

Sixth 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
Washington, D.C.

Water Resources Research Center
University of Minnesota
Room 107, Hubbell Hall
2675 University Avenue
St. Paul, Minnesota 55114

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

OCTOBER 1970
MINNEAPOLIS, MINNESOTA

WATER RESOURCES RESEARCH CENTER
UNIVERSITY OF MINNESOTA
GRADUATE SCHOOL

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Preface

This is the sixth 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, 1969, and ending June 30, 1970, 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 expand 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.

William C. Walton

Director

Water Resources Research Center

October 1970

DIRECTOR'S SECTION

Introduction

Stimulated into action by the passage of the Federal Water Resources Research Act of 1964 and recognizing the urgent need for a comprehensive approach to water resources research, the University of Minnesota established on Sept. 1, 1964, in the Graduate School, an interdisciplinary Water Resources Research Center. The Center did not find it necessary to seek and develop a competent team of researchers, for the faculty and graduate students working on the various problems of water resources had already demonstrated their ability. The Center has responsibility for unifying and stimulating University water resources research through the administration of funds associated with the Federal Water Resources Research Act of 1964 and made available by other sources; coordinating University Research with programs of local, state, and federal agencies and private organizations throughout the State; and assisting in training additional scientists for work in the field of water resources through research. The Center plans and arranges for Divisions of the University to conduct competent research of either a basic or practical nature, or both, in relation to water resources.

The government, management, and control of the Center and its affairs are vested in an Advisory Committee. The Advisory Committee is headed by the Dean of the Graduate School and consists of 15 faculty members appointed by the Dean of the Graduate School in consultation with the Director. Formal appointment includes provision for rotation for representatives from the various Schools, Departments, and Divisions having a vital interest in the work of the Center, by use of one, two, and three-year terms appropriately staggered. A Consulting Council composed of 19 representatives from organizations outside the University concerned with water resources counsels with the Director, assists in identifying needed research, assists in integrating and coordinating University research with projects outside the University, and provides public liaison. Consulting Council Representatives are appointed by the Director in consultation with the Advisory Committee. Formal appointment includes provision for rotation of representatives by three-year terms appropriately staggered. The present roster of the Center is given in Table 1.

Table 1. - Roster of Center (1969-70)

William C. Walton, Director
 John J. Waelti, Assistant Director
 Dagmar Tezla, Secretary

ADVISORY COMMITTEE

| <u>Professor</u> | <u>Department, School, or Division</u> |
|------------------|--|
| A.G. Anderson | St. Anthony Falls Hydraulic Laboratory |
| W.J. Barrett | Department of Geography |
| R.G. Bond | School of Public Health |
| A.J. Brook | Department of Ecology & Behavioral Biology |
| B. Crawford, Jr. | Graduate School |
| W.J. Hueg, Jr. | Agricultural Experiment Station |
| P.W. Manson | Department of Agricultural Engineering |
| J.J. Waelti | Department of Agricultural Economics |
| W.P. Martin | Department of Soil Science |
| O.C. Peterson | Department of Public Administration |
| G.J. Schroeffer | Department of Civil Engineering & Hydraulics |
| P.K. Sims | School of Earth Sciences |
| A. Mace | School of Forestry |
| T.F. Waters | Department of Entomology, Fish. & Wildlife |
| H.E. Wright | Limnological Research Center, School of Earth Sciences |

CONSULTING COUNCIL

| <u>Representative</u> | <u>Organization</u> |
|-----------------------|--|
| D.B. Anderson | U.S. Geological Survey, Water Resources Division |
| D.W. Barr | Consulting Hydraulic Engineer |
| A.D. Belmont | Research Division, Control Data Corporation |
| C.R. Collier | U.S. Geological Survey, Water Resources Division |
| J. Dobie | Minnesota Department of Conservation, Division of Game and Fish |
| H.M. Major | U.S. Department of Agriculture, Soil Conservation Service |
| G. Gere | Minnesota Department of Conservation, Division of Waters, Soils and Minerals |
| R. Haik | Attorney, Minneapolis |
| C.L. McGinnis | U.S. Army Corps of Engineers |
| E.A. Hickock | Consulting Hydrologist |
| S.E. Jorgensen | U.S. Bureau of Sport Fish. and Wildlife |
| D. Krenik | Minn. Association of Soil & Water Conserv. Districts |
| D.S. Bryson | Federal Water Pollution Control Administration |
| L. S'ith | Minnesota Pollution Control Agency |
| J.H. Strub | U.S. Weather Bureau |
| F.W. Thorstensen | Minnesota State Department of Highways |
| C.A. VanDoren | U.S. Dept. of Agriculture, Agric. Research Service |
| E. Weiberg | Minnesota Water Resources Board |
| R.W. Merz | U.S. Dept. of Agriculture, Forest Service |

One of the purposes of the Center is the stimulation of educational offerings for students which will prepare them for careers in the field of water resources. In doing this, it is appropriate for the Center to review the educational programs available in the University, both graduate and undergraduate, and to suggest to Departments, areas in which new offerings may be useful or appropriate; this is particularly helpful in connection with interdepartmental or interdisciplinary programs. Moreover, there is an increasing number of potential students interested in the area of water resources. The Center is assisting in recruiting such students, in attracting them to the University by informing them of the opportunities the University can provide, and in guiding them into appropriate programs of study.

The Center continuously compiles information on needed and neglected water resources research areas with the assistance of its Advisory Committee and Consulting Council. The selection of research projects to be sponsored gives due regard to research needs of the State and is approached on an interdisciplinary basis. During the winter months of 1966, about 350 people having an interest in water resources research in Minnesota were solicited by the Water Resources Research Center for information concerning needed areas of water resources research. Based on the results of a questionnaire and considering water resources problems in Minnesota, additional research is needed most in areas bearing on social-economic aspects, water pollution, and floods, about in that order. The Center conducts interdisciplinary seminars to acquaint students, faculty, and others with the broad aspects of water resources and it sponsors short courses and conferences. The Center publishes Pulletins presenting results of research projects. Mimeographed Information Circulars and Quarterly Newsletters are distributed to about 500 people in Minnesota.

The University of Minnesota through its Water Resources Research Center has demonstrated its interest and its capability during the past five years, and it is willing to further develop a truly outstanding water resources research facility for Minnesota. It has provided the mechanics for unifying water resources research throughout the state.

The Graduate School provided \$3,200 in F.Y. 1970 to cover part of the Center's office expenses. The University provides office space (250 square feet) for the Center's office operations in room 107, Hubbard Building, 2675 University Avenue, St. Paul, Minnesota, at a total cost of \$1,800 per year.

Director's Summary Statement

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. Fast 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. Expansions 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 1970 was directed toward: ascertaining the physiological and ecological requirements of the algae responsible for severe blooms on lakes to assist the State in devising remedial measures for over-fertilization of lakes (A-016-Minn); perfecting methods for rainfall-runoff predictions on ungaged small watersheds (A-017-Minn); devising institutional arrangements for better integrating water quality management with the management of the total water resources in the State (A-018-Minn); formulation of an optimizing model for water quality improvement on selected stretches of the Upper Mississippi River (A-019-Minn); determination of design floods for spillway and related structure analyses (A-020-Minn); provide information for legislative action on reorganization of State water resources agencies (A-021-Minn); assessment of the extent of eutrophication of the west end of Lake Superior (A-022-Minn); determining the role of bottom sediments in the phosphorus cycle for overfertilized lakes (B-009-Minn); development a mathematical model to predict the role of surface waters (B-012-Minn); investigation of methods for reducing transpiration from crops (B-013-Minn); study of the mechanics of soil moisture movement and retention (B-015-Minn); investigation of the ecology of periphyton in near-shore areas of the west end of Lake Superior (B-020-Minn); study of citizen's groups involved in improving the water resource environment in metropolitan areas (B-031-Minn); and determination of ecological conditions in the Mississippi River near Monticello, Minnesota before and after operation of a nuclear power plant (B-032-Minn).

The Center's program during the next five years will involve completion of above mentioned projects and it will likely stress social-economic-political aspects of water resources. The subject matter of projects will probably include: alleviation of lake pollution by utilization of aquatic plants for nutritional, medicinal, or industrial purposes; mathematical simulation of a large watershed using the systems approach to quantity and quality analysis; spatial variation in the perception of water resources and water problems in south central Minnesota; area financing of water resources development; social and economic factors in the adoption by industry of water pollution control measures; and attitudes toward the Mississippi river as a total resource in Minnesota.

Results from projects A-009-Minn on groundwater contribution to stream-

flow, 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-010-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-014-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-005-Minn on soil moisture and A-004-Minn on soil freezing in forests. The results of project A-015-Minn on water laws in Minnesota have assisted the legislature in identifying deficiencies in statutes.

The Center has been helpful in developing 20 new water resources courses, a graduate option in hydrogeology, a program of graduate education in water resources, and recruitment of 21 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.

Management of the Center is vested in an Advisory Committee headed by the Dean of the Graduate School and made up of faculty members and 15 units of the University. A Consulting Council, composed of 20 representatives from organizations outside the University, counsels with the Center and assists in identifying needed research and providing public liaison. The State contributed about \$34,500 to the Center's OWRR Allotment program and about \$106,900 to the Center's OWRR Matching Grant program in FY 1970.

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.

Center Publications

During FY 1970, the Center distributed to about 400 people interested in water resources in Minnesota mimeographed Information Circulars covering the following subjects:

| Information Circular Number | Title |
|-----------------------------|--|
| 97 | Summary of Information on State Administrative Structure & Institutional Arrangements for Water and Related Land Resources in Minnesota and Adjoining States, 1969. |
| 98 | Summary of Information on FY 1968 State Programs for Water and Related Land Resources in Minnesota. |
| 99 | Summary of Information on Federal Agencies and Responsibilities in Water and Related Land Resources Field in Minnesota |
| 100 | Summary of Information on FY 1968 Budgets and Staff Complements of the Minnesota Department of Conservation, Pollution Control Agency, Soil and Water Conservation Commission and Water Resources Board. |
| 101 | Four Alternative Charts for Possible Reorganization For the Improvement of State Government in the Field of National Resources. |
| 102 | The Role of the State of Minn. in Water Resources Planning. |
| 103 | Summary of Information on State Soil and Water Conservation Commission and Soil and Water Conservation Districts. |
| 104 | Recommendations Concerning the Improvement of State Government for Natural Resources. |
| 105 | Summary of Information on Pollution Control Agency. |
| 106 | State Legislature and Congressional Handling of Natural Resources. |
| 107 | Summary of Information on Minnesota Water Resources Board. |
| 108 | Summary of Information on Minnesota Dept. of Conservation. |
| 109 | A Collection of papers on "History of Federal Basin Planning Organizations; Evolution of Water Resources Planning; Comprehensive Water Resources Planning;" and "Water Development Policy." |

The Center also distributed quarterly newsletters to about 500 people

interested in water resources in Minnesota. Bulletins published by the Center during FY 1970 are listed in the section of this Annual Report entitled "Publications and Theses." The Center has had many requests for copies of its Bulletins, Newsletters, Annual Reports, Information Circulars, and Brochures. A few excerpts from letters expressing appreciation for the Center's publications are given below:

A faculty member has been passing on his copies of WATER RESOURCES RESEARCH NEWSLETTER to our Minnesota Room in Memorial Library. We would appreciate very much being put on your regular mailing list. There seems to be considerable interest in your Newsletter.

Mrs. Marilyn J. Lass, Librarian
Center for Minnesota Studies
Mankato State College
Mankato, Minnesota

The Water Resources Research Center of the University of Minnesota kindly sent me a copy of: Fox, J.L., T.O. Odlaug and T.A. Olson. 1969. THE ECOLOGY OF PERIPHYTON IN WESTERN LAKE SUPERIOR. PART I. TAXONOMY & DISTRIBUTION. Bulletin 14, Water Resources Research Center, Univ. of Minnesota Graduate School, St. Paul, Minnesota. This is an excellent publication, and I wish to thank you for it. I saw Professor Olson Friday evening in Minneapolis and congratulated him on the timeliness and excellence of the publication.

William B. Sarles
Professor of Bacteriology
The University of Wisconsin
College of Agricultural and Life
Madison, Wisconsin (Sciences

Would you be kind enough to send the Water Resources Research Center Information Circulars which have been issued since 94? I find these are excellent sources of information for hydrologists and I know that a great deal of effort on your part is responsible for their continued success. As far as I can determine, your Research Center is the most active of those established in the U.S. If you ever have the opportunity to enlarge your staff, please keep me in mind.

Dr. Jon L. Pau, Assoc. Professor
Kent State University
Kent, Ohio

We appreciate receiving a copy of your Bulletin 11 titled "Aspects of Water Resources Law in Minnesota," June 1969. In connection with the Comprehensive Framework Study of the Great Lakes Basin our work group which is studying laws and institutional arrangements would find a copy of this bulletin helpful. Will you please send a copy to: Mr. Karl R. Hosford, Water Resources Commission, Michigan Dept. of Natural Resources, 200 Will Street, Lansing, Michigan.

Leonard Crook
Great Lakes Basin Commission
Inst. of Science & Technology Bldg.
2200 North Campus Boulevard
Ann Arbor, Michigan

This Division has just received 150 copies of the Water Resources Research Center Bulletins No. 9 and 11 and we wish to take this opportunity to thank you for your generosity. These Bulletins will be issued to all of our Conservation Officers in the Division of Enforcement and Field Service. We feel that they will be a source of valuable information regarding the public waters and riparian owner rights in our state.

F.W. Johnson, Assistant Chief
Div. of Enforcement & Field Service
State of Minnesota
Department of Conservation
St. Paul, Minnesota

This is to request copies of the report entitled "Codified and Uncodified State Laws and Municipal Ordinances Bearing on Water and Related Land Resources in Minnesota." I have received and have enjoyed the recent work you and members of your staff published in relation to the water resources law of Minnesota. Our warmest congratulations for a job well done.

