental Protection Agency  
Investigation of the Development of Meander Systems  
Marin Spillway Studies - Harza Engineering Company

Bowers, C. E.  
Hydraulic Jump Analysis - National Science Foundation  
Mathematical Modeling of Floods - Corps of Engineers, United  
States Department of the Army  
Measurement of Urban Runoff Model Studies of Outlet Gates, Yguazu  
Dam, Paraguay - Charles T. Main, Inc.  
Physical Hydrologic Watershed Model

Hayden, J. W.  
Model Study of Encina Power Plant Cooling Water Intake Structure -  
Pioneer Service and Engineering Company  
Model Study of Zion Station Cooling Water Intake and Discharge  
Structure - Harza Engineering Company

Saturation - Permeability Relationships for Granular Materials  
Seepage and Stability Analysis of Taconite Tailings Basin - United States Steel Corporation  
Study of Moisture Separator - Reheater Drain System, Donald C. Cook Power Plant - American Electric Power Service Corporation  
Tension Characteristics of Cohesive Soil Water Resources Management for a Small Watershed in an Urbanizing Area

Killen, J. M.

Influence of Drag Reducing Polymers on Radiated Flow Noise-Naval Ship Research and Development Center, United States Department of the Navy  
Influence of Drag Reducing Polymers on Surface Pressure Fluctuation - Office of Naval Research  
Zero Rate Crossing as a Fluid Drag Measurement - National Science Foundation

Ripken, J. F.

Fragmentation of Rock by Impingement with Liquid and Solid Impactors - Bureau of Mines, United States Department of the Interior  
Hydrodynamic Study for a Large Water Test Facility - Naval Ship Research and Development Center, United States Department of the Navy  
Spillway Cavitation Damage - Harza Engineering Company

Silberman, E.

Heated Surface Discharge into Flowing Ambient Streams and Lakes Mixing and Dispersion at a Warm Water Outlet - Environmental Protection Agency  
Prairie Island Nuclear Plant Studies - Northern States Power Company  
Ygazu Spillway Model Studies - Charles T. Main, Inc.

Song, C. C. S.

Flutter of Cavitating Hydrofoils - Naval Ship Research and Development Center, United States Department of the Navy  
Forced Ventilation of Flows near a Boundary  
Generation of Internal Waves in Stratified Fluid - Office of Naval Research  
Stability of Separated Flows

Stefan, H.

Analysis of Aquatic Environments Energy Transfer into Large Bodies of Water  
Mixing and Dilution Processes near Cooling Water Outfalls - United States Department of the Interior

#### Geology and Geophysics

Banerjee, S. K.

Geomagnetic Record in Lake Sediments

Bradbury, J. P.

Distribution and Ecology of Diatoms in Minnesota in Natural and Polluted Aquatic Habitats - Atomic Energy Commission

Chase, C. G.

Mesozoic Evaluation of the Pacific Ocean Floor

Hall, H. T.

Mineralogical Control on Surface Water Chemistry

Hooke, R. L.

Shear Stress and Sediment Distribution in a Meander Bend - National Science Foundation

Normark, W. R.

Heat Flow in Lakes near the Mid-Continent Gravity High - National Science Foundation

Pfannkuch, H. O.

Correlation of Hydrological Parameters for Porous Media Flow with Microscopic Pore Morphology Measurements - Graduate School, University of Minnesota  
Electrical Conductivity in Saturated Porous Systems - National Science Foundation  
Hydrogeologic Studies of Groundwater in Selected areas of the Twin-Cities Metropolitan area - Minnesota Geological Survey  
Lake Pollution Control Program - Planning Agency, State of Minnesota; Department of Parks and Recreation, City of Minneapolis

Swain, F. M.

Biogeochemistry of Bay Sediments - United States Department of the Navy  
Biogeochemistry of Humus  
Biogeochemistry of Marsh Gases - Office of Naval Research  
Deep Sea Ostracoda of the Pacific - Graduate School, University of Minnesota  
Marsh Gases of Minnesota  
Mesozoic and Cenozoic Ostracoda of the Atlantic Coastal Plain - United States Geological Survey

Wright, H. E.

Community Analyses in the Littoral Zone of Lakes - Environmental Protection Agency  
Development of Lakes and Landscapes on Stagnant Glacial Ice in the Yukon - National Science Foundation  
Diatoms in Lake and Lake Sediments as an Index to Environment - Atomic Energy Commission

University of Minnesota - Duluth

#### Biology

Fluegel, W.

Smelt and Smelt Fishing

University of Minnesota - Morris

Science and Mathematics

Abbott, R. S.  
Eagle Lake Project - Minnesota Resources Commission

Latterell, J. J.  
Eagle Lake Project - Minnesota Resources Commission

Nord, B.  
Social and Economic Considerations Associated with an Antipollution  
Demonstration Project - Minnesota Department of Natural Resources

University of Minnesota - Crookston

Svedarsky, W. D.  
System Design Approach to Water Resources Approach to Water Resource  
Management in the Red River Basin

ANNUAL ALLOTMENT PROGRAM

NARRATIVE PROGRESS REPORTS

OWRR Project No.: A-024-Minn.

Annual Allotment Agreement No.: 14-31-000-3823

Project Title: Mathematical Simulation of a Large Watershed using the  
Systems Approach to Quantity and Quality Analysis

FCST-COWRR Research Category: 06-A

Name and Location of University where Project is being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970

Project Completed: June 30, 1973

<u>Principal Investigators</u>	<u>Degree</u>	<u>Discipline</u>
Charles C.S. Song	Ph.D.	Civil Engineering
C.E. Bowers	M.S.	Civil Engineering

<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
A.F. Pabst	M.S., Ph.D.	Civil Engineering
D. Ford	B.S.	Civil Engineering
K. Kim	M.S.	Civil Engineering

Narrative Statements

(A) Research Project Accomplishments.

The objectives of this study are: the development of a mathematical model capable of simulating the quantity and quality of flow in a fairly large basin or watershed such as the Minnesota River Basin, and direct application of the model to the Minnesota River Basin for the verification and improvement of the model.

In the early phases of the study consideration was given to the development of a new quantity model but the availability of existing models suggested that these be investigated before efforts were made to develop a new one. Existing models of special interest were the Standord model, the SSARR model (developed by the Corps of Engineers and the National Weather Service in the Columbia Basin), the Texas model, the Kentucky model, and a design-oriented model called HEC 1 developed by the Hydrologic Engineering Center. As the Stanford model is generally oriented toward small watersheds it was not studied as part of this project. The SSARR (Streamflow Synthesis and Reservoir Regulation) model had been successfully developed and used in the Columbia Basin and was selected for initial study under this project.

The 16,200 square mile Minnesota Basin was subdivided into 15 sub-watersheds, most of which were gaged by the U.S. Geological Survey; U.S.G.S. data are available for periods of up to about 50 years. Daily weather observations are available for 45 stations in or adjacent to the basin for various periods of up to 60 years in length.

While some records are very good, there are deficiencies, particularly in the quality parameters. For recent years there is more emphasis on quality data. In addition, the climatic data are available on tape from 1963 to the present, giving greater emphasis on the use of recent records.

The SSARR model was fitted to each of the sub-watersheds with primary emphasis on 1967 and 1968 plus the peak flood years of 1965 and 1969. It was necessary to modify some features pertaining to snowmelt in areas of high relief as the total variation in elevation in the complete basin was less than 1,000 ft. The model uses a Soil Moisture Index to determine the percent of runoff for each increment of rain or snowmelt; this relationship is in the form of a table. It was necessary to use a different relationship for winter and summer seasons and considerable difference was noted between sub-watersheds. In general the results indicated that the SSARR model can be fitted to the sub-watersheds quite well for a given year by variation of the appropriate parameters.

The quality aspect of the watershed simulation is less well developed at present. Thus, it was felt necessary to develop a model suitable to a large watershed that could be used independently or in conjunction with the quantity model. Although the model is intended to handle a number of water quality parameters, major emphasis was given to water temperature. The model developed under this research project consists of two parts: a deterministic stream-reservoir system model and a stochastic input data model.

The main stream and major tributaries of a watershed, including significant lakes and reservoirs, are taken to constitute the stream-reservoir system. Here, a lake or a reservoir is defined as a portion of the system which may stratify during a significant part of a year. Separate computer programs were written separately for the stream portion and the reservoir portion of the system. A one-dimensional time dependent finite difference equation was used to represent each quality parameter such as water temperature, BOD, and DO concentration. Complete mixing in lateral and vertical directions are assumed to take place in streams. Longitudinal dispersion and convections are included in the stream model. A reservoir is assumed as a two-layer system consisting of epilimnion and hypolimnion. Complete mixing within each layer and dispersion between the layers are assumed to take place. Thus, consistent with the overall objective, a one-dimensional time dependent model was also developed for the reservoir portion of the system.

Water quality input data at various locations in the system are required to perform a simulation process. These input data are very scarce and costly, especially in a larger watershed like Minnesota River Basin. For example, only two of the 15 tributaries have water temperature records. Furthermore, these records are mostly of extremely short duration. For the purposes of supplementing missing data and generating synthetic data for forecasting and designing, stochastic models for water-temperature and air-temperature input data were developed. They are based on the regression analysis of the available data at 11 stations in Minnesota and a station on the Illinois River. The water-temperature model is tied to the air-temperature model through a first order Markov chain. Thus the model is capable of reproducing the normal seasonal variation as well as the daily water temperature departures, including the serial correlation and purely random variations. A method for transferring the regression coefficients obtained for Minnesota River Basin to other watersheds are also suggested. Further work with regard to the transferability of the model to other watersheds is needed, however.

(B) Publications.

Song, C.S., Pabst, A.F., Bowers, C.E., Simulation of the Quantity and Quality of Flow in a Basin, St. Anthony Falls Hydraulic Laboratory Laboratory, Univ. of Minn. Project Report No. 145, June 1973.

(C) Project Status.

Project completed.

(D) Application of Research Results.

The mathematical model can be used as a tool for forecasting the quantity and quality of flow at selected locations, for studying the systems response to future water resources projects, and for systems analysis to achieve optimum management.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No.: A-025-Minn

Annual Allotment Agreement No.: 14-31-0001-3823

Project Title: Alleviation of Lake Pollution by Utilization of Aquatic Plants For Nutritional, Medicinal or Industrial Purposes.

FCST-COWRR Research Category: 05-E

Name and Location of University Where Project is Being Conducted:  
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970 Project Completed: June 30, 1973

Principal Investigator: E.J. Staba Degree: Ph.D.

Discipline: Pharmacognosy

Student Assistants:	Degree:	Discipline:
M. K. Lindhal	B.S.	Chemistry
J. Linn	B.S.	Animal Nutrition
J. J. Jhang	B.S.	Pharmacognosy
W. M. Tom	B.S.	Pharmacognosy

Narrative Statements(A) Research Project Accomplishments:

Efforts were concentrated on completing the chemical analysis of aquatic plants, determining how well aquatic plants can be silaged, and determining their acceptability as food by lambs. The chemical compositions of twenty-one aquatic plants were summarized. These results were reported as paper 117 at the Midwestern Section of the American Society of Animal Science, Chicago, Ill. (November, 1972), as Water Resource Research Center Bulletin (Aquatic Plants from Minnesota. IV. Nutrient Composition), and as part of a Masters Thesis (J. Linn).