William P. Poblete, P.E.
Public Health Engineer
Olmstead County Health Department
415 4th Street, S.E.
Rochester, Minnesota 55901

I wish to acknowledge receipt of "The photosynthetic pigments of Lake Superior Periphyton and Their Relation to Primary Productivity" by Drs. Stokes, Olson, and Odlaug. Thank you very much for this report representing an exhaustive study. The information is highly informative and is useful to both myself and my students.

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

I received a copy of Bulletin 11, "Aspects of Water Resources Law in Minnesota" the other day in the mail and I very much appreciate receipt of the bulletin. I am a practicing attorney in Minnesota and also a member of the Law Committee of the Sierra Club and, accordingly, I have an interest in bulletins of this type. As I review this bulletin, I am particularly impressed with the fine job that your people have done in preparing the material.

I have seen one other bulletin which was prepared by the Water Resources Research Center which particularly impressed me and of which I would like a copy for my library. I am referring to Bulletin #9, entitled "Codified and Uncodified State Laws and Municipal Ordinances Bearing on Water and Related Land Resources in Minnesota." If a copy is available, I would appreciate receipt of a copy and if the copy is out of print, I would like to be remembered when the bulletin is reprinted again. Thanks again for the Bulletin 11, which will be a valuable research asset for my library.

Harold D. Jastram
6804 Brook Drive
Edina, Minnesota

Center's Involvement in Academic Activities & Public Affairs

On March 26, 1970, a Conference on Ongoing Water Resources Research in Minnesota sponsored by the Center was held in the North Star Ballroom, Student Center, University of Minnesota, St. Paul Campus. About 75 people attended the Conference. The objective of the Conference was to acquaint those concerned with water resources in Minnesota with the nature of ongoing water resources research activities in the State. The papers presented at the Conference were published as a Center Bulletin and distributed to 500 people throughout the State. Representatives from 16 organizations having research programs participated in the Conference as indicated below:

Session 1

Opening Remarks and Water Resources Research Center, W.C. Walton
Minnesota Pollution Control Agency, J.P. Badalich
Federal Water Quality Laboratory at Duluth, D.I. Mount
Northern States Power Company, A.V. Dienhart
Agricultural Experiment Station, W.F. Hueg, Jr.
Minnesota Department of Iron Range Resources & Rehabilitation, A.M. DeYoannes
North Star Research & Development Institute, E.E. Erickson
U.S. Forest Service, R.R. Bay

Session 2

Limnological Research Center, R.O. Megard
Minnesota Department of Conservation, John Dobie
Department of Entomology, Fisheries and Wildlife, L.L. Smith
Dept. of Civil Engineering & Hydraulics, St. Anthony Falls Hydraulic
Laboratory, E. Silberman
U.S. Geological Survey, C.R. Collier
School of Public Health, C.P. Straub
U.S. Agricultural Research Service, C.A. VanDoren
Center for Urban & Regional Affairs, J.R. Borchert

The Conference was well received; a few excerpts from letters expressing appreciation for the Center's efforts are given below:

Enclosed, herewith, is a copy of the statement I presented before the conference on "Water Resources Research in Minnesota," on March 26, 1970. "I appreciate the opportunity you afforded me in making this presentation and I regret that I wasn't able to attend the balance of the conference. I did, however, have two members of my staff present during this conference and from their response, this conference was well received.

John P. Badalich, P.E.
Executive Director
Pollution Control Agency
717 Delaware Street S.E.
Minneapolis, Minn.

First, a word of thanks for inviting me and other League Members to the Conference on Ongoing Water Resources Research in Minnesota. I thought it was well-conceived, well-run, interesting and informative. I wonder if any State Legislators or their staff were invited. A briefing along these lines would be most beneficial to legislators, I would think, and not just those on the committees which handle water related bills. I would like to

order some publications from the Research Center: Bulletin #5, and Information Circulars: 18,20,22,28,37,40,46,49,54,55,58,62,63,76,77,81,82,85,97, 100,101,102,104,105,106,107.

Mrs. Richard Phillips
League of Women Voters
Fridley, Minn.

You will find attached a copy of the paper I gave at the recent Conference on Ongoing Water Resources Research in Minnesota. I want to compliment you on your foresight in arranging this Conference. I believe that all of us should have learned some things that day. Would you please send 65 reprints of this talk after it is published.

Cornelius A. Van Doren
Chief, Corn Belt Branch
U.S. Department of Agriculture
Agricultural Research Service
Soil & Water Conservation Research Div.
108 Soil Science Bldg., U. of M.
St. Paul, Minn.

Enclosed is a copy of my presentation at the conference on Ongoing Water Resources Research in Minnesota, March 26, 1970 which you requested. This was certainly one of the better sessions we have attended. The papers were most interesting and informative and the associations are most worthwhile. Your efforts are certainly appreciated.

C.R. Collier, District Chief
U.S. Dept. of the Interior
Geological Survey
1033 Post Office Bldg.
St. Paul, Minn.

As a Consultant to the Minnesota State Planning Agency, the Director of the Center assisted that agency in preparing the document "Minnesota's Water and Related Land Resources - First Assessment." The document has been well received; an excerpt from a letter concerning the Assessment is given below:

Mr. Raymond T. Olson, Director
State Planning Agency
St. Paul, Minn.

Dear Mr. Olsen:

This is in response to your letter of March 6, 1970, which forwarded "Minnesota's Water and Related Land Resources - First Assessment." I regret that the staff has not had time to review the report in the depth it deserves. However, there was general agreement that the report is a thoroughly competent piece of work. I assume that the final version will serve as input to the various Federal-State studies in which Minnesota is currently engaged.

Sincerely yours,

W. Don Maughan, Executive Director
Water Resources Council
Washington, D.C.

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

On behalf of the Student Affiliates of the American Chemical Society and the faculty of the Chemistry Department of the College of St. Thomas I want to thank you most sincerely for the splendid talk you gave before our recent symposium. We heard many fine comments from our students and from the teachers who attended. Thank you for having contributed so much to the success of the symposium.

James J. Carney, Prof. of Chemistry
College of St. Thomas
St. Paul, Minn.

I don't know when I have been more satisfied at hearing of someone's experience in planning as I was when you finished your presentation at the Washington State Water Research Center's symposium in Renton on April 9. Thank you for a very worthwhile experience.

Beecher Snipes, Asst. Director
Div. of Planning & Development
Washington State Dept. of Water Res.
335 General Administration Bldg.
Olympia, Wash.

On behalf of the 14th Annual Midwest Ground-Water Conference, I thank you for chairing the discussion of Ground-Water Runoff and Basin Characteristics. I could not attend this discussion, but I have heard numerous compliments regarding this group. I was delighted you could come to Lexington and I hope you enjoyed yourself. I hope you have a happy and prosperous New Year.

Harry M. Whitman, Geologist & Head
Water Section, Univ. of Kentucky
Lexington, Kentucky

A sincere thank you for your participation in Willmar High School's Earth Day program on Wednesday, April 22. Your participation was greatly appreciated and added immeasurably to the success which we feel the activities of that day achieved.

William Borth, Symposium Coordinator
Willmar Public Schools
Independent School District 347
Willmar, Minn. 56201

The Director of the Center, acting as part-time Water Resources Planning Director, Minnesota State Planning Agency served as Governor LeVander's representative on the Souris-Red-Rainy River Basins Commission and the Great Lakes Basin Commission during the period July 1, 1967 through June 30, 1969. Resolutions and letters commending the Director's efforts are given below:

WHEREAS Mr. William C. Walton, Representative of the State of Minnesota, has admirably served the Souris-Red-Rainy River Basins Commission since its organization in August, 1967, and has given generously of his time, talents,

and counsel for the Commission's effectiveness; and

WHEREAS he has, as the Commission's first Vice Chairman, laudably served as coordinating officer of the State members and has been an effective representative of the State Governments in Federal-State relations on the Commission; and

WHEREAS his duties as Director of the Minnesota Water Resources Research Institute and other demands on his time necessitate his resigning as Vice-Chairman effective July 1, 1969;

NOW, THEREFORE, BE IT RESOLVED by the Members of the SRRRBC, at its meeting of June 18, 1969, in Moorhead, Minn., that this Commission, individually and collectively, express their sincere appreciation and commendation to Mr. Walton for his challenging analyses, his viewpoint, and his selfless and generous efforts in behalf of the Commission;

BE IT FURTHER RESOLVED that copies of this Resolution be transmitted to the Members of Minnesota's Congressional Delegation; the Governors of the States of Minnesota, North Dakota, and South Dakota; Mr. E.D. Eaton, Acting Director, Office of Water Resources Research, U.S. Dept. of the Interior, Washington, D.C.; Dr. Malcolm C. Moos, President, University of Minnesota; and Ray Olsen, Director, Minn. State Planning Agency, St. Paul, Minn.

RESOLUTION

WHEREAS, William C. Walton, one of the original Commissioners of the Great Lakes Basin Commission, has played an objective and contributive role in the activities of the Commission; and

WHEREAS, as a nationally recognized authority in water resources planning, he has very ably represented the State of Minnesota; and

WHEREAS, he has given willingly of his time and energies to promote State and Federal cooperation in water and related land resource planning; and

WHEREAS, he will soon be devoting full time to the position of Director of the University of Minnesota's Water Resources Research Center, and in addition, special consultant to the State Water Resources Coordinating Committee;

BE IT HEREBY RESOLVED, that the Great Lakes Basin Commission hereby go on record as expressing sincere appreciation to WILLIAM C. WALTON for his dedicated and meritorious service.

A recent letter from Mr. Gray calls my attention to you valuable service as vice chairman of the Souris-Red-Rainy River Basins Commission for the past few years, and I wanted to compliment you on a job well done.

Malcolm Moos, President
University of Minnesota
202 Morrill Hall
Minneapolis, Minnesota

It has come to my attention that you have resigned as Vice Chairman of the Souris-Red-Rainy River Basins Commission. May I take this opportunity to extend my best wishes to you in your future endeavours. I know that your service to the Commission has been most valuable, and that you will continue to contribute a great deal to the field of water resource conservation and use through your work in research.

Odin Langen, Member of Congress
House of Representatives
Washington, D.C.

The Department of Agricultural Economics, through the participation of 2 staff members and 1 graduate student is participating in an interdepartment program on environmental quality led by the Center for Urban and Regional Affairs. The objective of this program is to formulate some guidelines for the State Planning Agency relating to waste management.

Faculty Research Bearing on Water Resources, 1968-69, in Addition to the Center's Program

Institute of Agriculture

Agricultural Experiment Stations

| | <u>Support</u> |
|--|--------------------------------|
| Northwest Experiment Station, Crookston Soine, Olaf, C. Crop - weather records | U |
| Soil heat and moisture characteristics related to evaporation from cropped land | U |
| Southern School & Experiment Station, Waseca Frazier, Russell D. Agricultural climatology in southern Minnesota | U |
| Relationship of sorption and desorption of pesticide residues in soil and their persistence & elimination | U |
| Soil factors influencing fate & activity of selected pesticides in Minn. soils | SGA/U |
| Southwest Experiment Station, Lamberton Nelson, Wallace W. Soil factors influencing fate of selected herbicides in Minnesota soils | D/U |
| Agricultural Extension Service Miles, William R. Conservation education in Minnesota | -- |
| Agricultural Economics Blank, O. Uel Economics of the tourism-recreation industry | AES |
| Maki, Wilbur R. Impact of metropolitan growth on regional resource use | AES |
| Raup, Philip M. Economic problems in the use, allocation & pricing of water | AES |
| Dissertation supervision: Economic investigation of the problem of water quality management in the Twin Cities-upper Mississippi River area | |
| Snyder, Robert W. Local government policy implications of seasonal home ownership in Minnesota | AXS/GAR |
| Agricultural Engineering Allred, Evan R. Agricultural production on sand lands of Minnesota | GAR |
| Disease hazards resulting from treatment of animal wastes in the Pasveer oxidation channel | USPHS AESR/CSR ^s |
| Farm animal waste disposal | HA |
| Supplemental irrigation in Minnesota | |
| Machmeier, Roger E. Supplemental irrigation in Minnesota: | GS/HA |
| Moore, James A. Treatment and disposal of animal wastes | AESR/CSR ^s |

Entomology, Fisheries & Wildlife

| | |
|---|-----------------------------------|
| Smith, Lloyd L. Effect of hydrogen sulfide on fish & fish food organisms | USDI |
| Investigation of commercial fish populations of Red Lakes, Minn. | HA/USDI |
| Investig. of herring populations of western L. Superior | MDC |
| Dissertation Supervision Early life history & survival factor in lake herring | |
| Factors determining survival of young Northern pike | |
| Population separation by electrophoresis | |
| Waters, Thomas F. Dynamics of freshwater stream invertebrate populations | NSF |
| Mechanisms of biological production in streams | AES |
| Dissertation supervision: Ecology of stream aphid | |
| Production rates of stream insects. | |
| School of Forestry Hansen, Henry L. Ecology & management of forest recreational areas | AES/CSR ^s / MRC/MST |
| Hughes, Jay M. Economics of forest resource use | GAR |
| Forestry in Lake of the Woods- Rainy Lake region | -- |
| Role of forest resources in economic development, N.E. Minnesota | GAR/USDA |
| Supply & demand, forest recreation, North Central Region | CSR ^s |
| Mace, Arnett C. Jr. Solar energy available for evaporation & transpiration at peatlands | NCFES |
| Watershed values as affected by forest management | GAR |
| Merriam, Lawrence C. Jr. Campsite conditions in Boundary Waters Canoe Area | NCFES/USDA/ USFS |
| Recreation management & user satisfaction in several Minnesota park & forest areas | MST |
| Role of outdoor recreation in management of Minn. Memorial Hardwood Forest | HA |
| Dissertation supervision Boundary Waters Canoe Area outfitters & campers: attitudes & interactions | |
| Recreation users & Minn. Memorial Hardwood Forest | |
| Soil Science Baker, Donald G. Characterization of agricultural climate | HA |
| Regional solar radiation receptor | GAR |
| Soil heat & moisture characteristics related to evaporation from cropped land | GAR/HA |
| Urban climatology | -- |
| Dissertation supervision: Light distribution in a soybean canopy | |
| Plant geometry & energy distribution | |
| Spatial & temporal variation of local precipitation | |
| <u>College of Biological Sciences</u> | |
| Botany Gorham, Eville | |

| | | | |
|--|----------|--|-----|
| Chemistry of Irish bog waters & peats | -- | Ecology & development of mink frog | |
| Cycles of major & minor elements in lakes & wetlands | GS/NSF | Ecology & morphology of <u>Coregonus artedii</u> | |
| Productivity of sedge fens | NRCC | Ecology & finescala date, <u>Chrosomus neogaeus</u> | |
| Sedimentary pigments as indices of lake productivity | GS/NSF | Food segregation in 3 species of minnows | |
| Tritium as tracer for water masses in wetlands & lake sediments | | Subnivean environs of small mammals | |
| Dissertation supervision: | | Williams, Frederick M. | |
| Computerized study of wetland vegetation by objective methods | | Energetic components of community stability | -- |
| Ecology of peatlands of northern Minn. | | Environmentally-induced shape change in algae | NSF |
| Ecology & Behavioral Biology | | Mathematical models of population structure | -- |
| Brook, Alan J. | AEC | Population regulation in continuously-cultured algae | NSF |
| Algal & bacterial microstratification in Minn. lakes | | Dissertation supervision: | |
| Desmid indicators of trophic status of lakes | | Biochemistry of algae shape change | |
| Ecological & taxonomic studies of Minn. algae | | Control of <u>Daphnia</u> populations | |
| Ecology, morphogenesis & taxonomy of <u>Caulerpa</u> | | Temperature and growth in continuous culture | |
| Polymorphism & taxonomy of <u>Staurastrum</u> | | | |
| Terrestrial algae on roofs | | | |
| Dissertation supervision: | | | |
| Biology of <u>Cocillatoria agardhii</u> w/ special reference to its microstratification | | | |
| Effects of heated discharges on river algae | | | |
| Growth studies of planktonic desmids in nature & culture | | | |
| Polymorphism in <u>Staurastrum chaetoceras</u> | | | |
| Megard, Robert O. | | | |
| Nutrients & growth rates of algae in Lakes | MRC | | |
| Productivity of Minn. lakes | | | |
| Zoology | | | |
| Huver, Charles W. | SC | | |
| Copper in L. Superior & tributary waters | | | |
| Effects of heated effluents on water quality of the St. Croix River | NaWF/SFI | | |
| Histological & physiological characterization of parathyroid glands of fishes | GS | | |
| Sex differentiation in the American eel, <u>Anguilla rostrata</u> | | | |
| Transmission of carcinogenic agent from acanthocephalan parasite to bluegill, <u>Lepomis macrochirus</u> | ACS | | |
| Dissertation supervision: | | | |
| Effects of copper sulfate on development of cisco eggs | | | |
| Histochemical study of malignant melanomass in bluegill | | | |
| Influence of histones on development of zebrafish | | | |
| Longevity, growth & sex ratios of yellow perch in relation to year-class strength | | | |
| Merrell, David J. | -- | | |
| Polymorphism in leopard frog | | | |
| Population dynamics of experimental <u>Dosophilis</u> populations | -- | | |
| Underhill, James C. | -- | | |
| Distribution of Minn. fishes | -- | | |
| Meristic variation in Cyprinidae | -- | | |
| Production of benthos in Lake Itasca | -- | | |
| Dissertation supervision: | | | |
| Ecology & development of green frog, <u>Rana clamitans</u> | | | |

University of Minnesota, Duluth

Division of Science and Mathematics

| | | | |
|---|--|--|------|
| Monson, Paul H. (Biology) | | | |
| Aquatic flora of Minnesota | | | -- |
| Collins, Hollie L. (Biology) | | Parental behavior of cichlid fishes | GS |
| Krogstad, Blanchard (Biology) | | Substrate fauna in North Shore stream | GS |
| Odlaug, Theron O. (Biology) | | Continuous plankton recorder studies | |
| Lake Superior periphyton in relation to water quality | | | USDI |
| Social Sciences Division | | | |
| Olsen, Dale W. (Pol. Sci) | | Extent of continuing use of hard pesticides in Minn. | -- |
| Political, administrative & legal aspects of federal & state environmental pollution control programs | | | -- |
| Wolff, Julius F. Jr. (Political Science) | | Legendry of the Quetico-Superior Country | -- |
| Minn. Dept. of Conservation | | | -- |
| Shipwrecks of Lake Superior | | | -- |

College of Medical Science

School of Public Health

| | | | |
|--|--|--|--|
| Olson, Theodore A. | | | |
| Dissertation supervision: | | | |
| Analysis of primary productivity of Lake Superior & Michigan surface waters using C-14 technique | | | |
| Biodynamics of Lake Superior periphyton as reflected by pigment analyses and respirometry | | | |
| Ecology of epilithic periphyton of Lake Superior | | | |
| Effect of chronic pneumonitis virus on tissues <u>In vitro</u> | | | |
| Growth response & nutritional studies w/ <u>Lemna</u> species in field and lab. experiments | | | |
| Investigation of <u>Pseudomonas</u> species as indicators of water quality | | | |
| Microbiology of surface waters | | | |

Organisms of 2nd trophic levels in L. Superior & Michigan
 as determined by continuous plankton recorder techniques
 Potential productivity of inland waters & L. Superior
 as determined by algal bioassay techniques
 Poultry mycotoxicosis as source of toxic fungal metabolites
 in man's food chain
 Vertical migration of copepods & relationship of this
 phenomenon to ecological factors in L. Superior

Institute of Technology

Civil Engineering & Hydraulics

Anderson, Alvin G.
 Design of erosion resistant channels for highway drainage NAS
 Experimental design: Karun Dam, Iran HEC
 Free streamline flow over boundary discontinuities NSF
 Dissertation supervision:
 Acoustic effects in sediment transport
 Probabilistic properties of low rates of sediment transport
 Stability of open channel flow on erodible bed

Bowers, C. Edward
 Computer programs in hydraulics & hydrology HCC
 Culvert inlets MSSD
 Mathematical model of storm runoff from urban area

Hayden, John W.
 Model study of power plant intake structure HEC
 Permeability-saturation-grain size relationship for
 infiltration into soils --

Johnson, Walter K.
 Nitrogen removal from waste water by denitrification USDI

Maier, Walter J.
 Removal of colloidal matter by biological processes --
 Soluble carbon as pollution parameter
 Dissertation supervision
 Biological oxidation kinetics
 Water filtration in mixed media filters

Ripken, John F.
 Closed conduit energy dissipator studies for high-head
 hydraulic structures NSF
 Reduction of hydraulic friction with polymer additives USN
 Flow meter studies ITT
 Water drop impact erosion studies Ge
 Water tunnel studies NSF

Silberman, Edward
 Hydraulic model studies for Lake Erie bulkhead BSC
 Mixing in stratified flow USDI
 Dissertation supervision
 Experimental & theoretical studies of supercavitating
 jet flapped hydrofoils

Song, Charles C.S.
 Finite difference method applied to separated flows
 near sharp edges USN
 Hydrodynamic flutter of cavitating hydrofoils USN
 Instability of Couette flows USN

Dissertation supervision:
 Cavitating flow in boundary layer
 Finite difference method applied to separated
 flows near sharp edges
 Instability of Couette flows

Stefan, Heinz
 Role of mixing in stratified flow USDI

Ward, Bruce D.
 Air ventilation into a boundary layer NSF
 Geology & Geophysics (School of Earth Sciences)

Bright, Robert C.
 Ecology of Minnesota diatoms LRC
 Geology & paleontology of area in southeastern Idaho MNH
 Paleogeology of lake in west central Minn. MNH
 Paleogeology of lakes in Wyoming LRC

Swain, F.M.
 Coastal & freshwater ostracoda NSF
 Mesozoic & Cenozoic carbohydrates NASA
 Ostracoda of Atlantic Coastal Plain USGS

Shapiro, Joseph
 Sediment Chemistry USDI
 Water Chemistry

Wright, Hubert E. Jr.
 Diatoms in lakes and lake sediments NSF
 Glacial geology of Minn. MGS
 Late Pleistocene vegetation history and Limnology NSF
 Primary productivity of selected Minn. lakes
 Dissertation supervision:
 Paleolimnology of Elk Lake, Itasca Park, Minn.
 Peat stratigraphy of Red Lake Bog, Minn.
 Pollen stratigraphy of Lake of the Clouds, Minn.

Sources of Support

-- No Granting Agency Reported

ACPA American Concrete Pipe Association

ACS American Cancer Society

AEC Atomic Energy Commission

AES Agricultural Experiment Station, University of Minnesota

AESR Agricultural Experiment Station, Rosemount, Minnesota

AGI American Geological Institute

ASF Automotive Safety Foundation

AXS Agricultural Extension Service, University of Minnesota

BSC Bethlehem Steel Company

CDMA Minnesota Concrete Drain Tile Manufacturers Association
 CSRS Cooperative State Research Service
 D Department or Division of which researcher is a member
 GAR General Agricultural Research Funds
 GE General Electric Research Foundation
 GS Graduate School, University of Minnesota
 HA Hatch Act Funds
 HCC Hart Carter Company
 HEC Harza Engineering Company
 HFF Hill Family Foundation
 IT Institute of Technology, University of Minnesota
 ITT International Telephone and Telegraph Corporation
 LRC Limnological Research Center, University of Minnesota
 MDA Minnesota Department of Agriculture
 MDC Minnesota Department of Conservation
 MDPH Minnesota Department of Public Health
 MGS Minnesota Geological Survey
 MLSA Minnesota Land Surveyors Association
 MNH Museum of Natural History, University of Minnesota
 MORRC Minnesota Outdoor Recreational Commission
 MRC Minnesota Resources Commission
 MSECG Minnesota Structural Engineering Computer Group
 MSSD Minneapolis-St. Paul Sanitary District
 MWF McGraw Wildlife Foundation
 NAS National Academy of Science, National Research Council
 NASA National Aeronautics and Space Administration
 NAWF North American Wildlife Foundation

NCFES North Central Forest Experiment Station
 NF National Foundation
 NRCC National Research Council of Canada
 NSF National Science Foundation
 SFI Sport Fishing Institute
 SGA Sugarbeet Growers Association
 U University of Minnesota
 USDA United States Department of Agriculture
 USDI United States Department of the Interior
 USFS United States Forest Service
 USFWS United States Fish and Wildlife Service
 USGS United States Geological Survey
 USN United States Navy
 USPHS United States Health Service

Center Director's Activities

During Fiscal Year 1970, the Center Director attended the following water resources meetings: July 7-8, 1969, attended Souris-Red-Rainy River Basins Commission meeting in Winnipeg, Canada; July 8, attended Upper Mississippi River Coordinating Committee meetings in Chicago, Illinois; July 15-17, attended and participated in International Seminar for Hydrology Professors in Urbana, Illinois; July 24, attended a meeting with officials of St. Cloud State College in St. Cloud, Minnesota; August 28, attended a meeting of the staff of the Souris-Red-Rainy River Basins Commission in Moorhead, Minn.; September 9, presented a talk on natural resources at Lake Nokomis Lutheran Church in Minneapolis, Minnesota; September 26, testified before State House of Representatives Committee, St. Paul, Minnesota; October 8-9, attended meeting of Souris-Red-Rainy River Basins Commission in Grand Forks, North Dakota; October 22, attended meeting of Upper Mississippi River Coordinating Committee in Des Moines, Iowa; October 23-24, attended a conference on water pollution in Washington, D.C.; October 28, presented a talk on natural resources at Jefferson Junior High School, Minneapolis, Minnesota; October 29, attended meeting of Water Resources Coordinating Committee, St. Paul, Minnesota; November 13, attended meeting of Minnesota-Wisconsin Boundary Area Commission, Minneapolis, Minnesota; November 14, attended meeting of League of Minnesota Municipalities, Environmental Committee, Minneapolis, Minn.; November 17, attended meeting of Great Lakes Basin Commission, Detroit, Mich.; November 18-19, participated in workshop on Planning-Research Interface in Maine, Univ. of Maine, Bangor, Maine; Nov. 21, attended meeting of House Committee on Land and Water Resources, St. Paul, Minn.; November 25, participated in Seminar in Water Resources Planning Concepts, Univ. of Minnesota, Minneapolis, Minn.; December 2, presented a lecture on water and related land resources to River Bend Association, St. Peter, Minnesota; December 10-12, attended 14th Annual Midwest Groundwater Conference, Louisville, Kentucky; December 15, attended Legislative hearing on River Basin Commissions, St. Paul, Minn.; January 4, 1970, presented a talk on Environmental Problems at Grace Presbyterian Church, Minneapolis, Minn.; January 8, presented a talk on Environmental Problems at Unity Church, St. Paul, Minn., and presented a lecture on water resources administration at School of Public Health Seminar, Minneapolis, Minn.; January 9, presented a talk on natural resources state agency reorganization to Rep. Party Platform Com., Minneapolis, Minn.; January 15, attended meeting of Minnesota-Wisconsin Boundary Area Commission, St. Paul, Minnesota; January 17, presented a talk on natural resources problems to Rep. Part Platform Com., Minneapolis, Minn.; January 23, attended meeting of Environmental Com. of League of Minnesota Municipalities and meeting of Water Resources Coordinating Com., State Planning Agency, St. Paul, Minn.; Feb. 2-4, attended annual meeting of Office of Water Resources Research-Center's Directors, Washington, D.C.; Feb. 16, attended Water Resources Coordinating Committee meeting, St. Paul, Minn.; February 19, testified on Minnesota's Water and Related Land Resources - First Assessment before House Land and Water Resources Committee, St. Paul, Minn.; February 20, attended meeting on Surface Water Resources of Metropolitan Area of Metropolitan Council, St. Paul, Minnesota; February 23, presented a talk on "Factors in Environmental Control" to League of Women Voters, Golden Val-

ley, Minn.; March 10, spoke on Natural Resources Government Reorganization to meeting of Citizens League, Minneapolis, Minn.; March 14, presented a talk on Environmental Factors to group of students at St. Thomas College, St. Paul, Minnesota; March 17-19, attended meeting of National Rivers & Harbors Congress, Washington, D.C.; March 23, spoke on Minnesota's Water and Related Land Resources - First Assessment to Water Resource Coordinating Committee, Minnesota State Planning Agency, St. Paul, Minnesota; April 9-11, participated in Seminar on Water and Related Land Resources Planning at University of Washington, Seattle, Washington; April 13-17, presented lectures on groundwater resource evaluation at Winnipeg, Saskatoon and Calgary, Canada; April 22, participated in Environmental Teach-In at Willmar, Minnesota; April 28, presented talk on water and related land resources planning at New Ulm, Minnesota; April 29, participated in Environmental Teach-In at Richfield, Minn.; May 11-13, attended meeting of Advisory Committee to U.S.G.S. Office of Water Data Coordination in New Orleans, Louisiana; May 19, presented talk on Environmental Factors to Sierra Club, Minneapolis, Minn.; May 27, testified before House Committee on Land and Water Resources on reorganization of natural resources agencies, St. Paul, Minn.; June 2, attended a meeting of State Soil and Water Conservation Commission to discuss research projects, St. Paul, Minn.; June 5, attended Water Resources Coordinating Committee meeting, St. Paul, Minnesota.