A variety of aquatic plant silage forms were prepared and compared with hay silage controls. Aquatic plants contained a higher digestible hemicellulose content after silage treatment; contained undesirable volatile fatty acids that were significantly reduced upon pre-sterilization of the aquatic plants; and a variable nitrogen content (10% approximate value as compared to plants collected the previous year (17% approximate value.) Lambs would accept aquatic plants as an exclusive food source but preferred it mixed with supplements.

The silage and animal studies are to be published as Water Resources Research Center Bulletin (Aquatic Plants from Minnesota. V. Silage and Animal Studies), as a journal article (Bulletin IV and V), and as part of a masters thesis (J. Linn).

Efforts to isolate the anticoagulant principal from Nuphar variegatum and Myriophyllum exalbeocens were unsuccessful because of their high variability when tested in an in vitro rodent blood test.

(B) Publications:

G. Su. June 12, 1971. Phytochemical, pharmacological and Anti-microbial Screening of Minnesotan Aquatic Plants. Ph.D. Thesis, University of Minnesota, Department of Pharmacognosy. 158 p., 25 tab., 13 figs., 342 ref.

Progress Report presented with above title at the American Pharmaceutical Association Meeting, San Francisco on March 30, 1971.

Aquatic Plants from Minnesota. I - Chemical Survey. K. Su and E.J. Staba. Water Resources Research Center Bulletin 46. February 1972.

Aquatic Plants from Minnesota. II - Toxicity, Anti-Neoplastic, and Coagulant Effects. K. Su and E. J. Staba. Water Resources Research Center Bulletin 47. February 1972.

Aquatic Plants from Minnesota. III - Antimicrobial Effects. K. Su, E.J. Staba, and Y. Abul-Hajj. Water Resources Research Center Bulletin 48. February 1972.

Aquatic Plants from Minnesota, IV - Nutrient Composition. J. Linn, E. J. Staba, R. D. Goodrich and J. C. Meiske. Water Resources Research Center Bulletin 56. April 1973.

Aquatic Plants from Minnesota. V - Silage and Animal Studies. J. Linn, E.J. Staba, R. D. Goodrich, and J.C. Meiske (at Press).

Preliminary Chemical Studies of Aquatic Plants from Minnesota. K. Su, E.J. Staba, Y. Abul-Hajj. Lloydia (at Press).

Toxicity, Anti-neoplastic, and Coagulation Effects of Aquatic Plants from Minnesota. K. Su and E.J. Staba. Lloydia (at Press).

Antimicrobial Effects of Aquatic Plants from Minnesota. K. Su., Y. Abul-Hajj, E.J. Staba. Lloydia (at Press).

(C) Project Status:

The project is completed.

(D) Application of Research Results:

The objective of the research is to find a nutritional, medicinal or industrial use for the unwanted aquatic plants in lake shoreline areas. It is possible that some aquatic plants may contain industrially useful gumsmucilages, or new useful antimicrobial, anticoagulant, or antineoplastic therapeutic principles. Aquatic plants will be collected from various lakes in Minnesota, identified, processed and phytochemically screened for useful compounds. Microbial and animal studies will be conducted. If a good industrial, medicinal, or nutritional use for

aquatic plants can be discovered, the results of the research could provide an economic incentive for aquatic plant collection and control. The successful completion of the project will significantly assist the State and Nation in partially solving their lake pollution problems.

(E) Work Remaining, and Progress Contemplated During Next Year:

None.

OWRR Project No.: A-026-Minn.

Annual Allotment Agreement No.: 14-31-0001-3823

Project Title: Phytoplankton Nutrition and Photosynthesis in Eutropic Lakes

FSCT-COWRR Research Category: 05-A

Name and Location of University Where Project is Being Carried Out.

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1971      To Be Completed: June 30, 1974

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
Robert O. Megard	Ph.D.	Limnology
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Helen Boyer	M.S.	Ecology
Arlo Knoll	B.A.	Ecology
Walter Combs	B.A.	Chemistry

Narrative Statements

(A) Research Project Accomplishments.

The research on Lake Minnetonka, near Minneapolis is proceeding essentially as it was proposed. Sewage effluents from two villages that contributed about 80 percent of the annual phosphorus influx to the largest basin of Lake Minnetonka were diverted from the lake during the winter of 1971-1972. Concentrations of phosphorus and chlorophyll at depth intervals are being measured every two weeks in order to determine whether or not concentrations of phosphorus and chlorophyll are decreasing according to predictions made on the basis of an analysis of the phosphorus budget during 1968 and 1969. There was a linear relationship between concentrations of chlorophyll and phosphorus during the summers of 1968 and 1969, suggesting that algal abundance should decrease as phosphorus concentrations decrease. Furthermore, if rates of phosphorus sedimentation were proportional to phosphorus concentrations, then the lake should reach a new phosphorus equilibrium within 3-5 years after the influx was reduced, and most of the change should occur during the first two years.

The data for 1972 suggest Lower Lake Minnetonka may in fact be responding according to the prediction. Mean concentrations of total phosphorus in the epilimnion during July, August, and September, 1972 ( $34 \text{ mg/m}^3$ ) were 60 percent as high as the mean for those months in 1969 ( $49 \text{ mg/m}^3$ ). Furthermore concentrations of chlorophyll a were only 30-50 percent as high during 1972 as during 1969.

The differences between 1969 and 1972 in Lower Lake Minnetonka may have been the result of meteorological differences between the two years, but this is unlikely because concentrations of phosphorus and chlorophyll during 1972 were similar to those in 1969 in basins of Lake

Minnetonka that were not affected by sewage diversion. Thus we are tentatively concluding that the reductions of phosphorus and chlorophyll that occurred are most probably the result of sewage diversion. The monitoring program is continuing during 1973 to determine whether or not the trends are persisting.

A limnological study of five lakes at Fairmont in Southern Minnesota was conducted during 1972. Chlorophyll concentrations, phosphorus concentrations, nitrate concentrations, ammonia concentrations, oxygen concentrations, temperatures, and rates of photosynthesis were measured 18 times (10-day to 14-day intervals) between May and November. These shallow lakes, with a combined surface area of 1,100 acres receive drainage from almost 17,000 acres of agricultural land. Concentrations of chlorophyll fluctuate between 40 and 120 mg/m<sup>3</sup> during the summer, indicating that algal population densities are 2-3 times higher than in Lake Minnetonka and the most polluted areas of Lake Erie. Concentrations of dissolved phosphorus, nitrate, and ammonia are so high that the algae probably cannot utilize them because the total photosynthesis beneath a unit of water surface is limited by mutual shading by the algae themselves. The total quantity of phosphorus in these lakes increases about 10-fold during June and July. Most of this probably comes from the sediments.

#### (B) Publications.

Rates of photosynthesis and phytoplankton growth in Shagawa Lake, Minnesota. R. O. Megard. Final Report for Environmental Protection Agency, Office of Research and Monitoring, Project No. 1610-DEG.

Mechanisms that regulate growth rates of phytoplankton in Shagawa Lake, Minnesota. R. O. Megard and P. D. Smith. Manuscript submitted to Limnology and Oceanography for publication.

#### (C) Project Status.

The project will continue during Fiscal Year 1974.

#### (D) Application of Research Results.

One of the motives for the work at Minnetonka was to determine whether or not planktonic algae would become less abundant if sewage effluents were diverted from the lake. This question is of interest to people living near the lake and to governmental agencies such as the Lake Minnetonka Conservation District, the Minnehaha Creek Watershed District, the Minnesota State Pollution Control Agency, and the Department of Natural Resources, who are responsible for establishing and enforcing water management policy.

The research at Fairmont was undertaken to determine the severity of the problem with algal blooms in the lakes. An engineering firm is determining the sources and quantities of algal nutrients delivered from the watershed. The limnological and engineering data will be used

to recommend a strategy for controlling nuisance algal blooms as part of a Title II OWRR Research Project received by the City of Fairmont (Identification of social, economic, and political causes of lake environmental problems in a rural community and remedial measures).

We have coordinated our efforts with the engineering firm retained by the city and given them free access to our data. Furthermore we have advised the city of Fairmont about how to establish its own monitoring program on the lakes, and the city water department has acquired the equipment necessary to begin a monitoring program.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

The monitoring program in Lake Minnetonka will continue until November, 1973. The data for 1972 from Lake Minnetonka are now being analysed for the purpose of preparing a manuscript about the population dynamics and the phosphorus nutrition of the phytoplankton. No additional field work will be undertaken at the Fairmont Lakes. A report about these lakes will be completed July 15, 1973, and submitted to the city of Fairmont.

OWRR Project No.: A-027-Minn.

Annual Allotment Agreement No.: 14-31-0001-3823

Project Title: Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management

FCST-COWRR Research Category: 07-A

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1971

To Be Completed: June 30, 1974

Principal Investigator

H.O. Pfannkuch

Degree

Ph.D.

Discipline

Geology

Student Assistants

Eric Madsen

Degree Held

B.S.

Discipline or Academic Background

Hydrogeology, Computer Science

Bruce Labno

B.A.

Hydrogeology, Land Use

Michael Kauper

B.S.

Environmental geology,  
Analog simulationNarrative Statements(A) Research Project Accomplishments.

The areas in which research was conducted during the report period of FY 1973 dealt with the formulation, conception and test running of different digital models to simulate aquifer performance, the introduction of procedures to optimize operational costs with total information available at the most accurate level, the collection of field data to serve as a basis for realistic modeling, the study of the role of water quality data in the optimization process, and the evaluation of continuous data gathering systems against intermittent or sporadic systems. The digital models that have been worked out and adapted deal with the following aquifer situations: 1. Artesian aquifer with recharge and leakage; 2. Water table aquifers in an infinite glacial aquifer under natural flow conditions; 3. Water table aquifers in alluvial material with recharge boundaries of varying geometry. For two of these aquifers extensive field data is available or being collected. In particular, a number of pumping tests are analyzed with respect to the accuracy of hydrologic parameters produced against the time of test duration which gives a direct indication of the cost of information. This is compared against operational losses incurred by optimizing production for different levels of accuracy in the hydrologic parameters as compared to the (assumed) true values. An extensive collection and gathering of field data and case histories has been carried out. The results will be used in the construction of realistic models. The main interest is to compare the shapes of curves for real information or accuracy to the shape of hypothetical and oversimplified curves in which sharp optimum points can be shown to exist.

A study of the economic influence of water quality in addition to technological operating costs is in progress. Preliminary data have been collected in the field in connection with an M.S. thesis project. Under the same project continuous monitoring systems were compared to intermittent data gathering systems in a study of the value of continuous records in groundwater management problems. On a preliminary basis it is found that certain questions of aquifer interconnectivity and responses to stress can be obtained at lesser cost than for example in a pumping test.

(B) Publications:

None.

(C) Project Status.

The project will continue in progress in fiscal year 1974.

(D) Application of Research Results.

The University of Minnesota, Physical Plant Services, have used results or are further interested in research about continuous monitoring of observation wells in a toxic waste disposal system operated by the University.

(E) Work Remaining, and Progress Contemplated During Next Year.

The main thrust for next year's activities will be the construction of cost against bits of information curves and the definition of optimal points for both generalized hypothetical systems as well as real life and real cost situations. In addition, an assessment of the influence of water quality as cost factor along with technical operation costs should be forthcoming.



Consultants (8 firms and individuals) conducted about 9 percent of the total water resources research in 1972. Private organizations (North Star Research and Development Institute) conducted about 4 percent of the total research. State and Private Colleges (Bemidji State College, St. Cloud State College, Winona State College, St. Mary's College, Gustavus Adolphus College, Moorhead State College and Southwest Minnesota State College) conducted about 3 percent of the total research. State agencies (Department of Natural Resources and Pollution Control Agency) conducted about 1 percent of the total research.

Organizations funding the greatest amounts of water resources research in 1972 were: Environmental Protection Agency, U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of the Navy, National Science Foundation, Atomic Energy Commission, Northern States Power Company, Department of Defense and State agencies.

In 1972, the average costs per man-years of water resources research effort ranged as follows according to the organization conducting the research: Private organizations - \$45,700, Consultants - \$24,600, Federal agencies - \$20,300, University of Minnesota \$16,700, State agencies \$14,500, and State and Private Colleges \$13,900. Salaries and wages, non-expendable equipment, expendable supplies and materials and other expenses are included in these costs. The average cost per man-year of effort rose from about \$16,000 in 1963 to \$18,600 in 1972. The average ongoing water resources research project in 1972 had a period of investigation of 3 years, an annual cost of about \$18,000, and a total cost of about \$48,000.

About 481 water resources research projects were completed during the period 1963 through 1972. Completed projects are grouped below into the water resources research categories used by the Committee on Water Resources Research, Federal Council for Science and Technology (FCST) to provide information on the nature of completed research projects.

FCST Research Category	Number of Completed Research Projects
I. Nature of Water	9
II. Water Cycle	156
III. Water Supply Augmentation and Conservation	7
IV. Water Quantity Management Control	5
V. Water Quality Management and Protection	133
VI. Water Resources Planning	83
VII. Resources Data	10
VIII. Engineering Works	78
IX. Manpower, Grants and Facilities	0
X. Scientific and Technical Information	0

In 1972, approximately 76 percent of expenditures for water resources research were Federal funds and about 24 percent were non-Federal funds. Expenditures for water resources research constituted about 3.5 percent of the total Federal and State outlays for water and related land resources programs in Minnesota.

An inventory was made of 194 water resources researchers in the State and a roster was prepared describing researchers' disciplines, training, experience and interest. A Conference on Toward a Water Resources Research Plan for Minnesota was held on May 9-10, 1973. Sixty-five people attended the Conference. The objective of the Conference was to discuss matters associated with developing the water resources research plan, and to devise ways and means for completing the plan.

(B) Publications:

Proceedings of Conference on Toward a Water Resources Research Plan for Minnesota. Water Resources Research Center. Mimeographed Report, May 1973.

(C) Project Status:

The project will continue in progress in fiscal year 1974.

(D) Application of Research Results:

The results of the research should assist the State in increasing the efficiency and relevance of water resources research efforts, improving the timely dissemination of research results, and scheduling expansions in research capabilities in advance of demands. Information concerning future research needs, manpower requirements, and costs should assist the State Legislature in formulating legislation concerning water resources research funding. The results of the research should assist the State in administering research funds associated with the Federal Water Resources Research Act of 1965 and other Federal legislation.

(E) Work Remaining, and Progress Contemplated During Next Year:

During fiscal year 1974, the Principal Investigator will place a heavy emphasis on the analysis of important water problems in Minnesota to determine defensible associated research requirements, i.e., the research necessary to give a reasonable level of assurance that the problems can be resolved in a cost-effective and timely fashion. A water resources problem-research analysis workshop conference program will be developed with full consultation and collaboration between the Center; appropriate faculty at the University of Minnesota and State and Private Colleges; leading water resources officials within the State, including appropriate State, Federal and local agency officials, and appropriate members of Interest Groups.

During fiscal year 1974, the following activities will be completed: review existing institutional arrangements for conducting water resources research in Minnesota; inventory all possible granting agencies and other organizations which have or might fund water resources research projects in Minnesota; identify present and projected manpower needs and formulate alternative institutional arrangements for improving the coordination of water resources research efforts in the State; and review water resources research project information dissemination procedures in the State - methods for improving communications between researchers and researchers and research users will be developed, and prepare the water resources research plan.

MATCHING GRANT PROGRAM

NARRATIVE PROGRESS REPORTS

Form OW-1 (1972)

OWRR Project No.: B-015-Minn.

Matching Grant Agreement No.: 14-01-0001-1916

Project Title: Characteristics of the Soil Matrix that Affect Water Storage and Movement.

FCST-COWRR Research Category: 02-G

Name and Location of University Where Project is being conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: January 1, 1969      Project Completed: June 30, 1973

<u>Principle Investigator</u>	<u>Degree</u>	<u>Discipline</u>
George R. Blake	Ph.D.	Soil Science
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Volker Schweikle, Postdoctoral	Ph.D.	Soil Science
L.M. Arya	M.S.	Soil Science
Katie Hauser	M.S.	Secretarial
John Corser	Undergrad.	Biology
Ronald Monson	Undergrad.	Forestry
Michael Lieser	Undergrad.	Soil Science
David Hegard	Undergrad.	Soil Science

Narrative Statements

(A) Research Project Accomplishments.

Dr. Schweikle completed work on thixotropic changes in pressed soil and prepared a manuscript for presentation at a forthcoming Int. Congress of Soil Scientists. Mr. Arya also completed his calculations based on measurements of soil water extraction by soybean roots and published these in a doctoral thesis printed by the Water Resources Research Center as Bulletin 60. It was shown that one could greatly shorten the time and work involved in calculating water fluxes in a drying profile by leaving the surface soil exposed to evaporation and by using a moving "zero flux" plane as a boundary condition. Evaporation rates agreed well with measured pan evaporation rates. Root densities tended to be higher near plant rows and in the 25 to 45-cm depths below the soil surface. In most of the surface 70-cm root densities were 1.0 to 2.0 cm/cm<sup>3</sup> soil. Data relating water uptake to root density and to hydraulic conductivity did not agree with a model proposed by Whistler et al. Efficiency of water use in sandy soils underlain by a thin asphalt layer continued under study in a field installation.

(B) Publications.

Palta, J.P., G.R. Blake and D.A. Farrell. 1972. Water transmission properties of an asphalt barrier. Soil Sci. Soc. Am. Proc. 36: 709-714.

Palta, J.P. and G.R. Blake. 1973. Effect of an asphalt barrier on water storage and drought probability. Manuscript submitted to Agron. Jour.

Blake, G.R. 1971. Asphalt Moisture Barriers. Minn. Agr. Expt. Sta. Misc. Report 14.

Blake, G.R., E. Schlichting and U. Zimmermann. 1973. Water recharge in a soil with shrinkage cracks. Soil Science Soc. Am. Proc. Vol. 37. No. 5.

Schweikle, V., G.R. Blake, and L.M. Arya. 1973. Matric suction and stability changes in sheared soil. Manuscript accepted by organizing Committee, 10th Int. Congress of Soil Science, Moscow, 1974.

MacGregor, J.M., G.R. Blake, and S.D. Evans. 1973. Mineral Nitrogen movement into subsoils and root zone pH following continued annual fertilization for corn. Manuscript submitted to Soil Sci. Soc. Am. Proc.

(C) Project Status.

The project has been completed.

(D) Application of research results.

The surface meter of the earth's crust is a dynamic buffer for water. Not only is infiltration and runoff dependent on the dynamic, momentary condition, but storage of water for plant sustenance between rains is a necessary function. Many soils will store 8 to 10 surface inches of available water in the root zone. Droughty sandy soils, the most deficient in this regard, but valuable for vegetable production can be made to store double their normal amount of available water by use of an asphalt barrier. The study of matrix changes in sheared soil contributes to our understanding of soil structure formation, necessary in maintaining adequate infiltration and conductivity of soil for water. Effects of root sinks on water movement and root zone hydraulic characteristics helps in developing good water management practices under growing crops.

(E) Work remaining and progress contemplated during next year.

None.

OWRR Project No.: B-032-Minn

Matching Grant Agreement No.: 14-31-0001-3097

Project Title: Mississippi River Ecology Associated With Heated Power  
Plant Effluent

FCST-COWRR Research Category: 05-C

Name and Location of University Where Project is Being Conducted:

St. Cloud State College, St. Cloud, Minnesota 56301

Project Began: July 1, 1969

Project Completed: December 31, 1972

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
Alfred J. Hopwood	Ph.D.	Limnology
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Robert A. Andersen	M.A.	Biology
Jane M. Nemanick	M.A.	Biology
Stephen V. Thrune	M.A.	Biology

Narrative Statements(A) Research Project Accomplishments.

The Mississippi River ecosystem at Monticello, Minnesota has a trophic structure based upon the combined energy input from terrestrial vegetation, such as leaves, nutrients from runoff and from wastewater, and the interaction of these with sunlight and epilithic algae (principally *Cladophora glomerata*). Aquatic vascular plants are sparse in the Monticello reach of the river, thus the main line of production in the biotic community appears to be energy exchange from imported materials through the benthic fauna to the vertebrates. Previous studies within the scope of this project have established quantitative and qualitative data on the river fauna in the area affected by the Northern States Power Company power plant at Monticello, Minnesota. Three studies completed in Fiscal Year 1973 have added to the knowledge on the effects of the heated discharge from the power plant upon the benthic fauna and, in turn, upon the dominant fishes and bird species inhabiting the area. These studies show that the effects of the heated discharge have been minimal since the power plant began operating in January 1971.

Water quality -- Temperature:

Monthly average values for minimum and maximum temperatures measured at the river bottom were calculated for the years 1969 through 1972. Water temperature varies the least about 34F during the iced-over period of January through March. After the river becomes ice-free in April the temperature rises rapidly to the maximum in July, showing only slight variation from year to year between April and June. Yearly differences in summer maxima appear to be related inversely to discharge. At stations within the first 5000 feet below the power plant, the river temperature is influenced more by the discharge in the first six months of the year (about 8F) than in the July-December period; i.e., variability between years is increased for the period from January through June (about 2.5F),

but the variation in the summer maxima and fall decline are not different from the pattern shown for the upstream stations.

Water chemistry:

Water chemistry data compiled since 1968 shows more variation from one year to the next than from upstream to downstream in the post-operational period.