During Fiscal Year 1970, the Center Director served on the following committees:

Water Resources Coordinating Committee, State Planning Agency; Advisory Committee on Water Data for Public Use, U. S. Geological Survey; Chairman, Meinzer Award Subcommittee, Hydrogeology Division, Geological Society of America; Ad Hoc Intercollegiate Committee on Environmental Studies, University of Minnesota; and Environmental Pollution Committee, League of Minnesota Municipalities.

Information Concerning Research Project Proposals
Submitted to OWRR by Center, F.V. 1965-71

Lists of Annual Allotment, Matching Grant and Title II research project proposals submitted to OWRR by the Center during the period FY 1965-1971 are given below. Tables summarizing the number of Center proposals funded or rejected by OWRR and the number of research projects submitted by all Centers in the Nation to OWRR and funded by OWRR, FY 1965-70 are also given.

No Title II proposals submitted to OWRR by the Center have been funded. About 31% of Matching Grant Proposals have been funded and 100 % of Annual Allotment proposals have been funded.

During the period FY 1965-70, Center Annual Allotment and Matching Grant support was provided for research projects in the following FCST Categories: V. Water Quality Management and Protection, II. Water Cycle, IV. Water Quantity Management and Control, and VI. Water Resources Planning. The volume of support to FCST Categories was greatest in FCST Category V and least in FCST Category VI in the order given above. OWRR Annual Allotment support on a nationwide basis was provided for research projects in all FCST Categories except X. Information Retrieval and Dissemination.

List of Annual Allotment Research Project Proposals Submitted to OWRR
By Center, Fiscal Year 1965 through 1971

Fiscal Year 1965

(*Proposals funded)

- * Studies on the Use of Planktonic Desmids as Indicators of the Trophic Status and Water Quality of Freshwater Lakes (A-007-Minn)
A.J. Brook, Dept. of Botany
- * Water Quality, Organic Productivity, and the Distribution of Organisms in Minnesota Lakes (A-008-Minn)
H.E. Wright, Limnological Research Center
- *Analysis of Factors Affecting Aquifer Test Results Under Induced Streambed Infiltration Conditions with Electric Analog Computers (A-010-Minn)
W.C. Walton, Graduate School
- *The Effect of Pothole Drainage Upon Groundwater Resources (A-001-Minn)
P.W. Manson, Department of Agricultural Engineering
- * Factors Influencing Soil Freezing in Forests and the Importance of their Effect on Surface Runoff (A-004-Minn)
D.B. Thorud, School of Forestry
- * Water Adsorption and its Interactions with Clay & Quartz (A-006-Minn)
G.R. Blake, Dept. of Soils Science
- *A Study of the Open Water Distribution and Abundance of Net Plankton as an Index of Eutrophication in Lake Superior (A-011-Minn)
T.A. Olson, School of Public Health

Fiscal Year 1966

- *Study on the Use of Planktonic Desmids as Indicators of the Trophic Status & Water Quality of Freshwater Lakes. (A-007-Minn)
A.J. Brook, Dept. of Botany

- *Water Quality, Organic Productivity, and the Distribution of Organisms in Minnesota Lakes (A-008-Minn)
H.E. Wright, Limnological Research Center
- *Analysis of Factors Affecting Aquifer Test Results Under Induced Streambed Infiltration Conditions with Electric Analog Computers (A-010-Minn)
W.C. Walton, Graduate School
- *The Effect of Pothole Drainage Upon Groundwater Resources (A-001-Minn)
P.W. Manson, Dept. of Agric. Eng.
- * Factors Influencing Soil Freezing in Forests and the Importance of their Effect on Surface Runoff (A-004-Minn)
D.B. Thorud, School of Forestry
- *Water Adsorption & its Interactions with Clay & Quartz (A-006-Minn)
G.R. Blake, Dept. of Soils Science
- * A Study of the Open Water Distribution & Abundance of Net Plankton as an Index of Eutrophication in Lake Superior (A-011-Minn)
T.A. Olson, School of Public Health
- * Groundwater Contribution to Streamflow and Its Relation to Hydrogeologic Basin Characteristics & Recharge Rates to Aquifers in Minn. (A-009-Minn)
E.A. Ackroyd, Minn. Geological Survey
- * Review & Analysis of Precipitation & Runoff Data for Selected Watersheds in Minnesota (A-013-Minn)
C.E. Bowers, St. Anthony Falls Hydraulic Lab.

Fiscal Year 1967

- *Study on the Use of Planktonic Desmids as Indicators of the Trophic Status & Water Quality of Freshwater Lakes (A-007-Minn)
A.J. Brook, Dept. of Botany
- * Water Quality, Organic Productivity, & the Distribution of Organisms in Minnesota Lakes (A-008-Minn)
H.E. Wright, Limnological Research Center
- *Analysis of Factors Affecting Aquifer Test Results Under Induced Streambed Infiltration Conditions w/ Electric Analog Computers (A-010-Minn)
W.C. Walton, Graduate School
- * The Effect of Pothole Drainage Upon Groundwater Resources (A-001-Minn)
P.W. Manson, Dept. of Agric. Eng.
- * Factors Influencing Soil Freezing in Forests and the Importance of their Effect on Surface Runoff (A-004-Minn)
D.B. Thorud, School of Forestry
- * Water Adsorption & its Interactions with Clay & Quartz (A-006-Minn)
G.R. Blake, Dept. of Soils Sci.
- * A study of the Open Water Distribution & Abundance of Net Plankton as an Index of Eutrophication in L. Superior (A=011-Minn)
T.A. Olson, School of Public Health
- * Groundwater Contribution to Streamflow and Its Relation to Hydrogeologic Basin Characteristics & Recharge Rates to Aquifers in Minn. (A-009-Minn)
E.A. Ackroyd, Minnesota Geological Survey.
- * Review & Analysis of Precipitation & Runoff Data for Selected Watersheds in Minnesota (A-013-Minn)
C.E. Bowers, SAFHL
- * Recharge from Induced Infiltration Under Varying Stream State and Aquifer Water-Level Conditions (A-014-Minn)
W.C. Walton, Graduate School.

Fiscal Year 1968

- * The Effect of Pothole Drainage Upon Groundwater Resources (A-001-Minn)
P.W. Manson, Dept. of Agric. Eng.
- * Water Adsorption & its Interactions w/ Clay & Quartz (A-006-Minn)
G.R. Blake, Dept. of Soils Science
- * A Study of the Open Water Distribution & Abundance of Net Plankton as an Index of Eutrophication in Lake Superior (A-011-Minn)
T.A. Olson, School of Public Health
- * Review & Analysis of Precipitation and Runoff Data for Selected Watersheds in Minnesota (A-013-Minn)
C.E. Bowers, SAFHL
- * Hydrologic & other Aspects of Water Laws in Minn. (A-015-Minn)
W.C. Walton, Graduate School
- * Primary Productivity of Selected Minn. Lakes (A-016-Minn)
H.E. Wright, Limnological Research Center.
- * Effects of Areal & Time Distribution of Runoff Supply on Watershed Hydrographs (A-017-Minn)
C.L. Larson, Dept. of Agric. Eng.
- * Methodology for Integrating Water Quality Management with Management of the Total Water Resources in Minn. (A-018-Minn)
C.P. Straub, School of Public Health

Fiscal Year 1969

- * A Study of the Open Water Distribution & Abundance of Net Plankton as an Index of Eutrophication in L. Superior (A-011-Minn)
T.A. Olson, School of Public Health
- * Hydrologic & other Aspects of Water Laws in Minn. (A-015-Minn)
W.C. Walton, Graduate School
- * Primary Productivity of Selected Minn. Lakes (A-016-Minn)
H.E. Wright, Limnological Research Center
- * Effects of Areal & Time Distribution of Runoff Supply on Watershed Hydrographs (A-017-Minn)
C.L. Larson, Dept. of Agric. Eng.
- * Methodology for Integrating Water Quality Management with Management of the Total Water Resources in Minnesota (A-018-Minn)
C.P. Straub, School of Public Health
- * Economics of Water Qual. Control in the Upper Mississippi River-Minn. (A-019-Minn)
J.J. Waelti, Dept. of Agric. Econ.
- * Evaluation of Selected Computer Programs in Hydrology (A-020-Minn)
C.E. Bowers, SAFHL

Fiscal Year 1970

- * Primary Productivity of Selected Minn. Lakes (A-016-Minn)
H.E. Wright, Limnological Research Center
- * Effects of Areal & Time Distribution of Runoff Supply on Watershed Hydrographs (A-017-Minn)
C.L. Larson, Dept. of Agric. Eng.
- * Methodology for Integrating Water Quality Management with Management of the Total Water Resources in Minn. (A-018-Minn)
C.P. Straub, School of Public Health
- * Economics for Water Quality Control in the Upper Mississippi River -

Minnesota (A-019-Minn)

- J. J. Waelti, Dept. of Agric. Econ.
- * Evaluation of Selected Computer Programs in Hydrology (A-020-Minn)
C.E. Bowers, SAFHL
- * Water Resources Administration in Minnesota (A-021-Minn)
W.C. Walton, Graduate School
- * Zooplankton Biomass & Incipient Eutrophication in L. Superior (A-022-Minn)
T.A. Olson, School of Public Health

Fiscal Year 1971

- * Economics of Water Quality Control in the Upper Mississippi River - Minnesota (A-019-Minn)
J. J. Waelti, Dept. of Agric. Econ.
- * Evaluation of Selected Computer Programs in Hydrology (A-020-Minn)
C.E. Bowers, SAFHL
- * Water Resources Administration in Minnesota (A-021-Minn)
W.C. Walton, Graduate School
- * Zooplankton Biomass & Incipient Eutrophication in Lake Superior (A-022-Minn)
T.A. Olson, School of Public Health
- * Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics (A-023-Minn)
C.L. Larson, Dept. of Agric. Eng.
- * Mathematical Simulation of a Large Watershed Using the Systems Approach to Quantity and Quality Analysis (A-024-Minn)
C.C.S. Song, SAFHL
- * Alleviation of Lake Pollution By Utilization of Aquatic Plants for Nutritional, Medicinal or Industrial Purposes (A-025-Minn)
E.J. Staba, Dept. of Pharmacognosy

List of Matching Grant Research Proposals Submitted to OWRR by Center, Fiscal Year 1966 through 1971

Fiscal Year 1966

(*Proposals funded)

- * Study of Factors Affecting the Channel Phase of Runoff from Small Watersheds by Mathematical Modeling (B-007-Minn)
C.L. Larson, Dept. of Agric. Eng.
- The Effect of Rainfall Interception on Transpiration Rates of Forest Trees and Its Significance in the Hydrologic Cycle (B-004-Minn)
D.B. Thorud, School of Forestry
- * Storage & Movement of Water in Soils as Related to Spatial and Time Changes in the Clay-Quartz Matrix (B-003-Minn)
G.R. Blake, Dept. of Soil Sci.
- * Diatoms & Zooplankton in Minnesota Lakes (B-001-Minn)
H.E. Wright, Limnological Research Center
- * The Effect of the Natural Sealing of Potholes Upon Water Movement and Groundwater Resources (B-002-Minn)
P.W. Manson, Dept. of Agric. Eng.
- An Experimental Study of Hydrograph Characteristics (B-006-Minn)
C.E. Bowers, SAFHL

* Vertical Migration of Moisture in the Soil Induced by Winter Thermal Gradients and Its Influence Upon Spring Water Resources (B-005-Minn.)
D.G. Baker, Dept. of Soil Science

Fiscal Year 1967

Ostracoda of Minn. Lakes & Streams as Indicators of Natural & Artificial Biogeochemical Outfall (B-008-Minn)
F.M. Swain, Dept. of Geology & Geophysics
*Relation of Phosphorus in Lake-Bottom Deposits & Pollutional History of Minnesota Lakes (B-009-Minn)
Joseph Shapiro, Limnological Research Center
*A Study of Techniques for Determining Changes in Phytoplankton Populations in Clouds of Fluorescent Dye Moving on the Mississippi River (B-010-Minn)
C.D. McNabb, Biology Dept., St. Mary's College