Bottom organisms:

In July 1971 a program of weekly sampling was begun to determine the colonization and growth rate of benthic organisms on artificial substrates in the river above the power plant, and to compare upstream data to the same parameters observed at the end of the discharge canal. Data collection was completed in July 1972. A group of 20 samples were placed in sets of four in each of two transects, one above the power plant (control), the other just below the end of the discharge canal (experimental). Beginning seven days after placement, at 7-day intervals, one set of four concrete block samplers were removed from each transect. All 20 blocks were replaced on the 35th day, the last or 5-week set being replaced immediately after the sample was taken. Eight such cycles were completed between 12 July 1971 and 21 July 1972. Overall the trichopterans made up 55% of the population, mayflies 12%, dipterans 29%, and miscellaneous others 4%. At the 95% level of significance caddisflies made up a higher percentage of the total benthos by number and weight at the experimental stations than at the control stations. Dipterans made up more of the benthic biomass by weight at the control stations than at the experimental stations. Trichopteran percentages were higher in the heated water than in the control transect during the July-October period. Mayflies made up a larger percentage of the population at the control transect in July-August, and May-July periods. The benthic fauna contained more dipterans at the control transect than in the heated transect during the September-November period. Regression lines were plotted for the growth rate of the numbers and weights of invertebrate samples from the upstream and downstream transects. With few exceptions regression coefficients were above 0.7. The slope of growth lines on data from the experimental and control stations were not significantly different. Confidence limits (95% level) about the control lines included the experimental lines. The heated water appears to accelerate or retard the growth or colonization rate of some benthic forms just enough to change the generic percentage composition at certain times of the year. Indigenous warm water forms are favored in the zone affected by the discharge. Trichopterans were more numerous and comprised a higher percentage of the sample weight at the downstream transect than that upstream. Mayflies and dipterans generally declined at the downstream transect.

Fish:

A total of 131 shorthead redhorse, *Moxostoma macrolepidotum* Lesuer, and 100 carp, *Cyprinus carpio* L., were collected from three sectors in the Mississippi River by seining and electrofishing from July 1971 through

June 1972. The length-weight regression,  $\log W = 4.8955 + 2.9682 \log L$ , was calculated for the shorthead redhorse. Condition factors,  $K(TL)$ , for the shorthead redhorse varied with length, season, and sex, and had an annual average of 1.08. The carp length-weight regression was  $\log W = -4.6920 + 2.9334 \log L$ . Carp condition factors did not vary with length, but varied with seasons and sex. The volume of food for redhorse over 150 mm total length was 96.3% immature insects, mostly Trichoptera and Tendipedidae. Shorthead redhorse under 50 mm total length ate *Diffugia*, Copepoda, Cladocera, mud, and diatoms. The carp fed primarily on algae from July through October, and ate immature insects and detritus in November, May, and June. Algae comprised 55.17% of the total annual volume. Both fishes consumed the largest amounts of food in the summer and fall. As the shorthead redhorse total length increased over 150 mm the volume of trichopterans 3-6 mm decreased, 6 mm and longer increased, and 0-3 mm remained the same. Shorthead redhorse from the area within 5000 feet below the power plant discharge (Sector B) had a larger volume of trichopterans in their stomachs (73.6%), than from upstream locations (Sector A) (60.5%), or 3 miles downstream (Sector C) (51.4%). Mayflies were taken in the largest volume in sector C (39.8%), as were dipterans (8.1%). The food of carp also varied by sector. Algae comprised 71.4% of the total volume in sector C, 59.6% in sector A, and only 9.3% in sector B. Detritus made up 46.5% by volume in sector B, 4.4% in sector C, and 3.8% in sector A. Ephemeroptera contributed the largest volume in sector A (12.5%), compared to 4.5% for sector B, and 1.7% for sector C. The shorthead redhorse and carp occupy separate niches in the study area based on different feeding times, differences in food items taken, unequal amounts of similar items, food taken from different areas of the river, and different habitats occupied.

#### Birds:

A program of field observations was devised to determine how bank and rough-winged swallows utilize the river habitat as a total resource and how the power plant affects that resource with regard to the birds. The program was initiated in June 1971, and terminated in September, 1972. Swallow colonies in river banks were inspected and various parameters were recorded. Production of new river bank sites suitable for nesting depends upon the erosive action of floods and ice jams against the banks. The swallows preferred banks with a vertical slope at least 2.5 feet high. The amount of talus slope or fallen sod below did not seem to matter. Birds were observed during nesting and fledging periods to determine behavior. Swallows were mist-netted and banded to determine ranges in hatching and fledging dates and to determine the size of the local breeding swallow community. Band recapture data for 1972 indicated a dispersal of birds banded in 1971 and marked habitat preference. Post-fledging data indicated a marked preference for foraging over a rapids upstream of the power plant and for perching on transmission wires near this rapids. The normal operation of the power plant did not appreciably alter the usage of the river by bank and rough-winged swallows. These birds eat flying insects only, but because the young are initially fed only soft-bodied insects by their parents, the nesting sites should be near water where emerging soft-bodied insects pre-

dominate. The small changes noted in biomass and generic composition of benthic immature stages have not affected the swallows inhabiting the area.

#### (B) Publications:

Andersen, R. A. 1972. Food habits, length-weight relations, and condition of the shorthead redhorse, *Moxostoma macrolepidotum* (Lesuer), and the carp, *Cyprinus carpio* L., collected from the Mississippi River near Monticello, Minnesota. Master's Thesis, 111 p. August, 1972, St. Cloud State College.

Nemanick, J. M. 1973. Recolonization of macroinvertebrates on artificial substrate samplers in the Mississippi River near Monticello, Minnesota. Master's Thesis, 106 p. February 1973, St. Cloud State College.

Throne, S. V. 1973. Band and rough-winged swallow use of the Mississippi River near Monticello, Minnesota. Master's Thesis, 48 p. May, 1973. St. Cloud State College.

#### (C) Project Status.

The project is completed.

#### (D) Application of Research Results:

The results of post-operational studies on the Mississippi River at Monticello, Minnesota, adjacent to the Northern States Power Generator should be of interest to federal and state agencies and individuals involved in the site selection, monitoring and regulation of power plants and power production.

#### (E) Work Remaining, and Contemplated During Coming Year.

None.

OWRR Project No.: B-042-Minn.

Matching Grant Agreement No.: 14-31-0001-3292

Project Title: Spatial Variations in the Perception of Water Resources  
and Water Problems in South Central Minnesota

FCST-COWRR Research Category: 06-B

Name and Location of University Where Project is Being Carried Out:

Gustavus Adolphus College, St. Peter, Minnesota 56082

Project Began: July 1, 1970

To Be Completed: December 31, 1973

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
Robert T. Moline	Ph.D.	Geography
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Jerome Schimelpfenig	Undergrad	Sociology
Lorene Larson	Undergrad	Geography
Dennis Wellnitz	Undergrad	Physics

Narrative Statements(A) Research Project Accomplishments.

The principal object of the project is to determine the spatial variation in the perception of water resource problems. The research plan as changed and reported last year consisted of the analysis and interpretation of two nearly identical survey questionnaires mailed to two different samples of people. A total of 1185 responses were received and analysis of these responses is well underway. A number of basin newspapers were perused for comments about water resource problems. Very briefly, some preliminary findings are: It appears that the amount of discussion of water related problems in local newspapers is directly proportional to the intensity of local water crises. This is not surprising. Almost no continuing discussion of general water problems is carried in newspapers. This is especially true of the weeklies. Respondents were asked to rank their top three sources of information about water problems. Broadcast media were declared the primary source by the largest number of respondents (22 percent) with newspapers and magazines chosen by 16 percent.

Respondents were asked to rank what they perceived to be the three most important water problems in their area. Water pollution was ranked first in 10 of the 13 sub-basins of the Minnesota River with recurrent drought ranked first in three of the western sub-basins, the Little Minnesota in South Dakota, the Yellow Bank in Minnesota and the Big Stone basin in Minnesota. For the entire Minnesota River basin 32 percent of the respondents ranked water pollution as the primary water problem, 16 percent ranked inadequate water resources planning first, 12 percent ranked wet fields first, and surprisingly, only 10 percent ranked flooding as the primary problem.

The larger part of the questionnaires consisted of a series of statements, soliciting agree-disagree responses. Analysis of this data is similarly incomplete but some general impressions can be given. Most respondents have confidence in water resources planning and do not wish to simply accept water problems as inevitable, but most would prefer that water planning be done by State and local agencies rather than Federal units. Most respondents are strongly supportive of more rigorous control of private lakeshore development, preserving wetlands as holding areas for surplus water or as wildlife habitat and encouraging upstream watershed land treatment practices as a major solution to flood damages. There seems to exist divided feelings about the value of small or large dams in reducing flood damages. Similarly divided are the responses to statements about the opportunity of citizens to participate in water resources planning, the use of irrigation in agricultural land management, the use of weather modification to increase water supplies, the adequacy of water based recreation opportunities, and the relationship of agricultural drainage to flooding. No sub-basin analyses have yet been made of this part of the questionnaires.

(B) Publications.

None.

(C) Project Status.

Originally the project was to have been completed by June 30, 1973. A six month extension was asked for and granted to allow for some personal interviews with water influentials, the resolution of some computer programming problems, the production of cartographic visuals including computer-produced maps, and the completion of the analysis. The project will be completed on or before December 31, 1973.

(D) Application of Research Results.

The Soil Conservation Service and the Corps of Engineers have expressed interest in the project. Recently, the League of Women Voters and the Minnesota Water Resources Board have also shown interest and would like to see the project completed soon.

(E) Work Remaining, and Progress Contemplated During Next Year.

Analysis of the questionnaire responses will be completed. The results will be published as a small monograph and will include the publication of maps, photographs and other graphics. The project is spatially oriented and cartographic display of results is essential. The monograph will be aimed at the interested members of the general public as well as professionals so the final layout will require careful planning.

OWRR Project No.: B-044-Minn.

Matching Grant Agreement No.: 14-31-0001-3293

Project Title: Area Financing of Water Resource Development

FCST-COWRR Resource Category: 06-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1970

Project Completed: June 30, 1973

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
W.R. Maki	Ph.D.	Agricultural Economics
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Kathleen M. Schiminsky	M.A.	Economics
John T. Shiner	B.A.	Biology
Ernesto C. Venegas	M.S.	Agricultural Economics
Oscar M. Lund, Jr.	M.S.	Economics

Narrative Statements(A) Research Project Accomplishments.

Results of the research are embodied in the concepts, techniques and data for area economic analysis of water resource systems. A 14-county pilot-study area in West Minnesota was selected for study because of the diversity of its water resource problems and the difficulty of acquiring the public financing for water resource development. Nine of the 14-counties are now organized into a multi-county Regional Development Commission (RDC). The research findings bear directly upon the work of the RDP and other resource development and planning organizations in the 14-county area.

Project accomplishments are as follows: Water resource-related capital plant: an inventory of the existing water resource related capital plant of the 14-county study area, including those facilities identified as basic community facilities by the Subcommittee on Economic Progress of the Joint Economic Committee Congress of the United States (In "State and Local Public Facility Needs and Financing," U.S. Govt. Print. Off., 1966).

Settlement alternatives: Projection of two distinctly different patterns of population growth and industry development in the large multi-state region (of which the study area is a part) as a data basis for water resource planning in a multi-county development region.

Development potentials: assessment of the projected industry employment and output levels and distributions under the two settlement alternatives with specific reference to water resource and related community facility requirements.

Decision models: institutional and organizational considerations are presented in a presentation of problem areas legislation and its implementation, governmental participation, priority systems (for construction and funding of water supply, waste water collection, waste water treatment, water-related recreation and solid waste disposal) and selected community comparisons.

Fiscal-ecologic accounts: interindustry and interinstitutional transactions are monetized for a base year and target year in a multi-sector tabular representation of the present and projected 14-county economy and its internal linkages, including those with the natural environment.

Financing strategies: alternative federal, state and local approaches to the financing of basic community facilities are summarized with reference to the 14-county study area; selected new approaches to development financing also are assessed.

Community resource mobilization: alternative models of citizen and community participation in areawide water resource planning and development are proposed for multi-county groupings in the 14-county study area.

Because of the many local organizations and financing sources considered in the study, the research findings relate to a variety of issues and institutions in water resource development. However, the main thrust of the study is the formulation of areawide approaches to the analysis and implementation of water resource plans and proposals. Concept-building and technique-development for area resource management are two primary contributions of the study. In addition, specific data in a multi-county economic-environmental system are presented for the use of the RDC and other areawide resource planning organizations in the study area.

(B) Publications.

Wilbur R. Maki, "Social/Environmental Systems for Regional Development Planning," Regional Science Perspectives, Vol. 3, 1973.

Wilbur R. Maki, "Financing Alternatives for Regional Resource Development." Paper prepared for Fifth Annual Meeting of the Mid-Continent Regional Science Association, Oklahoma State University, Stillwater, Oklahoma, April 13-14, 1973.

Wilbur R. Maki, "Area Wide Planning: Public Facility Location and Environmental Concerns." Paper prepared for Conference on Public Facility Location, University of Iowa, Iowa City, Iowa, June 29, 1973.

Wilbur R. Maki, Ernesto C. Venegas, Kathleen M. Schiminsky, John T. Shiner, and Oscar M. Lund, Jr., Area Financing of Water Resource Development, (At press), 1973.

(C) Project Status.

Project was completed on June 30, 1973.

(D) Application of Results.

Project results are being used in educational programs and consulting in the study area and other resource planning areas in Minnesota. In addition, segments of the project were used in classroom activities on the University of Minnesota campuses. A summary of specific applications of project results includes: Public affairs programs and conferences for resource planning groups in outstate Minnesota; data and information services for local government planning and decision making in 14-county study area; consulting services for regional planning commissions, resource conservation and development project committees and other groups; undergraduate and graduate courses in resource development and planning; and continuing education classes for local government officials, staff members, community leaders, and others interested in financing water-resource development and related activities.

The Principal Investigator has participated in two public affairs programs sponsored by the Minnesota Commission on the Humanities (June 7 in Roseau, Minnesota, and June 8 in Barnesville, Minnesota) which pertained to issues and data of concern to the newly-organized Regional Development Commissions in two of Minnesota planning regions (1 and 4). Water-related public facilities are an important concern in these two regions.

Information request from local governmental units and educational institutions in the study area have been received in the past few months which pertain to the project findings. With the completion of the project report, brief information releases will be prepared to satisfy these requests.

The Principal Investigator has met with the West Minnesota Resource Conservation and Development Committee, community industrial development organizations and other groups about the local impacts of particular development proposals. Again, completion of study provides information for more complete response to these questions than heretofore possible.

Because of the strong interest and approval expressed for the playing of an environmental management game (which was developed as part of this project), an educational development grant proposal was prepared. Announcement of the award was received recently, thus providing University support for the development of the environmental management game as a teaching tool. Proposal for simulation-gaming laboratory is being prepared as a major teaching follow-up on the project report.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No.: B-047-Minn.

Matching Grant Agreement No.: 14-31-0001-3294

Project Title: Social and Economic Factors in the Adoption by Industry of Water Pollution Control Measures

FCST-COWRR Research Category: 06-E

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970

Project Completed: June 30, 1973

Principal Investigator

Degree

Discipline

R.E. Rickson

Ph.D.

Sociology

Student Assistants

Degree Held

Discipline or Academic Background

Jane Rodenkirchen

M.A.

Mass Communication & Sociology

Margaret Cawley

B.A.

Sociology

Barbara Bender

Undergrad.

Political Science

Christine Lohr

M.A.

Sociology

Narrative Statements(A) Research Project Accomplishments.

In the last year, 102 industries from the original sample of 128 were selected for a second analysis. For the sake of analysis, the firms were selected so that we would have enough organizations of different size. Size is an important organizational variable. All studies of change in organization must consider the effect of size either as an independent or a control variable. Production managers in the selected companies were interviewed for the second time. Interviews were conducted with standard schedules listing the data required. The data were attitudinal and descriptive. Attitudinal data were collected regarding the production manager's view of the proper role of technical experts, public agencies, local communities, and private conservationist groups in the regulation of industrial water use. Descriptive data refers to social and economic factors characteristic of each firm.

Innovation or change in organizations has long been of interest to social scientists and policy-makers. Especially now, change is a critical variable since most of our problems, including water pollution control, involve convincing, legislating, or otherwise pressuring large, powerful organizations to change modes of operation. In general, the process of change develops in such a manner that groups, public and private, form to change industrial water use. The purpose of the present study is to add to our knowledge of change in organizations. Our focus is the critical problem of industrial pollution control.

Change can be understood by using two general conceptual models. One concentrating on the internal characteristics of the organization while the other asserts that external factors such as outside pressure is the principle motivator of change in water using firms. Both of these models are impor-

tant. Industrial firms are profit-maximizing bodies and change their operations to insure continued profit and growth in production. One of the most influential variables explaining rates of production change is the level of the organization's sophistication, i.e., knowledge. By knowledge, is meant the organization's production technology and the level of administrator's education in each of the firms. Both of these factors reflect the organization's capacity for change. The level of knowledge is related to the ability of the organization to survive in a competitive market, to create and incorporate new information necessary for the accomplishment of its goals.

On the other hand, problems now exist such as environmental pollution that have proven to be quite difficult. Difficulties are present because of industrial commitment to profit and production goals. Because environmental quality has not been a major concern to industry or the general society until recently, there has been little impetus for change in industrial water use. Now such organizations are being asked to make changes that, in the short run, are felt by companies to run counter to their main goals of production and profit. Consequently, we need to include in our analysis of change, the pressure and power of outside groups, public and private, that are asking firms to make operational changes that do not directly contribute to production goals. Industrial organizations are being asked by public agencies to make environmental quality an objective equal to production and profit making. Therefore, we propose that the nature of the firm's relationship to public regulatory agencies responsible for water management will be important to understanding changes in industrial water use.

Organizational knowledge was measured by determining the level of production technology and through averaging the educational requirements for industrial managers across 102 firms. The level of production technology varied from work based primarily on power tools and power machines to the use of more sophisticated technology including computers. Production managers were asked to respond to items in standard interview format. They were asked to judge the extent to which their company's operation was characterized by each of the following alternatives: hand tools and manual machines, powered machines and tools, single cycle automatic and self-feeding machines, automatic: machines repeat cycles, self-measuring and adjusting machines: automatic feedback, and computer control: automatic feedback and control. A technology scale was developed by using the managers responses to each of the above items.

Change was measured by using a fifteen item scale related to the manager's judgment about the firm's change in the past ten years in use of new water pollution control technology, allocation of resources to pollution, consultation with scientists and technical experts, etc. Our attempt was to measure changes across important dimensions of organizational function. These include production, marketing, capital procurement and allocation, employee training and education, and waste control. The organization's studied varied from reporting a very low degree of change across these dimensions to a very high rate of change. The control variables included in this analysis were measured by using a standardized interview format.

Understanding change in organizations requires attention to internal characteristics of the organization and to outside pressures. This is evident in table 1. In order to specify these relationships further, we statistically controlled for organizational size (number of employees), volume of water use, and volume of waste. Variables that were of consistent importance using controls included: (1) level of technology and (2) contact between agencies and industries. There was a consistently high relationship between the first variable and change across all controls. The values ranged from a low of 0.43 to a high of 0.55. Contact was also consistently related, ranging from a low of 0.20 to a high of 0.31.

Table I

<u>ORGANIZATIONAL CHARACTERISTICS</u>	<u>Pearson-Product-Moment Correlation Coefficients of Each Organizational Characteristic with Change</u>
Knowledge	
Technology	0.39*
Administrator's Education	0.27*
Agency-Industry Relationships	
Agency Authority	0.09
Agency Power	
1. Degree of Agency Regulation	0.30*
2. Degree of Agency Pressure	0.32*
Contact	0.29*
Clarity of Agency Standards	0.19*
Agency Expertise	0.09

\* Relationships are statistically significant at the .05 level.

A conclusion to be drawn is that industries will change the way they use water provided they possess the capacity for change. Large organizations where the work is relatively routine but have high volumes of water use and waste are the most problematic. In these instances, pressure and contact by agencies is most significant.

Organizations change, according to our data when their technology is relatively sophisticated and when there is consistent contact and pressure from public agencies. A critical variable is, therefore, the nature of the contact between industries and agencies. In many cases, two conditions are present in the relationship between industries and agencies: (1) agencies can be controlled by the industries they are supposed to regulate and agencies are often so understaffed that consistent examination of industrial operations becomes impossible. Consequently, agencies become dependent on the industry for data about their own operations. In both situations, sound programs for controlling industrial waste is difficult to develop. When we say that contact is an important variable, we must carefully spell out the kind of contact we are talking about.

(B) Publications.

Rickson, R.E., and C.E. Simpkins. 1972. Industrial Organizations and the Ecological Process: The Case of Water Pollution, in M.B. Brinkerhoff and P.R. Kunz, Complex Organizations and Their Environment. Dubuque, Iowa: W.C. Brown Co., Publishers.

Rickson, R.E. May 1972. Integration of Scientific and Managerial Functions in Industrial Society: Problems in Use of Knowledge to Control Waste. Paper read at Pacific Sociological Association meetings in Scottsdale, Arizona.

Rickson, R.E. 1972. Self Interest and Pollution Control, The Journal of Environmental Education, 4 (Fall): 1972, pp. 43-49.

(C) Project Status.

The project has been completed.

(D) Application of Research Results.

Results can be applied to overall problems of planned development. Both industrial and agency representatives have requested final reports of the project's findings. Numerous requests for speaking and reporting to industrial groups and public agencies at all levels of government have been answered.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No.: B-049-Minn.