Fiscal Year 1968

Ostracoda of Minn. Lakes & Streams as Indicators of Natural and Artificial Biogeochemical Outfall (B-008-Minn)
F.M. Swain, Dept. of Geology & Geophysics
*Relation of Phosphorus in Lake-Bottom Deposits & Pollutional History of Minn. Lakes (B-009-Minn)
Joseph Shapiro, Limnological Research Center
*A study of Techniques for Determining Changes in Phytoplankton Populations in Clouds of Fluorescent Dye Moving on the Mississippi River (B-010-Minn)
C.D. McNabb, Biology Dept., St. Mary's College

Fiscal Year 1969

Use of pasveer oxidation channel for disposal of animal wastes (B-011-Minn)
E.R. Allred, Dept. of Agric. Eng.
*Development of a mathematical model to predict the role of surface runoff & ground water flow in overfertilization of surface waters (B-012-Minn)
C.P. Straub, School of Public Health
*Influence of mist irrigation on moisture stress, growth yields and quality of potatoes & other vegetable crops (B-013-Minn)
R.E. Nyland, Dept. of Horticultural Science
Experimental studies of selected diatoms in iron-rich springs (B-014-Minn)
A.J. Brock, Dept. of Ecology & Behavioral Biology
*Characteristics of the soil matrix that affect water storage & movement (B-015-Minn)
G.R. Blake, Dept. of Soils Science
Spatial Variation of Precipitation within the Mpls.-St. Paul area (Urban & Rural) & its effect on water resources (B-024-Minn)
D.G. Baker, Dept. of Soils Science
Simulating Alternative Strategies in Locating & Financing Water Recreation Projects in Growing & Distressed Areas (B-025-Minn)
W.R. Maki, Dept. of Agricultural Economics
Lake Millelunkka as a Resource: Perceptions of an Urban Lake in Minn. (B-026-Minn)
F.E. Lukerman, Dept. of Geography
The Diatoms of Minn. Lakes as Indicators of the Nutrient Level (B-027-Minn)
R.C. Bright, Bell Mus. of Natural History
Water Infiltration & Soil Erodibility as Influenced by the Energy of Rain-fall at the Soil Surface (B-027-Minn)
W.E. Larson, Dept. of Soils Sci.

Methods for Evaluating the Impact of Water Quality & other factors in recreational use of waste water areas (B-028-Minn)
U. Blank, Dept. of Agric. Econ.
Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics (B-029-Minn)
C.L. Larson, Dept. of Agric. Eng.
Effects of Urbanization on Groundwater Resources & Criteria for Their Management (B-030-Minn)
C.P. Straub, School of Public Health
*Participatory Ecology: A Study of Citizens Groups Involved at the Grass Roots to Improve the Water Resources Environment (B-031-Minn)
L.P. Gerlach, Dept. of Anthropology

Fiscal Year 1970

Reduction of Irrigation Water Losses Resulting from Subsurface Injection & Recharge through use of Artificial Soil Mulches (B-016-Minn)
E.R. Allred, Dept. of Agric. Eng.
The Influence of Environmental factors in Fresh Waters on Microbial Uptake & Release of Orthophosphate; Growth Efficiency; Synthesis & Hydrolysis of Polyphosphate; & Oxidation of Ammonia to Nitrite (B-017-Minn)
A.B. Hooper, Dept. of Genetics & Cell Biology
Retention & transmission of Liquid Water in a Snow Pack (B-018-Minn)
A.C. Mace, School of Forestry
Community Analysis of Macrophytes & Invertebrates in the Littoral Zone of Selected Polluted & Unpolluted Lakes in Minnesota (B-019-Minn)
H.E. Wright, Limnological Research Center
*Pollution & the Ecology of Near-shore Periphyton of L. Superior (B-020-Minn)
T. A. Olson, School of Public Health
Some Sociological Dimensions of Industrial Behavior Toward Water Pollution Control in Minn. (B-021-Minn)
R.E. Rickson, Dept. of Sociology
Study of Porosity & Tortuosity Parameters on a Laboratory Scale & their Directional Dependence in Anisotropic Aquifers (B-022-Minn)
H.O. Pfannkuch, Dept. of Geology & Geophysics
Aquifer Contamination from Fertilizer Nitrate, Sulfate & Chloride Applied to Soils (B-023-Minn)
A.C. Caldwell, Dept. of Soils Sci.
*Mississippi River Ecology Associated with Heated Power Plant Effluent (B-032-Minn)
A.J. Hopwood, Dept. of Biology, St. Cloud State College

Fiscal Year 1971

Spatial & Temporal Variation of Precipitation Within the Mpls.-St. Paul Area (Urban & Rural) and Its Effect on Water Resources (B-033-Minn)
D.G. Baker, Dept. of Soils Science
Water Infiltration & Soil Erodibility as Influenced by the Energy of Rain-fall at the Soil Surface (B-027-Minn)
W.E. Larson, Dept. of Soils Science
Study of Porosity & Tortuosity Parameters on a laboratory scale & their directional dependence in anisotropic aquifers (B-034-Minn)
H.O. Pfannkuch, Dept. of Geology & Geophysics
Aquifer Contamination from fertilizer nitrate, sulfate & chloride applied to soils (B-035-Minn)
A.C. Caldwell, Dept. of Soils Science

Reduction of irrigation water losses resulting from subsurface injection and recharge through use of artificial soil mulches (B-036-Minn)
 E.R. Allred, Dept. of Agricultural Engineering
 Alleviation of Lake Pollution by utilization of aquatic plants for nutritional, medicinal or industrial purposes (P-037-Minn)
 E.J. Staba, Dept. of Pharmacognosy
 The Influence of Environmental Factors in fresh waters on microbial uptake and release of orthophosphate; growth efficiency; synthesis & hydrolysis of polyphosphate; and oxidation of ammonia to nitrate (B-038-Minn)
 A.B. Hooper, Dept. of Genetics & Cell Biology
 Diagnosis of Nutrient Pollution in Lakes (B-039-Minn)
 R.O. Megard, Limnological Research Center
 Predicting Peak Flow of small watersheds by use of channel characteristics
 C.L. Larson, Dept. of Agricultural Eng. (B-040-Minn)
 Circulation & Reaeration of stratified & non-stratified water by air injection (B-041-Minn)
 C.S. Song, SAFHL
 *Spatial Variation in the perception of water resources & water problems in south central Minn. (B-042-Minn)
 R.T. Moline, Dept. of Geography, Gustavus Adolphus College
 Retention & transmission of liquid water in a snow pack (B-043-Minn)
 A.C. Mace, School of Forestry
 *Area Financing of water resources development (B-044-Minn)
 W.R. Maki, Dept. of Agric. Econ.
 Mathematical Simulation of a larger watershed using the systems approach to quantity and quality analysis (B-045-Minn)
 C.S. Song, St. Anthony Falls Hydraulic Lab.
 Study of snowmelt contribution to floods in large watersheds (B-046-Minn)
 C.E. Bowers SAFHL
 *Social & economic factors in the adoption by industry of water pollution control measures (B-047-Minn)
 R.E. Rickson, Dept. of Sociology
 Effects of urbanization on groundwater quality & criteria for its management (B-030-Minn)
 C.P. Straub, School of Public Health
 Analysis of changing physical & hydrological Basin characteristics as a result of urban growth (B-048-Minn)
 H.O. Pfannkuch, Dept. of Geology & Geophysics
 *A Survey of Attitudes Toward the Mississippi River as a total resource in Minnesota (B-049-Minn)
 J.P. Ludwig, Center for Environmental Studies, Bemidji State College

List of Title II Research Project Proposals submitted to OWRR by Center, Fiscal Year 1968 through 1971

Fiscal Year 1968

(* Proposals Funded)

A Study of the Institutional Environment Affecting the Management of Water Resources in Minnesota
 C.A. Warp, Public Administration Center
 A Study of Physical Models of Hydrologic Systems
 C.E. Bowers, St. Anthony Falls Hydraulic Lab.

Fiscal Year 1969

Spring Runoff as Affected by Soil Permeability on Two Forested Watersheds
 A.C. Mace, School of Forestry
 A Study of Physical Models of Hydrologic Systems
 C.E. Bowers, SAFHL
 Algal Growth Rates in a Suburban Eutrophic Lake
 R.O. Megard, Limnological Research Center
 Influence of Siltation on Release or Sedimentation of Organic Pollutants
 R.S. Adams, Dept. of Soils Science
 Developing a System Analysis Model for Water & Related Land Resources Planning in Minn.
 S.R. Arora, Mechanical Eng. Dept.
 Studies of Factors Controlling the Distribution of Planktonic Desmids in Lakes and of Their Significance as Indicators of Water Quality
 A. J. Brook, Dept. of Ecology & Behavioral Biology

Fiscal Year 1970

Spring Runoff as Affected by Soil Permeability on Two Forested Watersheds
 A.C. Mace, School of Forestry
 Influence of siltation on release or sedimentation or organic pollutants.
 R.S. Adams, Dept. of Soils Science
 Developing a system analysis model for water & related land resources planning in Minn.
 S.R. Arora, Mech. Eng. Dept.
 Studies of factors controlling the distribution of planktonic desmids in lakes & of their significance as indicators of water quality
 A. J. Brook, Dept. of Ecology & Behavioral Biology
 Hydrodynamic design design considerations for improved particle sampling devices
 C.C.S. Song, SAFHL
 Acoustic Generation of Microbubbles for Artificial Aeration of Lakes
 C.C.S. Song, SAFHL
 Circulation of reaeration of stratified and non-stratified water by air injection
 C.C.S. Song, St. Anthony Falls Hydraulic Lab.
 Mathematical Modeling of the Urban Runoff System
 C.E. Bowers, SAFHL
 Development and testing of a mathematical model for heat flow and dispersion phenomena in the Upper Mississippi River and major tributaries
 Heinz Stefan, SAFHL

Fiscal Year 1971

Systems Approach to Hydrodynamic Transport and Dispersion Phenomena Associated with Discharges from Urban and Industrial Areas
 Heinz Stefan, SAFHL
 Mathematical Modeling of the Urban Runoff System
 C.E. Bowers, St. Anthony Falls Hydraulic Lab.

Number of Research Project Proposals Submitted to OWRR by Center & Funded or Rejected, Fiscal Year 1965 through 1971

| Fiscal Year | Allotment | | | Matching Grant | | |
|-------------|-----------|----------|-------|----------------|----------|-------|
| | Funded | Rejected | TOTAL | Funded | Rejected | TOTAL |
| 1965 | 7 | 0 | 7 | - | - | 0 |
| 1966 | 2 | 0 | 2 | 5 | 2 | 7 |
| 1967 | 1 | 0 | 1 | 0 | 5 | 3 |
| 1968 | 2 | 0 | 2 | - | 2 | 5 |
| 1970 | 2 | 0 | 2 | 3 | 15 | 18 |
| 1971 | 3 | 0 | 3 | 4 | 15 | 19 |
| TOTAL | 21 | 0 | 21 | 17 | 38 | 55 |

| Fiscal Year | Title II | | TOTAL |
|-------------|----------|----------|-------|
| | Funded | Rejected | |
| 1968 | 0 | 2 | 2 |
| 1969 | 0 | 6 | 6 |
| 1970 | 0 | 9 | 9 |
| 1971 | 0 | 2 | 2 |
| TOTAL | 0 | 19 | 19 |

Number of Research Project Proposals Funded by OWRR, FY 1965-70, subdivided by FCST Category

| FCST Category | Allotment | | Matching Grant | | Title II | |
|---|-----------|----------------------|----------------|----------------------|----------|----------------------|
| | Minn. | OWRR Total in Nation | Minn. | OWRR Total in Nation | Minn. | OWRR Total in Nation |
| I. Nature of Water | 0 | 58 | 0 | 2 | 0 | 0 |
| II. Water Cycle | 5 | 478 | 4 | 84 | 0 | 12 |
| III. Water Supply Augmentation and Conservation | 0 | 184 | 0 | 26 | 0 | 2 |
| IV. Water Quantity Management and Control | 4 | 203 | 2 | 54 | 0 | 5 |
| V. Water Quality Management and Protection | 6 | 994 | 4 | 104 | 0 | 6 |
| VI. Water Resources Planning | 3 | 515 | 3 | 150 | 0 | 69 |
| VII. Resources Data | 0 | 95 | 0 | 10 | 0 | 0 |
| VIII. Engineering Works | 0 | 63 | 0 | 9 | 0 | 3 |
| IX. Manpower, Grants, and Facilities | 0 | 4 | 0 | 0 | 0 | 1 |
| X. Information Retrieval and Dissemination | - | --- | - | --- | - | -- |
| TOTAL | 18 | 2,594 | 13 | 444 | 0 | 98 |

The volume of support to FCST Categories by OWRR was greatest in FCST Category V and least in FCST Category IX in the following order: V, VI, II, IV, III, VII, VIII, I, and IX. OWRR Matching Grant support on a nationwide basis was provided for research projects in FCST Categories in the following level of support order: VI, V, II, IV, III, VII, VIII, and I. OWRR Title II support on a nationwide basis was provided for research projects in FCST Categories in the following level of support order: VI, II, IV, V, VIII, III, and IX. OWRR total support on a nationwide basis was provided for research projects in FCST Categories about in the following level of support level: V. Water Quality Management, VI. Water Resources Planning, II. Water Cycle, IV. Water Quantity Management and Control, and the rest of Categories.