Matching Grant Agreement No.: 14-31-0001-3295

Project Title: A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota.

FCST - COWRR Research Category: 06-B

Name and Location of University Where Project is Being Conducted:

Bemidji State College, Bemidji, Minnesota 56601

Project Began: July 1, 1970

Project Completed: September 30, 1972

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
J. P. Ludwig	Ph.D.	Ecology

<u>Students Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
None		

Narrative Statements(A) Research Project Accomplishments:

A survey of the attitudes of Minnesotans toward the use maintenance and development of the Mississippi River in Minnesota was conducted. Background information on the diverse physical nature of the project Universe (those 23 Minnesota counties which the River flows through or is adjacent to) was collected covering the topics of waterflow, soils, population change, changing riparian land use, and recreational opportunities. Great physical and cultural diversity was found in the project Universe. Attitudes of residents were measured by a 40 item mail questionnaire sent to 5,000 residents of the project Universe; 101 in-depth interviews were also conducted. Respondents provided data on their characteristics, evaluated the desirable and undesirable characteristics of the River, evaluated the role of media in providing them with environmental information, expressed attitudes towards the use of the River, how River pollution should be controlled and financed, and provided data on what aspects of their life styles they were and were not willing to change to improve environmental quality. Secondary students were also surveyed in a separate effort to quantify significant difference of attitudes held by youth and adults. Two significant findings were that Minnesotans do not desire to curtail their uses of energy to improve environmental quality, and the perceived present uses of the River are exactly opposite to the uses the public desires.

(B) Publications:

Baron, N.J., E.J. Cecil, P.L. Tideman and J.P. Ludwig. September 1972. A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota. Water Resources Research Center, Univ. of Minn. Bulletin 55. 160 p., 70 tab., 19 fig., 23 ref.

(C) Project Status:

Project is completed.

(D) Application of Research Results:

A wide variety of people including politicians, the League of Women Voters, and more than 100 non-state-college persons at large have requested copies of the final report. The planning sections of several power companies, the cities of Minneapolis and St. Cloud, and faculty from eleven colleges of Minnesota and Wisconsin have requested copies of the final report as well. It is difficult to assess how the project results will be used by all these diverse interests. Since a major portion of the study has assessed current attitudes toward river development and use, it seems clear that this study will be exceptionally valuable to estimate public response to development programs and hence valuable for all levels of planners.

(E) Work Remaining, and Progress Contemplated During Next Year:

None.

OWRR Project No.: B-053-Minn.

Matching Grant Agreement No.: 14-31-0001-3600

Project Title: A Hydronomic Analysis of Forest Management Alternatives for Environmental Quality: A Case Study of Itasca County

FCST-COWRR Research Category: 06-G

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1971

To Be Completed: June 30, 1974

<u>Principal Investigators</u>	<u>Degree</u>	<u>Discipline</u>
A.C. Mace	Ph.D.	Forestrv
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Arthur P. O'Hayre	M.S.	Hydrology
John C. Clausen	B.S.	Forest Hydrology
Frank M. McCorison	B.S.	Forest Hydrology

Narrative Statements(A) Research Project Accomplishments.

Direct and direct-plus-indirect water use coefficients determined for the 34 economic sectors of Itasca County were used to evaluate the effects of alternative forest management systems on water use. Water required to process forest products resulting from these management systems was shown to reduce total water yield. However, if water used by plants through transpiration is charged to production, the type of management system becomes an important determinant for increased water yield.

Estimates of thermal pollution, sediment nitrates and phosphate levels associated with the alternative forest management systems is near completion. In addition, contributions of these potential pollutants from economic sectors associated with the processing of forest products have been estimated. Total contribution of these parameters and the subsequent effect on water quality in Itasca County has been partially completed.

(B) Publications.

None

(C) Project Status.

The project will continue in progress in fiscal year 1974.

(D) Application of Research Results.

Results of this project will provide Federal, State, local and private agencies with a tool and information to evaluate effects of alternative land management systems on water requirements, economic and environmental elements for multi-objective planning.

Agencies or groups which have expressed an interest in these results include: Itasca County Advisory Commission, Itasca County Board, Minnesota State Planning Agency, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency and the U.S. Forest Service.

(E) Work Remaining, and Progress Contemplated Next Year.

Estimates of potential water quality pollutants directly and indirectly associated with alternative forest management systems will be completed. Major emphasis will be placed on linking economic and environmental effects to these systems and examining in detail their interactions. Various multi-objective approaches utilizing the input-output framework will be explored and tested. Non-linear responses of various economic sectors to environmental factors will be evaluated using decomposition and other techniques. Sensitivity analysis will be used to identify areas where additional information is critically needed.

Preparation of manuscripts for publication of work completed will constitute a major portion of the work load during the next fiscal year.

OWRR Project No.: B-054-Minn.

Matching Grant Agreement No.: 14-31-0001-3601

Project Title: Socio-Economic Implications of Alternative Water Resources Policies in Minnesota

FCST-COWRR Research Category: 06-E

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1971

To Be Completed: June 30, 1974

<u>Principle Investigator</u>	<u>Degree</u>	<u>Discipline</u>
John J. Waelti	Ph.D.	Agricultural & Applied Economics
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Alan R. Hopeman	M.S.	Agricultural Economics
Rodney Christianson	B.S.	Economics
Keith Larson	B.S.	Chemistry

Narrative Statements

(A) Research Project Accomplishments.

An economic analysis of flood damage reduction alternatives in the Minnesota river basin was completed. The results of the analyses are given below.

Incidence of flood costs analysis provides justification for the imposition of land-use restrictions in flood plains in Minnesota. The analysis indicates that governmental units were the ultimate bearers of nearly half the flood costs in the Minnesota River Basin in the 1965 and 1969 floods. Government units have a substantial, justifiable interest in keeping flood costs down. Flood damage potential will continue to rise over time unless land use controls are instituted. Moreover, government costs are likely to make up an even larger proportion of flood costs in the future, with the advent of Federal flood insurance and an expanded Federal role in the provision of disaster relief. Therefore, thorough and vigorous enforcement of the 1969 Flood Plain Management Act is recommended.

Whenever thorough economic analyses show them to be feasible, the alternatives of permanent evacuation or construction of local protection works ought to be considered. These two alternatives are probably feasible in some areas. In areas where neither evacuation nor structural protection is economically feasible, land-use restriction alone will have to suffice to curtail flood losses.

The beneficiaries of structural flood control works ought to be assessed for a fair share of the costs of such works. This policy is not so crucial for existing flood plain developments, but is important for areas where new developments are permitted. The alternative approach to improve transportation river crossings in such a way that flooding will not cause traffic interruptions shows promise. Such interruptions accounted for over 50 percent of urban flood damages in the 1969 Minnesota River flood, and accounted for about 20 percent of total flood costs.

Of the six basic approaches to reducing flood damage potential in the Minnesota River Basin (do nothing, delimit new development in flood hazard areas, evacuate flood prone areas at public expense, build local protection works, construct a series of large reservoirs, and improve transportation river crossings), only two were found to be altogether infeasible at this time. One is the large reservoir alternative, which simply requires too much capital investment, given the amounts of benefits that would be forthcoming from such a project. The other is the "do-nothing" alternative, which has been superseded by the 1969 Flood Plain Management Act. Even so, it is doubtful that the "do-nothing" alternative would be the least cost solution to flood problems in this area.

The State of Minnesota should implement a flood data collection unit. The Federal and state governments should amend their tax laws to correct the inequity of the casualty loss provisions. The State and Federal governments should explore ways of reducing agricultural flood losses. The possibilities to be explored should include indemnification programs; flood forecasting and information dissemination; and the feasibility of structural solutions. The Federal share of various alternatives to a particular water resource problem should be placed on the same cost-share basis. The language of Minnesota's Flood Plain Management Act should be altered slightly so as to state in no uncertain terms that the State's policy is to oppose further flood plain encroachment. The discount rate for public investment projects in flood control should be raised to a level that accurately reflects the opportunity cost of the funds used.

(B) Publications.

Hopeman, A. R., May 1973. An Economic Analysis of Flood Damage Reduction Alternatives in the Minnesota River Basin. Water Resources Research Center, Univ. of Minn., Bulletin 58. 77 p., 16 tab., 1 fig., 80 ref.

(C) Project Status.

The project will continue in progress in fiscal year 1974.

(D) Application of Research Results.

The Minnesota State Planning Agency and the Department of Natural Resources in addition to offering cooperation necessary for the projects completion have expressed an interest in the flood control analysis. Insofar as major policy decisions will be made in Minnesota in the near future it is anticipated that the State Legislature will be interested in the results of the research. While the manuscript on environmental alternatives will be of interest to water resource professionals and public agencies, it will be geared to aid public understanding of the implications of public policy alternatives.

The Minnesota Department of Natural Resources expressed interest in the study to the extent that additional resources were available by that department to Mr. Hopeman to do further analysis on flood control policy

in Minnesota. In addition, Mr. Hopeman presented the results of his analysis to the Southern Minnesota River Basin Commission.

(E) Work Remaining, and Progress Contemplated During Next Year.

Further work remains on relating Minnesota water problems to more general environmental problems in Minnesota. In addition, a closer look is planned with respect to problems and issues dealing with navigation.

OWRR Project No.: B-057-Minn.

Matching Grant Agreement No.: 14-31-0001-3602

Project Title: Subsurface Irrigation With Heated Water, Its Management and Application Toward Reduction of Thermal Pollution Problems.

FCST-COWRR Research Category: 04-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1972To Be Completed: June 30, 1974

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
E. R. Alfred	M.S.	Agricultural and Civil Engineering

<u>Staff Cooperators</u>	<u>Degree</u>	<u>Discipline</u>
Paul E. Read	Ph.D.	Horticultural Science
L.L. Boyd	Ph.D.	Agricultural Engineering
J. R. Gilley	Ph.D.	Agricultural Engineering

<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
John E. Gilley	B.S.	Agricultural Engineering and Physics
Gary Johnson	Undergraduate	Agricultural Engineering

(A) Research Project Accomplishments:

All research effort during FY 1973 was conducted at the University of Minnesota Sand Plains Experimental Station at Elk River, Minnesota. Because of certain performance inadequacies which appeared in the subsurface irrigation system, during the previous year, a completely new system was installed. The new design consisted of two completely separate subsurface systems. One system was closed and used 1/2" copper pipe, which served to provide heat energy for soil warming. The second system, utilizing rigid plastic pipe with emitters spaced on 18" centers, provided irrigated water as needed by the crop. Both systems were buried 12" below the soil surface.

Well water, heated by LP gas to a temperature of 90°F to 105°F, was circulated continuously in the closed copper pipe system at a rate of 12 gallons per minute. As tensiometers indicated the need for irrigation, heated water was also introduced into the plastic subsurface system. Having the two systems made it possible to introduce large amounts of heat energy into the soil mass without risk of over-irrigation of the crop.

Warm water was circulated within the closed system beginning March 1, at which time an 8-inch cover of snow existed. Within one week all snow had melted from plots and by March 12 soil temperatures had reached a range of 45-50°F in the upper 18" depth. Potatoes were planted in one-half of the warmed plots on March 19, with the remaining plots planted on March 26. First signs of emergence occurred on April 10 in the early-planted plots, and on April 13 in the later plantings.

Since one of the objectives of this study was to determine the degree of frost protection as provided by the heated soil mass, no special measures were taken to avoid crop damage from frost. As a result, frost damage of several degrees of severity occurred during April and early May. The last killing frost occurred on May 5. Potatoes planted in unheated check plots on April 11 did not emerge until May 4, thus escaped major frost damage. All plants in the soil heated plots recovered quickly from frost damage and remained well ahead of plants in the check plots.

Initial trial digging of potatoes was made on June 7. Although many tubers were found to be undersize, an average of eight tubers of edible size were found per hill. One third of the heated plots were dug on June 22, another third on June 29 and the remainder on July 6. The entire area was then replanted in potatoes as part of the double-cropping scheme.

On the basis of data obtained thus far in 1973 the following tentative conclusions can be made.

(a) In order to extend the growing season in Minnesota into early April, some form of above ground frost protection is necessary. Warming of soil with water at temperatures normally found in industrial waste discharges was found not to provide sufficient protection against frost during the 1973 season.

(b) Even without above ground frost protection, it was possible in 1973 to advance harvest season in excess of three weeks. With the higher-valued vegetables and crops such an advance would provide marked price advantage for the grower using such waste heat.

(c) As the result of early harvest, another of the same (or different) crop can be planted to increase total yearly production and income.

(d) On the basis of the data obtained for the first crop of the 1973 season, potato yields are not increased appreciably as the result of applying waste heat to the soil, as compared to a single crop grown under normal field conditions. The principal advantage or benefit appears to be from earlier harvest.

(B) Publications:

None.

(C) Project Status:

The project will continue during fiscal year 1974.

(D) Application of Research Results:

Several power companies and other industries have expressed an interest in the data being obtained in this project. Most notable of these inquiries have come from representatives of Northern States Power Company, Minnesota Power Company, and Otter Tail Power Company. Certain data and methods employed relative to soil heating are of direct interest to NSP

in their attempts to utilize waste heat for agricultural purposes at their Monticello and Becker generator plants. Farmers are also interested in the results being obtained in this study with an eye toward increasing their income through the higher prices obtainable for early market crops, and from double cropping.

(E) Work Remaining and Contemplated During Next Year:

Data similar to that obtained during 1973 will be sought in 1974, since weather and other conditions will present a somewhat difficult environment. Attempts will be made during late 1973 and early 1974 to protect aboveground crops from frost, over part of the plots. From these data a comparison can be made of maturity rates and yields between crops grown in natural soil or of those grown in artificially heated soils. All data will then be processed and final report will be written.

OWRR Project No.: B-067-Minn.

Matching Grant Agreement No.: 14-31-0001-3900

Project Title: Role of Scientist-Technician in Water Policy Decisions at the Community Level: A Study in Purposive Communication

FCST-COWRR Research Category: 06-E

Name and Location of University Where Project is being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1972      To Be Completed: June 30, 1974

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
Roy E. Rickson	Ph.D.	Sociology

<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
Margaret Cawley	B.A.	Sociology
Paul Fine	B.A.	Sociology

Narrative Statements

(A) Research Project Accomplishments.

During the past fiscal year, four communities were studied. The research design calls for analysis of these communities by means of interviewing members of the public, community leaders, media personnel, as well as scientists and technical experts that have been involved with the community's environmental issues. Seven hundred people have been interviewed across the four communities. One hundred persons in each of two communities, 200 in another, and 300 in the last community we studied. The subjects were randomly selected and representative of the general population of the communities. There was generally a very low refusal rate with the highest (.09) occurring the last community we studied. In the other communities, the refusal rate was never higher than .05. Community leaders were interviewed in each of the areas and their responses will be compared with those of the general public. We have yet to interview scientists and technical experts that have been involved in the four community's environmental issues.

The analysis of the data is now being undertaken, but some preliminary results are available. The following data to be reported comes from only one community and is not a compilation of all four. It is clear that there is a great deal of public concern about the issue of sewage disposal in this community and its affect on water resources. Seventy-six percent of those interviewed said that decisions about sewage disposal would have a direct effect upon them. In turn, eighty-eight percent indicate that regardless of direct effects upon them, they are very concerned about whether proper sewage disposal standards are met. Obviously, the level of public concern over this issue is very high. The rather high level of conflict that has been connected with this issue was reflected in the fact that seventy-three percent of the respondents felt that the sewage disposal issue was a very touchy subject. Furthermore, these citizens are rather willing to accept individual sacrifice and support public action to counter

lake and stream pollution. For example, when they were asked to choose between lower taxes and better waste disposal methods, sixty-seven percent said they would choose the latter. Seventy-six percent said they would be willing to give up cleaning and laundry detergents that could harm public waters. Seventy-eight percent felt that the quality of public water should be preserved at any cost. In a choice between putting people out of work and cleaning public water, seventy-nine percent chose the latter. Seventy-eight percent disagreed with the following statement: "Some lakes and rivers should be given up as lost, because it's simply too costly to stop all pollution." The community members are also strong advocates of public action. Eighty-three percent felt that local government bodies should develop a regional sewer district program. Eighty-eight percent felt that regional cooperation among communities was necessary. In general, they perceived that the problem was beyond the local community and district planning was necessary. The subject population in this area represents about four subcommunities.

To some degree, the subjects perceive that science and scientists can solve their problem. Forty-eight percent said that every practical problem can be solved by scientists, it is just a matter of time. Also, sixty-nine percent said that public leaders would make better decisions if they used scientific information more than they presently do. Other items show that scientific information is valued by the community and should be used more extensively for dealing with pollution problems. On the other hand, few indicate that scientists should take an aggressive role in decision-making. Only fourteen percent felt that scientists should have the most influence in decision-making about pollution problems. And, fifty-three percent said that scientists should have about the same amount of influence they have now. The role of the technical expert and scientist has been of considerable importance in this community as opposing groups consulted with scientists and engineers and each supported their view with scientific testimony and other evidence. As in other communities, it was evident that a high degree of disagreement could be found among technical experts dealing with the problem.

It is clear from the above data that there is widespread public acceptance of action to control lake and stream pollution. Individuals are willing to accept a rather high level of personal sacrifice and think that vigorous public action is necessary. However, of the communities we studied, conflict and public controversy were greatest in this community when action was finally taken. The findings suggest that conflict was not due to a lack of public legitimacy for government action or that individuals were unwilling to change the way they used public water. The implication is that the procedural means for dealing with the problem is at the base of the ensuing conflict. This community is representative of most communities seeking to deal with their pollution problems. There is widespread public acceptance of action, but disagreement as to how the problem will be solved. There is, in other words, considerable conflict over means but not over the eventual goals. This and other data call into doubt opinions and other research that suggest that individuals and communities are unconcerned about environmental problems and that individuals

are unwilling to change in order to preserve environmental quality. The data do suggest that the problem lies in the organization of community action and the decision-making process. Of particular importance is the scientist's role and influence.

(B) Publications.

None.

(C) Project Status.

The project will be continued in fiscal year 1974.

(D) Application of Research Results.

The communities being studied have all requested input from the study results. Newspapers in each of the areas have all asked for information. Public agencies involved in each of the communities have also asked for copies of the final report. Numerous individuals in the communities have asked for final copies. Results will provide an analysis and further understanding of the social dimensions of pollution control and the underlying conflicts that are influencing the direction of natural resource planning.

(D) Work Remaining, and Progress Contemplated During Next Year.

The work to be done includes interviewing a sample of scientists and technical experts who have been involved in the environmental issues of the target communities. The data analysis on the other aspects of the project will continue and be completed in the next year.

OWRR Project No.: B-068-Minn

Matching Grant Agreement No.: 14-31-0001-3901

Project Title: Spatial and Temporal Variation of Precipitation of a Concentrated Network in Both Urban and Rural Environments

FCST-COWRR Research Category: 02-B

Name and Location of University Where Project is being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1972      To Be Completed: June 30, 1975

<u>Principal Investigator</u>	<u>Degree</u>	<u>Discipline</u>
Donald G. Baker	Ph.D.	Soil Science
<u>Student Assistants</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
J.W. Enz	M.S.	Soil Science
J.C. Klink	M.S.	Geography
G. McCormick	Undergrad.	Soil Science
D. Pauling	Undergrad.	Soil Science

Narrative Statements

(A) Research Project Accomplishments.

The data, which come from five different voluntary sources totaling more than 1500 daily observations per month and include both current data and an accumulation of several years, are being prepared for computer analysis. A computer program which edits and summarizes the data on a daily and monthly basis on a county and state-wide basis has been prepared and tested. A small portion of the data has been analyzed by means of the computer program. Base maps of both the state and of the Twin Cities metropolitan area have been prepared to aid in the analysis of the data. New precipitation normals have been calculated for the 1941-1970 period from the National Weather Service data and monthly and seasonal maps of the normals have been completed. Five years of May-September precipitation data from a variety of sources in the Twin City metropolitan area have been analyzed by hand. This study has been completed, a manuscript prepared and accepted for publication.

The results from this study are the following: one rain gage was inadequate because it greatly underestimated what actually occurred in this area of only 30-mile radius. Results indicated that about 50 gages would be required for a "true" sample of the area. The gages required varied from about 45 in May to 60 in July. It was found that the areas extent of rainfalls of given amounts was generally least in July and greatest in June. For example, the mean area of a daily rainfall of 0.05 inch or more was about 300 square miles in July and 695 square miles in June. The large differences in even the mean seasonal precipitation emphasized the necessity of as dense a rain gage network as possible.

(B) Publications.

Baker, D.G. and E.L. Kuehnast. 1973. Climate of Minnesota: Part VII. Areal Distribution and Probabilities of Precipitation in the Twin Cities Metropolitan Area. Minnesota Agricultural Experiment Station. Technical Bulletin 293. At Press.

Baker, D.G. March 1973. Climatological Notes of 1972. Department of Soil Science, Univ. of Minn. A Report on Field Research in Soils. Soil Series 89. 25 p.

(C) Project Status.

This project will continue in fiscal year 1974.

(D) Application of Research Results.

The following organizations have used the data or have indicated a need for the data in the near future:

1. Department of Natural Resources, State of Minnesota
2. Office of Civil Defense, State of Minnesota.
3. Corps of Engineers, U.S. Army.
4. Bureau of Reclamation, U.S. Department of the Interior.
5. Soil Conservation Service, U.S. Department of Agriculture.
6. National Weather Service, U.S. Department of Commerce.

The interest expressed in the data is from the viewpoint of detailed storm analyses and as a means of monitoring an element (water) which will become increasingly important in the near future. The precipitation network that has been established in conjunction with this project is nearly unique in the United States. As a result of the data obtained agricultural interests are becoming increasingly aware of precipitation variability and its influence upon fertilizer, crop variety and herbicide trials.