Expected Results from Projects Initiated in FY 1971

OWRR Project No.: A-023-Minn
Project Title: Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics
FCST Research Category: II-E
Project Began: July 1, 1970 Scheduled Completion: June 30, 1972
Principal Investigator: C.L. Larson, Dept. of Agricultural Engineering

The research project will test a method for predicting the effects of channel characteristics, including watershed size and shape, on peak flow from small watersheds with data from actual watersheds and thereby determine whether a developed analytical routing model adequately represents the runoff process. Suitable modifications of the method will be made if found necessary. Existing runoff and rainfall data for selected small watersheds in Minn. and other states will be used. The method to be tested involves a watershed time parameter and a routing coefficient. The results of the research will assist Federal and state agencies in planning water resources projects for small watersheds. Such projects may include erosion control structures, floodwater detention reservoirs, highway culverts, floodways, and other works which affect the quality as well as the availability of water.

OWRR Project No.: A-024-Minn
Project Title: Mathematical Simulation of a Large Watershed Using the Systems Approach to Quantity and Quality Analysis
FCST Research Category: VI-A
Project Began: July 1, 1970 Scheduled Completion: June 30, 1973
Principal Investigators: C.S. Song and C.E. Bowers St. Anthony Falls Hydraulic Laboratory

A comprehensive mathematical model will be constructed, simulating the engineering aspect of a typical large water resources system. Starting from suitable mathematical models for each component of the system, such as surface flow, groundwater flow, mass transport, movement and change of pollutant, and snow melt, a comprehensive response function of a system will be constructed. The validity of the model will be tested by applying the model of the Minn. River Watershed using the available field data on physical parameters of the watershed, pollution, land use, precipitation, runoff and the quality of water. Sensitivity analysis of the model will also be carried out. Depending on the progress made on the initial state of the investigation, one or more of the following items may also be performed: 1. stochastic analysis of the input and output of the system and response of the system to stochastic input. 2. prediction of the quantity and quality of water in Minnesota river watersheds and comparison with the additional field data. 3. Systems analysis for the purpose of optimum design and management of the watershed. This model will be helpful to state, local and federal agencies in making decisions concerning the development and management of the water resources of basins.

OWRR Project No.: A-025-Minn
Project Title: Alleviation of Lake Pollution by Utilization of Aquatic Plants for Nutritional, Medicinal or Industrial Purposes.
FCST Category: V-E

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973
Principal Investigator: E.J. Staba, Dept. of Pharmacognosy

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 gums-mucilages, or new useful antimicrobial, anti-coagulant, or antineoplastic therapeutic principles. Aquatic plants will be collected from various lakes in Minn. and identified, processed and phytochemically screened for useful compounds. Microbial and animal studies will be conducted. If a good industrial, medicinal, or nutritional use of aquatic plants can be discovered, the results of the research could provide an economic incentive for aquatic plant collection & control. The successful completion of the project might significantly assist the State and Nation in partially solving their lake pollution problems.

OWRR Project No.: B-042-Minn
Project Title: Spatial variation in the perception of water resources & water problems in south central Minn.
FCST Category: VI-B
Project Began: July 1, 1970 Scheduled completion: June 30, 1973
Principal Investigator: R.T. Moline, Dept. of Geography, Gustavus Adolphus College, St. Peter Minn.

Comprehensive water resources planning is just beginning in southern Minn. with two basin studies currently underway by the Army Corps of Engrs. The passage of the Regional Development Act of 1969 by the Minn. State Legislature authorizes the creation of regional development commissions that will make decisions affecting water resource development. Local Citizen's groups with interest in water resources have recently become active in the area. It is believed that the degree to which water resource planning can be successfully implemented is a function of local perceptions of water. The purpose of this project is to determine the areal variation in ways local people perceive water resources, effect of professional water planning studies on local attitudes toward the water resource base. Finally, it is hoped that a "Perceptual" model can be constructed, that will be useful in other areas where water resource planning is getting underway. Data will be gathered through the use of two mailed questionnaires and a series of personal interviews with an extensive list of local decision makers and other citizens.

OWRR Project No.: B-044-Minn
Project Title: Area Financing of Water Resource Development
FCST Research Category: VI-E
Project Began: July 1, 1970 Scheduled Completion: June 30, 1972
Principal Investigator: W.R. Maki, Dept. of Agric. Econ.

This research project is concerned with the testing of economic criteria for locating and financing water recreation investments in a) high density population centers and b) areas peripheral to major population centers. An economic model of the multi-state Twin Cities Metropolitan Region will provide the analytical framework for an intensive examination of the 7-county West Central Minn. development area in the context of

a) local demands for water recreation facilities and b) economic multiplier effects of water recreation activities.

OWRR Project No.: B-047-Minn
Project Title: Social and Economic Factors in the Adoption by Industry of Water Pollution Control Measures
FCST Category: VI-E
Project Began: July 1, 1970 Scheduled Completion: June 30, 1973
Principal Investigator: R.E. Rickson, Dept. of Sociology

This research will consider certain sociological variables involved in the adoption by industry of the technology associated with water pollution in Minn. The variance in compliance with innovations in water pollution control between and within categories of industries will be studied. Managers of heavy water-using industries will be interviewed. The increased use of water in Minn. has resulted in increased pollution. Some change in the behavior of users toward water pollution control is, therefore, an urgent necessity. The result of this research should improve the understanding of the social dimensions of the problem and provide valuable information concerning the process by which change occurs or is resisted.

OWRR Project No.: B-049-Minn
Project Title: A Survey of Attitudes towards the Mississippi River as a "Total" Resource in Minnesota
FCST Research Category: VI-B
Project Began: July 1, 1970 Scheduled Completion: Sept. 30, 1972
Principal Investigator: J.P. Ludwig, Center for Environmental Studies, Bemidji State College, Bemidji, Minn.

This project will concentrate specifically on the upper Mississippi River from the Iowa border to its source in northern Minn. It is a joint project of natural scientists and social & behavioral scientists at 3 Minn. State Colleges -- Bemidji, St. Cloud, and Winona -- which are located in the river's valley. Researchers in the various involved disciplines will gather, evaluate, and collate existing data using modern tools, such as the computer, to provide a basic framework concerning the present state of man's attitudes toward and knowledge of one immediate natural resource -- the Mississippi River. The proposed project will foster a cooperative inter-institutional, inter-agency, and inter-disciplinary study, providing a sound basis for future planning in such areas as additional scientific study of river ecology if necessary, and possible recovery programs. The project will also work toward much needed public information and education programs. Relevant findings will be disseminated through the news media, workshops, seminars, education programs, and publication in appropriate journals. Base line data will be collected on population, land use, statutes and ordinances. An attitudinal survey will be conducted which will gather information relation to attitudes toward use of the Mississippi River and regulatory anti-pollution programs. Findings will be used as a basis for educational programs designed to raise the general educational level and promote more positive attitudes toward intelligent use of water resources.

ANNUAL ALLOTMENT PROGRAM, NARRATIVE PROGRESS REPORTS (Form OW-1)

OWRR Project No.: A-016-Minn

Annual Allotment Agreement No.: 14-31-0001-3023

Project Title: Primary Productivity of Selected Minnesota Lakes

FCST Category: V-C

Name & Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minn. 55455

Project Began: July 1, 1967

Scheduled Completion: June 30, 1970

Principal Investigator: H.E. Wright

Degree: Ph.D.

Discipline: Geology

Student Assistants:

Degree:

Discipline:

Kathleen Baker

BS

Botany

John Joyce

BS

Ecology

Melbourne Whiteside

MS

Zoology

Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

The productivity (average daily gross photosynthesis) of the most productive lakes in Minn. is more than 10 times higher than the least productive. The range is from 0.4 g carbon/m² in Clearwater Lake in N.E. Minnesota to 5.0 g carbon/m² in Tanager Lake, a portion of Lake Minnetonka in east-central Minn. that is enriched with municipal sewage effluents. A model for the photosynthetic system of the phytoplankton that was developed during the study of L. Minnetonka suggests that the latter value is very near the upper limit imposed by light and temperature at this latitude.

The productivity of 18 lakes has now been measured, although there have been more measurements at Lake Minnetonka than in all the others combined because the model developed there provided a theoretical basis for simplifying the measurement of lake productivity. Normally it is necessary to measure photosynthesis at depths-intervals in the photic zone in order to estimate total photosynthesis beneath a unit of lake surface (integral photosynthesis). Obtaining these depth profiles requires so much effort that it is usually possible to determine the productivity of only one or a few localities at one time. With the new method however, integral photosynthesis may be estimated for many areas simultaneously by bringing single samples from many localities to one locality, incubating them together at the depth where illumination is optimal, and measuring the chlorophyll concentration in each sample. Integral photosynthesis (Ep) at each locality may then be computed with the equation

$$E_p = ab^{-n} \cdot p_{\max} \quad (1)$$

where n is the population density as measured by the chlorophyll concentration, p_{max} is the rate of photosynthesis during incubation at optimal illumination, and a and b are constants. The model is based on the common observation that photosynthesis at the depth of optimal illumination (P_{max}) increases as population densities (n) increase, whereas the thickness of the photic zone, as measured by the depth z_i, decreases:

$$p_{\max} = nP_{\max} \quad (2)$$

$$z_i = ab^{-n} \quad (3)$$

where P_{max} is the maximum photosynthetic capacity of the phytoplankton. The depth z_i is defined as the ratio of integral photosynthesis to maximum photosynthesis:

$$z_i = E_p/p_{\max} \quad (4)$$

and the coefficients a and b in equation (1) are obtained from the regression equation of this ratio on n for a series of photosynthesis profiles. The depth z_i is the depth at which the intensity of green light is only 10-15% of its intensity at the surface and 50% of the intensity that is saturating for photosynthesis. Equation (1) may be rewritten to give

$$E_p = z_i n P_{\max} \\ = n_i P_{\max}$$

where n_i = z_iⁿ. The term n_i includes most of the phytoplankton in the photic zone; it approaches a limiting value of 100 mg chlorophyll/m² when chlorophyll concentrations (n) reach 70 mg/m³. The average value of P_{max} is highly dependent on temperature, and usually does not exceed 50 mg carbon/mg chlorophyll/day. Thus integral photosynthesis at this latitude rarely exceeds 5 g carbon/m²/day, the average observed in Tanager Lake at Minnetonka.

Lake Minnetonka is a large (14,469 acres), complex lake with 15 interconnected basins. Phytoplankton productivity varies substantially from basin to basin. Although average integral photosynthesis exceeds 4 g carbon/day in 2 basins that receive major tributaries, and exceeds 2 g carbon/day in most others, it is only 1.2 g carbon/day in the least productive area (Table 1). This area is no more productive than is Lake Itasca, an unpolluted lake in northwest Minnesota. Lake Minnetonka has been studied intensively as part of a project supported by the Minnesota Pollution Control Agency for the purpose of designing a nutrient abatement program for the watershed. Algal densities and daily rates of photosynthesis have been measured for 2 yrs. to provide a baseline for evaluating the effectiveness of any nutrient-abatement programs that may be initiated, and it has been demonstrated that phosphorus is the critical nutrient during the summer, when algal densities are highest. Furthermore the lake should respond very quickly if the phosphorus influx is reduced. Phosphorus that enters the lake is precipitated into the sediments very soon after entering, and most of it remains in the sediments after it is deposited. The net rate of phosphorus deposition is about 0.5 g/m²/yr. 5 lbs/acre. The total quantity deposited each year is approximately equal to the quantity that enters the lake from tributaries. Thus the sediments are a very effective trap for nutrients.

The other lakes that are more productive than 2 g carbon/m² are in southern and western Minn. (Fish, Kandiyohi, Shetek, Dead Corn, & Salliee), except for Shagawa Lake, which is in the northeast. The southern and

Table 1. Phytoplankton Productivity (integral Photosynthesis) of 18 Minnesota Lakes.

| <u>Southern & Central Lakes</u> | County | Latitude & Longitude | Average gross Photosynthesis g carbon/m ² /day |
|-------------------------------------|------------|----------------------|---|
| Minnetonka | Hennepin | 44°55'N, 93°37'W | |
| Tanager Lake | | | 5.0 |
| Halsted Bay | | | 4.2 |
| West Arm | | | 2.6 |
| North Arm | | | 1.9 |
| Crystal Bay | | | 1.9 |
| Gale Island | | | 2.9 |
| Wayzata Bay | | | 2.6 |
| Browns Bay | | | 2.1 |
| Cooks Bay | | | 2.4 |
| Crane Island | | | 2.2 |
| Carman Bay | | | 1.3 |
| Christmas Fish | Hennepin | 44°54'N, 93°32'W | 0.8 |
| Big Kandiyohti | Jackson | 43°50'N, 95°03'W | 3.7 |
| Shetek | Kandiyohti | 45°00'N, 94°55'W | 3.2 |
| Dead Coon | Murray | 44°07'N, 95°45'W | 2.7 |
| Francis | Lincoln | 44°22'N, 96°07'W | 2.4 |
| St. Croix | Le Sueur | 40°13'N, 93°43'W | 0.9 |
| | Washington | 45°02'N, 92°47'W | 1.3 |
| <u>Northwestern Lakes</u> | | | |
| Sallie | Becker | 46°47'N, 95°55'W | 2.6 |
| Itasca | Clearwater | 47°12'N, 95°12'W | 1.3 |
| Long | Clearwater | 47°17'N, 95°17'W | 0.9 |
| Elk | Clearwater | 47°10'N, 95°14'W | 0.8 |
| Mary | Hubbard | 47°10'N, 95°10'W | 0.4 |
| Nokay | Crow Wing | 46°22'N, 93°58'W | 0.9 |
| <u>Northeastern Lakes</u> | | | |
| Shagawa | St. Louis | 47°55'N, 90°52'W | 2.0 |
| Kimball | Lake | 47°52'N, 90°12'W | 0.8 |
| Trout | Lake | 47°52'N, 90°14'W | |
| Clearwater | Lake | 48°54'N, 90°20'W | 0.4 |

western lakes have relatively high salinities and they are naturally fertile, although their fertility is undoubtedly enhanced by drainage from farmland and all the lakeside septic tanks. Shagawa Lake, on the other hand, is in a region where the salinity and fertility of lakes is low; the productivity of 3 other lakes in that area (Kimball, Trout, and Clearwater) is less than 0.7 g/day. However, Shagawa receives municipal sewage effluents from the town of Ely.

Algal population densities and photosynthesis in several bays of Shagawa Lake were studied intensively in 1967 and 1968 and the effects of sewage effluents on algal populations were studied in 1969 as part of a project supported by the Federal Water Qual. Admin. Nutritional bioassays are being used in connection with the analysis of phytoplankton density and photosynthesis during 1970 in an attempt to evaluate the relative importance of nitrogen and phosphorus. A major objective of the study at Shagawa Lake is to provide a baseline for evaluating the effectiveness of an advanced sewage treatment plant that may be installed at Ely. It is anticipated that the limnological investigations will provide information that will be useful for designing and operating the new facilities.

The study of L. Minnetonka is part of a larger program in cooperation with an engineering firm to devise a comprehensive nutrient-abatement program for the watershed. The study of Shagawa Lake is continuing with support from the Federal Water Qual. Admin, which plans to build a full-scale advanced sewage treatment facility. The results in general, provide a yardstick for evaluating the degree of lake eutrophication in lakes throughout the state. Phytoplankton population densities were determined during this project as measures of phytoplankton population densities. These data will be analysed in the future, primarily to establish the relationship between lake productivity and the standing crops of phytoplankton, and to determine whether or not the model for the photosynthetic system of the phytoplankton developed for Lake Minnetonka is generally applicable.

Project Related Publications

- Megard, R.O. 1969. Algae & photosynthesis in Shagawa Lake, Minn. Univ. of Minn. Limnological Research Center. Interim Report No. 5. 20 p., 5 fig., 10 tab., 3 ref.
- Megard, R.O. 1969. Phytoplankton, Photosynthesis, & Phosphorus in Lake Minnetonka, Minn. Manuscript submitted for publication in Limnology and Oceanography. 44 p., 20 fig., 10 tab.

Statements of Project Work Remaining to be Accomplished: None

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year: None

OWRR Project No.: A-017-Minn

Annual Allotment Agreement No.: 14-31-0001-3023

Project Title: Effects of Areal & Time Distribution of Runoff Supply
on Watershed Hydrographs

FCST Category: II-A

Name & Location of University Where Project is being Conducted:

Univ. of Minn., St. Paul, Minn 55101

Project Began: July 1, 1967 Scheduled Completion: June 30, 1970

Principal Investigator: C.L. Larson Degree: Ph.D.

Discipline: Agricultural Engineering

Student Assistants: Degree: Discipline:
T.C. Wei M.S. Agric. Eng.

Description of Research Performed & Any Findings, Results, or
Conclusions Relating Thereto:

Development of the mathematical watershed model was completed and the model was put into operation. Last year's annual report described several problems encountered with the method of characteristics for routing runoff on a watershed basis. Resolution of these problems led to excessive computer time requirements. During the earlier part of the year, ways of reducing the computer time were explored with some success. In addition, the model watershed was reduced in size, from 4th to 3rd order for most of the studies. 4 different studies with the model watershed have been completed, one of which required considerable modification of the model. Each study will be described separately. In each case, the results were compared to a "standard" input to the model of the "standard" watershed, as appropriate. The standard input chosen for the model watershed was a constant rainfall excess of 1.0 in/hr with a duration of 30 min. uniformly distributed over the watershed.

A series of triangular time distributions of rainfall excess were used in addition to the standard one. The position of the maximum input rate was varied from the beginning to the end of the 30-min. duration. In general, the triangular input patterns increased the peak discharge from the watershed, but the greatest increase was only 11%. Input patterns with a delayed peak (during the 2nd half of the duration) caused the highest peak discharges, while advanced patterns (early peaks) gave a small increase or decrease as compared to the standard, rectangular time distribution. The ratio of the peak discharge in each case to that for a uniform time distribution was related to a dimensionless parameter indicating the time of peak input.

A series of different area distributions of rainfall excess were used as input in addition to the uniform distribution. These included an upstream concentration, a midstream concentration and a downstream concentration, all with the same runoff volume as the uniform areal distribution. Peak discharge ratios were related to the centroid of rainfall excess on a dimensionless basis. The downstream concentration did not significantly increase the peak discharge, as one might expect. The upstream concentration, on the other hand, increased the peak flow by 19%. Since the patterns were not highly concentrated, the results do not represent the maximum possible effects.

To determine the effects of storm movement, a storm was moved axially

through the model watershed, both upstream and downstream. A typical areal distribution was used for the rainfall excess, and it was constant with respect to time. The same pattern was held stationary over the watershed for a duration sufficient to produce the same runoff volume.

For each experiment in this series, the arrangement of the channel system was changed. 4 watershed shapes were used: compact, standard, elongated and most elongated. Values of the shape factor A/L^2 were 0.470, 0.386, 0.307, and 0.243, respectively. The watershed area was the same in all cases. As expected, the compact watershed produced the highest peak discharge and the most elongated watershed the lowest, varying from 1.08 to 0.68 times the peak flow for the "standard watershed." This ratio was related to the shape factor. In the various experiments described above the effects on time to peak, and log time were also studied, but the results will not be described here.

Research results can be used to improve the accuracy of and confidence in estimating peak flows from small watersheds for the design of many types of water control structures. Improvements of this type are sorely needed, since it is generally conceded that errors of 25 to 50% are common. In estimating runoff from small watersheds, peak flows are usually estimated by assuming a constant rainfall excess, uniform areal distribution and a stationary storm. Watershed shape is considered indirectly or not at all. The results of each phase of this study are presented as dimensionless coefficients which can be used to adjust peak flows estimated for these standard conditions, where appropriate. In each case, the effect is related to an input parameter to permit direct application.

Project-related Publications:

- T.C. Wei. June 1970. Effects of Areal & Time Distribution of Rainfall on Runoff Hydrographs, Univ. of Minn. Ph.D. Thesis. Dept. of Agric. Eng. 195 pages, 31 fig., 28 tab., 71 ref.
- T.C. Wei & C.L. Larson. Effects of Areal Distribution of Rainfall and Watershed shape on Runoff Hydrographs. Paper in Preparation.
- T.C. Wei & C.L. Larson, Effects of Time Distribution of Rainfall and Moving Storms on Runoff Hydrographs. Paper in preparation.

Statement of Project Work Remaining to be Accomplished: None

Additional Project Progress Contemplated for the Remainder
of the Current Calendar Year: None

OWRR Project No.: A-018-Minn

Annual Allotment Agreement No.: 14-01-0001-3023

Project Title: Methodology for Integrating Water Quality Management with Management of the Total Water Resources in Minnesota

FCST Category: V-G

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., Minneapolis, Minn. 55455

Project Began: July 1, 1967 Scheduled Completion: June 30, 1970

Principal Investigator: C.P. Straub Degree: Ph.D.

Discipline: Public Health

Student Assistants:

Degree:

Discipline:

Ulric P. Gibson

Ph.D.

Public Health

Description of Research Performed & Any Findings, Results, or

Conclusions Relating Thereto:

This project, aimed at developing criteria for the management of water quality as an integral part of water resources management and methodology for implementing such integrated management in Minnesota, is now completed. The concept of integrated water resources management has been developed in some detail through many aspects such as the need for, and type of governmental involvement; institutional arrangements; judicial and economic policies; technical measures; the importance of socio-economic considerations; and the need to consider the widest possible range of alternatives. Approaches to this type of water resources management in 3 western European countries, Canada, and the U.S. have been examined.

Existing arrangements for water resources management in Minn. are found to be characterized by a multiplicity of agencies, fragmented and duplicated responsibilities, a lack of centralized control and clear lines of authority. The institutional system is significantly deficient with respect to all of the seven criteria proposed.

Three proposals have been made for integrated water resources management in Minn. These take into consideration the physical characteristics of the resources, the problems associated with the use of those resources, the deficiencies with respect to the criteria adopted, and the prevailing governmental system. All proposals provide for decentralization through hydrologically based regions and for water resources management as a part of natural resources management. Central control is exercised by a Natural Resources Board which is widely representative of public interests. Proposal No. 1 provides for separate quality management and development agencies coordinated by the Natural Resources Board, applying the full range of techniques through regional divisions. These agencies are combined in Proposal No. 2. In Proposal No. 3, the Board and its agencies are mainly regulatory in nature, providing the policy framework in which locally controlled River Basin authorities would operate. Special districts would be abolished. Proposal No. 2 is favored for its strong State role and ease of administration. Research needs are indicated.

The study provides information upon which the reorganization of water resources management in Minn. may be undertaken. It is anticipated that the findings and recommendations of the study would be useful to the 1971 State Legislature in its consideration of reorganization of water resources management in the State. The report may also be useful to other States undertaking similar reorganization of water resources management programs.

Project-related Publications:

Ulric P. Gibson, June 1970. Integrating Water Quality Management into Total Water Resources Management in Minn. Univ. of Minn. Ph.D. Thesis. School of Public Health. p.376, fig. 53, tab. 14, ref. 112.

Statements of Project Work Remaining to be Accomplished:

None

Additional Project Progress Contemplated for the Remainder of the Current Calendar year:

None

OWRR Project No.: A-019-Minn

Annual Allotment Agreement No.: 14-31-0001-3073

Project Title: Economics of Water Quality Control in the Upper-Mississippi River- Minnesota

FCST Research Category: VI-B

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., St. Paul, Minn. 55101

Project Began: July 1, 1968 Scheduled Completion: June 30, 1971

Principal Investigator: J.J. Waelti Degree: Ph.D.

Discipline: Agric. Econ.

Student Assistants:

Degree:

Discipline:

Robert C. Lewis

B.S.

Agricultural Economics

Richard Hoelner

B.S.

Agricultural Economics

Description of Research Performed, and Findings, Results or

Conclusions Relating thereto:

The objective of the project is to formulate a model which incorporates both physical and economic criteria that would be useful for formulating a strategy for minimizing costs of attaining dissolved oxygen standards in the Twin Cities Metropolitan area of the Mississippi River. During the past year, effort was centered on gathering the physical data relating to the assimilative capacity of the river and the economic data relating to the costs of waste treatment of the existing treatment plants in the study area. These data were incorporated into a linear programming model designed to yield least cost strategies of treatment to attain given dissolved oxygen standards for various reaches of the river. A Master's thesis on this subject is currently in progress. The Twin Cities Metropolitan Council has been delegated the authority of central management of all the waste treatment plants in the Metropolitan Area. The question then becomes one of coordinating the operation of the plants in such a way as to minimize costs of attaining given standards of dissolved oxygen. This is where the research results are expected to be of value - to lend insights into the coordination of these plants.

Project-related Publications:

R.C. Lewis. The Marginal Cost of Alternative Levels of Water Quality in the Upper Mississippi River. Univ. of Minn. M.S. Thesis. Department of Agric. Econ. In Preparation.

J.J. Waelti. July 1969. Understanding the Water Quality Controversy of Minnesota. Agricultural Extension Service, Univ. of Minn. 28 p. 16 fig., 2 tab., 13 ref.

J.J. Waelti & R.C. Lewis. 1969. Some Economic Aspects of Water Quality. In Minnesota Science, Agric. Experiment Station, Univ. of Minn., 2p.

Statements of Project Work Remaining to be Accomplished:

Work remaining to be accomplished is to obtain preliminary results from the model, to discuss these results with personnel of the Metropolitan Council and appropriate State Agencies, to test and evaluate the model under alternative assumptions, and to obtain final results and review their implications for future waste treatment strategy in the Metropolitan area. A report must be prepared.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

It is expected that preliminary results will be available this calendar year and discussed with personnel of the Metropolitan Council and the Minnesota Pollution Control Agency.

OWRR Project No.: A-020-Minn

Annual Allotment Agreement No.: 14-01-0001-3023

Project Title: Evaluation of Selected Computer Programs in Hydrology

FCST Category: II-E

Name & Location of University where Project is Being Conducted:

Univ. of Minn, Mpls., Minn. 55455

Project Began: July 1, 1968

Scheduled Completion: June 30, 1971

Principal Investigator: C.E. Bowers

Degree: M.S.

Discipline: Civil Engineering

Student Assistants:

Degree:

Discipline:

Civil Engineering.

A.F. Pabst

M.S.

" "

S.P. Larson

M.S.

" "

N.V. Pundarikanthan

M.S.

" "

L. Muller

B.S.

" "

C. Henningsgaard

B.S.

" "

H. Peterson

Undergrad.

Description of research Performed and Any Findings, Results, or

Conclusions Relating Thereto:

The objective of the study proposed herein is an evaluation of some existing computer programs and mathematical models relating to the analysis of storm runoff and flood routing.

Currently many individuals and organizations are developing new models and programs. While this is commendable, there appears to be a need for wider use of these developments by design engineers. That this has not occurred is due in part to: (1) a lack of communication between the research and design groups; (2) failure to make some developments available in readily usable form; and (3) reluctance on the part of the designers to depart from established techniques.

At the International Hydrology Symposium held at Fort Collins in 1967, considerable concern was indicated on the part of the consulting engineers as to the lack of communication between the researchers and the practicing engineers. While the results of the research are usually published, they may not be readily usable for design purposes. Further, considerable work is necessary to compare various programs, arrive at the selection of one which might be used for specific design problems, and develop confidence in the applicability of the program or method to critical design problems. As a result, the application of research lags very far behind the current research efforts.