(E) Work Remaining, and Progress Contemplated During Next Year.

Assemble and prepare for computer analysis all of the precipitation data now on hand and to analyze the summarized data. Prepare a manuscript describing the new 1941-70 precipitation normals for the state. Analyze in detail the severe storms.

OWRR Project No.: B-077-Minn

Matching Grant Agreement No.: 14-31-0001-3902

Project Title: Forecasting Rainfall and Snowmelt Floods on Upper Mid-western Watersheds

FCST-COWRR Research Category: 02-E

Name and Location of University Where Project is being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1972

To Be Completed: June 30, 1974

<u>Principal Investigators</u>	<u>Degree</u>	<u>Discipline</u>
C.E. Bowers	M.S.	Civil Engineering
D.G. Baker	Ph.D.	Soil Science

<u>Student Assistant</u>	<u>Degree Held</u>	<u>Discipline or Academic Background</u>
A. F. Pabst	M.S., Ph.D.	Civil Engineering
K. Kim	M.S.	Civil Engineering
C.S. Chu	M.S.	Civil Engineering
J.W. Enz	M.S.	Soil Science
R. Lundstrom	Undergrad.	Civil Engineering

Narrative Statements

(A) Research Project Accomplishments.

The objective of this study is the development of analytical procedures and the correlation of hydrologic data to assist in the prediction and control of spring floods in Upper Midwest watersheds. The study involves three phases. The first, performed under an earlier contract, involved assembly and preliminary evaluation of some mathematical simulation models and assembly of meteorological and hydrological data concerning past spring floods.

The second phase, covered during the 1972-73 fiscal year, has involved: the procurement of additional simulation models, application of the models to the 16,200 square mile Minnesota River Basin or, for some models, to sub-basins, and procurement of exploratory field data on soil temperatures, frost depth, and soil moisture during the spring runoff period.

The hydrological and meteorological data were procured on tape and selected portions stored on random access disks for input to the models. As some of the models are of the continuous synthesis type, large amounts of data were used on input.

Simulation models used in the study include: the SSARR model, developed by the Corps of Engineers and the National Weather Service for the Columbia Basin, HEC-1, developed by the Hydrologic Engineering Center of the Corps of Engineers, the Stanford model, the NWSRFS models, developed by the National Weather Service, the T.V.A. Continuous Daily

Streamflow Model, and the Kentucky model and OPSET. Studies are still under way with most of these models.

Significant observations regarding the studies performed to date are as follows:

It is possible to simulate past flood events using a number of models. The SSARR and HEC-1 models performed best for spring snowmelt floods, but studies on some models have not progressed far enough for proper evaluation.

Continuous synthesis models such as the SSARR, Stanford, Kentucky, and NWSRFS models require a considerable amount of input data.

Regardless of the model and associated parameters employed, forecasting the volume of spring runoff is one of the most difficult tasks.

To improve the accuracy of snowmelt flood computations in the Upper Midwest, some model functions should be revised. In the SSARR model the degree-day melt coefficient should be made a function of a moving accumulation of degree-days. A similar modification is recommended in HEC-1.

The depth and solidity of the frost in the ground have a significant effect on the runoff.

As an exploratory study of frost depths and soil temperatures during the critical snowmelt period, several wooden rods were equipped with thermistors and inserted in the ground at representative locations in the basin. The studies indicated that the thaw or frost melt occurred frost both the surface and the area below the frost line and that during the melt, frost may be present at depths of three to five feet, but the area near the surface may be thawed and capable of absorbing part of the melt. Studies are continuing.

(B) Publications.

None.

(C) Project Status.

The project will continue in fiscal year 1974.

(D) Application of Research Results.

The National Weather Service (Washington, Kansas City, and Minnesota offices) and the Corps of Engineers (Hydrologic Engineering Center and St. Paul District) have indicated interest in the studies and have cooperated in providing programs and data.

(E) Work Remaining and Progress Contemplated During Next Year.

Complete evaluation of most promising simulation models; documentation of modifications made in the models and comparative performance.

PROGRAM UNDER P.L. 88-379

NEW COURSES DEVELOPED

University of Minnesota

CE 8-419 -- Simulation of Water Resource Systems - interdisciplinary course for those with adequate mathematical background. Deterministic models and stochastic models related with water resources systems including various types of watershed quantity and quality models, economic models, and socio-political aspects of the systems are discussed. In addition to lectures, students are given opportunities to write their own computer programs or to study and evaluate the existing programs using the University's computer facility.

Understanding Pollution - The interdisciplinary course was directed toward community leaders and technicians working with water resources problems. The course focus was on the social and economic aspect of environmental quality: (1) planning (2) diffusion of knowledge and implementation of programs, and (3) water resources planning as one aspect of overall community and societal development.

ADDITIONAL WATER RESOURCES RELATED  
STAFF MEMBERS ADDED

University of Minnesota

William K. Easter	Ph.D.	Department of Agricultural and Applied Economics
Arthur P. O'Hayre	Ph.D.	College of Forestry

NEW RESEARCH AND TRAINING FACILITIES  
OTHER THAN RESEARCH EQUIPMENT ITEMS

University of Minnesota

The Institute of Agriculture Remote Sensing Center has been located in the College of Forestry. This center has the capability for instruction and research related to water quantity and quality analysis by remote sensing techniques. Image enhancement and density slicing are among the present capabilities of the Center.

St. Cloud State College

The Biology Department now occupies 32,861 sq. ft. of space in a new building of which 3,942 sq. ft. is in use for undergraduate and graduate instruction in limnology and fisheries. The facility includes an indoor boat and field equipment garage, laboratory-classroom, storage-preparation room, and wet laboratory facility for holding and experimentation with aquatic organisms. Water treatment facilities include a 50 gpm well

water pump, water chiller and heater to supply water ranging 32 to 120F at 10 gpm. Well water can be used as environmental water after aeration and filtration, or can be deionized and reconstituted to known desired quality.

NUMBER OF STUDENTS RECEIVING EMPLOYMENT AS RESEARCH PROJECT OR PROGRAM ASSISTANTS THROUGH THE P.L. 88-279 PROGRAM.

<u>Category of Students</u>	<u>No. by Scientific Discipline or Major Field of Study (Engineering, Biology, Economics, etc.) 2/</u>	<u>Scientific Discipline of Student</u>	<u>Number</u>
<u>(1) Undergraduates</u>			
	Agricultural Engineering		1
	Biology		1
	Civil Engineering		1
	Forestry		1
	Geography		1
	Physics		1
	Political Science		1
	Sociology		1
	Soil Science		4
<u>(2) Master's Students</u>			
	Agricultural Engineering		1
	Animal Nutrition		1
	Biology		1
	Chemistry		3
	Civil Engineering		1
	Ecology		1
	Economics		1
	Forestry		2
	Hydrogeology		3
	Pharmacognosy		1
	Sociology		3
<u>(3) Doctoral Students</u>			
	Biology		3
	Civil Engineering		3
	Ecology		1
	Economics		4
	Forestry		1
	Geography		1
	Sociology		2
	Soil Science		4
<u>(4) Postdoctoral Students</u>			
	Civil Engineering		1
	Soil Science		1

<sup>2/</sup>This refers to educational background prior to employment as research assistant on P.L. 88-279 projects--not to departments in which projects are being conducted.

The number of students receiving employment as research project or program assistants varied during the period 1965-73 as follows: 1965-2, 1966-38, 1967-45, 1968-50, 1969-39, 1970-37, 1971-56, 1972-53 and 1973-51.

EMPLOYMENT STATUS OF MAJORS IN WATER-RELATED FIELDS WHO GRADUATED DURING THE SCHOOL YEAR ENDING ABOUT JUNE AND WHO RECEIVE P.L. 88-379 SUPPORT.

<u>EMPLOYMENT STATUS</u>	<u>CATEGORY OF SCHOOL YEAR GRADUATE BY DEGREE OBTAINED</u>			
	<u>Bachelor's Degree</u>	<u>Master's Degree</u>	<u>Doctoral Degree</u>	<u>Total</u>
1. No. employed in water-related positions in:				
Total -----	0	3	3	6
Federal Agencies -----	0	1	2	3
State & Local Agencies ---	0	1	0	1
University or College ----	0	0	1	1
Other - Including private enterprise -----	0	1	0	1
2. No. graduates returning to school for advanced degree -----	2	1	0	3
3. No. going into military service -----	0	0	0	0
4. No. unemployed or working in other fields -----	0	0	0	0
5. No. status unknown -----	3	0	0	3
6. Totals -----	5	4	3	12

The number of M.S. and Ph.D. majors in water-related fields who graduated and received support during the period 1965-73 varied as follows: 1965-0, 1966-1, 1967-3, 1968-3, 1969-4, 1970-5, 1971-5, 1972-9 and 1973-7.

TYPE OF EMPLOYMENT OF THOSE SCHOOL YEAR GRADUATES WHO RECEIVED P.L. 88-379 SUPPORT AND WHO ARE KNOWN TO HAVE GONE INTO WATER-RELATED POSITIONS.

PROJECT-RELATED REPORTS AND THESES

PUBLISHED DURING 1973

CATEGORY OF SCHOOL YEAR GRADUATE  
BY DEGREE OBTAINED

Number of Graduates Engaged in Water-Related Work In:	Bachelor's Degree	Master's Degree	Doctoral Degree	Total
1A. Federal Agencies:		1	2	3
a. Primarily Research -----		1	1	2
b. Primarily Planning -----		0	0	0
c. Primarily Development ---		0	0	0
d. Primarily Operations ----		0	0	0
e. Primarily Management ----		0	1	1
f. Other or not known -----		0	0	0
1B. State & Local Agencies:		1	0	1
a. Primarily Research -----		0	0	0
b. Primarily Planning -----		0	0	0
c. Primarily Development ---		0	0	0
d. Primarily Operations ----		0	0	0
e. Primarily Management ----		1	0	1
f. Other or not known -----		0	0	0
1C. University or College		0	1	1
a. Primarily Teaching -----		0	0	0
b. Primarily Research -----		0	0	0
c. Primarily Research & Teaching --		0	1	1
d. Other or not known -----		0	0	0
1D. Other - Including Private Enterprise:		1	0	1
a. Primarily Research -----		0	0	0
b. Primarily Planning -----		0	0	0
c. Primarily Development ---		0	0	0
d. Primarily Operations ----		0	0	0
e. Primarily Management ----		1	0	1
f. Other or not known -----		0	0	0
Totals -----		3	3	6

Selected summary of above data - from the "Total column":

Research (1Aa, 1Ba, 1Cb, 1Cc & 1Da)-----	2
Planning (1Ab, 1Bb & 1Dd)-----	0
Development (1Ac, 1Bc & 1Dc)-----	0
Operations (1Ad, 1Bd & 1Dd)-----	0
Management (1Ae, 1Be, & 1De)-----	3

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