In some instances, government agencies have prepared programs for specific areas in which they are interested, and have made them available to cooperating organizations. Examples of this are the Hydrologic Engineering Center of the Corps of Engineers, the U.S. Geological Survey, the Bureau of Public Roads, and the Soil Conservation Service. In some instances, the primary effort has involved preparation of digital computer programs to assist in the solution of established hydrologic procedures. In others, the established methods may be involved, with optimization techniques used to assure the best solution. In still others, new procedures are developed. Relative to the present project, during the past year the primary effort has been devoted to the following: (1) review of the literature and published information on programs in hydrology and hydraulics; (2) contacting of organizations and individuals relative to program

listings and source decks; (3) review and study of programs received, and (4) use of selected programs to assist in evaluating their characteristics. As a result of these efforts, approximately 48 programs have been accumulated. The primary source of programs in this area has been the Hydrologic Center of the Corps of Engineers, with other contributions from the Soil Conservation Service, the U. S. Geological Survey, the Bureau of Reclamation, the T.V.A., and several universities, including the Univ. of Minn.

As a result of the recommendations by the Water Resources Council for the use of a "Uniform Technique for Determining Flood Flow Frequencies," based on the log-Pearson Type III theory, a number of computer programs have been developed. Included among these are programs by the USGS, the SCS, the Bureau of Reclamation, and the University of Minnesota. In addition to these, the Corps of Engineers has several programs based on the log-Pearson Type III method but with slight differences in comparison with the other programs. Some of these were in operation prior to the Water Resources Council recommendation.

With the exception of the Corps of Engineers programs, they all give essentially the same results. In addition to theoretical discharge values for various levels of probability or recurrence interval, the USGS program has a plot routine. The Univ. of Minn. program provides the discharge data for the actual skewness of the record plus similar data for zero skewness and a specified regional skewness. It is apparent that it will not be possible to properly evaluate all of the programs assembled under this project because evaluation of many of the programs requires considerable use in order to ascertain the method of operation and the best features of the program. However, selected programs are being used and evaluated. In addition to the log-Pearson III frequency analysis programs, a group of programs have been prepared for computation of surface profiles in natural channels. W. Eichert of the Corps of Engineers has provided a comparison of some of these programs.

Of special interest to the writer are 2 program (or series of programs) permitting the computation of runoff from natural watersheds. One of these is the TR-20 Program (Project Formulation Hydrology) prepared by the Soil Conservation Service. Comments on this and several other programs are included below:

a. SCS - TR 20 - Hydrology

This program was developed to assist planners in making complete studies of a watershed by analyzing a greater number of alternatives. Its aim is to cut down overall project costs by finding the most economical solution. The program is capable of computing surface runoff from sub-areas of a given watershed due to a natural or synthetic rainstorm. The runoff hydrographs can then be combined and routed through stream channels and/or reservoirs. Although the program is large (12600g + storage locations), the input data is kept to a minimum and is easy to understand. This program would be very beneficial to individuals or agencies who wish to analyze rainfall-runoff problems.

b. HEC 23-Js-L232 Hydrograph Combining and Routing

This program is capable of routing hydrographs using a number of routing techniques, combining hydrographs, computing unregulated hydrographs, or computing local inflows. The program's size (40000g) does not limit

it to any great extent. The input data required present no great difficulty and input parameters are defined clearly in the HEC publication. Although the program is able to perform all of the above operations, it would probably be more valuable if it were incorporated with other programs to form a larger program capable of complete watershed analysis.

c. HEC-2 Water Surface Profiles

This program is capable of computing water surface profiles for river channels of any cross section for flows greater or less than critical. Hydraulic structures such as bridges, culverts, etc., can be considered by the program. The program has many other capabilities, but is hindered by its size and complexity. The program instructions require all available storage locations on the Univ. of Minnesota's CDC 6600 computer in order to operate. The great number of options available to the user create very complicated input requirements. Thus, although the program is very useful and able to perform a great variety of operations, its size and complexity may restrict its use.

d. HEC 23-J2-L228 Unit Graph & Hydrograph Computations

This program was developed to compute runoff hydrographs from a given unit hydrograph or from a computed unit hydrograph, based primarily on existing Corps of Engineers design procedures. The program is capable of punching output which can be used as input data for the hydrograph combining and routing program. The size and complexity of the program are not factors in determining its value. If this program were combined with other programs, such as the hydrograph combining and routing program, the result could be used to analyze rainfall runoff problems for watersheds.

The Federal agencies generally have the background to develop or modify existing programs for their own use. However, many state and other government agencies generally have the background to develop or modify existing programs for their own use. However, many state and other government agencies, as well as consulting engineers, would profit from the use of programs studied under this project. By describing the programs and procedures for placing them in operation, it is hoped that the project will assist in the use of programs and result in a more efficient use of funds in water resources development studies.

Project-Related Publications:

- C.E. Bowers & N.V. Fundarikathan. Survey of Computer Programs concerning the Statistical Analysis of Floods. To be delivered at ASCE Hydraulics Div. Conference, Aug. 19, 1970.
- C.E. Bowers, A.F. Pabst, & S.P. Larson. July 1970. Computed Program for Statistical Analysis of Floods by Log-Pearson Type III Method. St. Anthony Falls Hydraulic Lab. Computer Program No. 1. 20 p.
- C.E. Bowers, Computer Program for Computation of Water Surface Profiles in Prismatic Channels. Center for Civil Eng. Studies. 20 p. In Preparation.

Statements of Project Work Remaining to be Accomplished:

Remaining work includes assembly of additional programs, use of numerous programs now on hand, and preparation of a final report.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Currently the TR 20 program of the SCS and a combination of several Corps of Engineers programs that accomplish a similar objective are being used on the CDC 6600. Upon completion of this work a preliminary summary of all programs will be prepared.

OWRR Project No.: A-021-Minn

Annual Allotment Agreement No.: 14-31-0001-5023

Project Title: Water Resources Administration in Minnesota

FCST Research Category: VI-E

Name & Location of University Where Project is Being Conducted:

Univ. of Minn.- St. Paul, Minn. 55114

Project Began: July 1, 1969

Scheduled Completion: June 30, 1972

Principal Investigator: W.C. Walton

Degree: B.S.

Discipline: Water Resources

Student Assistant: D.L. Hills Degree: B.S. Discipline: Water Resources

Description of Research Performed and Findings, Results, or Conclusions

Relating Thereto:

Officials of the Minn. Dept. of Conservation, Pollution Control Agency, Soil & Water Conservation Commission, and Water Resources Board were interviewed and information was obtained on the following subjects: membership, powers, duties, staff, budgets, policy, relations with other organizations, organization, funding, historical data, proceedings, district establishment and funding, plans, and programs and projects. The State Statutes for Minnesota, Iowa, So. Dakota, No. Dakota, Wisconsin and Michigan were examined and information was assembled concerning administrative structure and institutional arrangements for natural resources in Minnesota and adjoining States. The "State Program and Operations Manual" prepared jointly by the Minnesota State Planning Agency and The Dept. of Administration was reviewed and data was assembled concerning natural resource agency programs, sub-programs, activities, and expenditures. Federal-State regional planning documents were examined and information was obtained on federal agencies and responsibilities in the natural resources field in Minnesota. A review was made of proposed legislative measures that were introduced in the 1969 session of the Legislature pertaining to Natural resources. All the above mentioned information was summarized in 11 Information Circulars distributed by the Water Resources Research Center to 550 people throughout the State concerned with water resources for their review and comment.

Preliminary conclusions reached by the Principal Investigator concerning the need for reorganization of State government for natural resources, deficiencies and weaknesses in State government, and a recommended plan of reorganization were summarized in an Information Circular and distributed to 550 people. The information was presented to stimulate discussion concerning reorganization and to assist the State Legislature and Executive Branch in formulating needed improvements in government for natural resources. The Principal Investigator testified before the House Land and Water Resources Committee on two occasions and met with Republican Party Platform Committees, the Citizens League and other groups to discuss the need for reorganization.

Preliminary conclusions reached are given below. Minnesota's State government contains at least 46 departments, agencies, boards, commissions and committees which have primary or substantial responsibilities in the natural resources field. There are over 640 pages of law dealing with these organizations. No State mechanism exists for effectively coordinating the activities of these organizations. More than one State Agency has responsibilities in most functional areas and responsibilities of State agencies overlap. Except for the Dept. of Conservation and

State Planning Agency, all other agencies are plural bodied; agency members serve staggered terms and are to an appreciable extent independent of direct control by the Governor. State agencies have little capability in the following functional areas: comprehensive water and related land resources planning; flood control; land drainage, treatment and control; waterborne transportation; and power. There are 87 counties in the State, 96 Soil and Water Conservation Districts, 25 Watershed Districts, 4 Conservancy Districts, and Lake Conservation and Sanitary Districts all involved in the planning, development and management of natural resources. These entities are to an appreciable extent independent of one another; cooperation between special purpose districts is limited. A plan of reorganization is presented which involves consolidation of major administrative functions associated with natural resources within a Dept. of Natural Resources and the establishment of a companion Commission on Environment on which people from private life would serve in an advisory capacity.

Papers prepared:

Summary of Information on State Administrative Structure and Institutional Arrangements for Water and Related Land Resources in Minnesota and Adjoining States, 1969. W.C. Walton. Information Circular No. 97. Water Resources Research Center 37 p.

Summary of Information on FY 1968 State Programs for Water & Related Land Resources in Minn. W.C. Walton. Information Circular No. 98. Water Resources Research Center. 33 p.

Summary of Information on Federal Agencies & Responsibilities in Water and Related Land Resources Field in Minnesota. W.C. Walton. Information Circular No. 99. Water Resources Research Center. 26 p.

Summary of Information on FY 1968 Budgets and Staff Complements of Minn. Dept. of Conservation, Pollution Control Agency, Soil & Water Conservation Commission, and Water Resources Board. W.C. Walton, Information Circular No. 100. Water Resources Research Center. 4p.

Four Alternative Institutional Charts for Possible Reorganization for the Improvement of State Government in the Field of Natural Resources. W.C. Walton. Information Circular No. 101. Water Resources Research Center. 5 p.

Summary of Information on State Soil and Water Conservation Commission and Soil & Water Conservation Districts. W.C. Walton. Information Circular No. 103. Water Resources Research Center. 22p.

Recommendations Concerning the Improvement of State Government for Natural Resources. W.C. Walton. Information Circular No. 104. Water Resources Research Center. 14 p.

Summary of Information on Pollution Control Agency. W.C. Walton. Information Circular No. 105. Water Resources Research Center. 30 p.

State Legislative and Congressional Handling of Natural Resources. B. Jensen & W.C. Walton. Information Circular No. 106. Water Resources Research Center. 19 p.

Summary of Information on Minnesota Water Resources Board and Watershed Districts. D.L. Hills. Information Circular No. 107. Water Resources Research Center. 24 p.

Summary of Information on Minn. Dept. of Conservation. D.L. Hills. Information Circular No. 108. Water Resources Research Center. 40 p.

Statement of Project Work Remaining to be Accomplished:

Officials of natural resources Federal agencies and special interest groups with offices in Minnesota must be interviewed and pertinent information obtained and summarized. A review must be made of proposed Legislative measures that will be introduced in the 1971 session of the Legislature. An in-depth analysis of information on water resources administration must be made and a report prepared describing the results of the research.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Information on natural resources Federal agencies and special interest groups will be assembled, summarized and published as Information Circulars.

OWRR Project No.: A-022-Minn

Annual Allotment Agreement No.: 14-31-0001-3023

Project Title: Zooplankton Biomass & Incipient Eutrophication in Lake Superior

FCST Research Category: V-C

Name & Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Egan: July 1, 1969

Scheduled Completion: June 30, 1972

Principal Investigator: T.A. Olson

Degree: Ph.D.

Discipline: Public Health

Student Assistants: None receiving employment through project

Description of Research Performed & Findings, Results, or Conclusions

Relating thereto:

Attention has been directed to the vertical distribution of some of the principal zooplankters in Western Lake Superior. These analyses were based on sequential samples taken by means of the Hardy Plankton Indicator, an instrument developed for oceanographic work by the Scottish Marine Biological Association of Edinburgh, Scotland. Zooplankters were taken at regular intervals between one and 40 meters of depth. In all instances, samples were taken on a 24-hour basis to include both periods of daylight and darkness. Organisms were filtered onto No. 60 Swiss Silk Grit Gauze (60 mesh per inch). Zooplankton collections were made on two principal routes; transect runs of 7.2 miles each direction from Knife River, Minn., to Two Harbors, Minn., and back again; and an equilateral triangular course of 2½ miles in length in a fixed area, off Knife River.

Significant differences were noted in the diurnal variations throughout the water mass. Highest concentrations in the surface samples were noted during the nighttime hours. Interesting shifts of density distribution were apparent throughout the year. Available data were correlated with existing thermal and light regime information.

In general, the relatively shallower depths (one and five meters) showed a wide variation in terms of zooplankton concentration. In the surface waters marked aggregations of organisms were consistently observed in the hours just preceding midnight. This increase in numbers at the surface was not always reflected in a corresponding decrease of organisms at the 25 or 30 meter depth. Frequently, these layers maintained a steady baseline rate at relatively low numbers, while the surface waters increased in organism concentration.

In addition to the studies done with the Multi-depth Plankton Indicator (Hardy Plankton Indicator), tows were also made with the Miller High Speed Sampler. These samplers were operated at depths of 8, 18, and 28 meters, respectively. On the whole, the Miller High Speed Sampler data for the smaller zooplankton compare favorably with the data obtained with the Hardy Plankton Indicator. For example, the Miller High Speed Sampler running at 8 meters of depth on the whole compares rather well with a Hardy Plankton Indicator running at 10 meter depth, as does 18 meters compared with 20 meters, and 28 meters compared with 30 meters. Overall, the Miller High Speed Sampler appears to take fewer organisms per 100 liters of water filtered than does the Plankton Indicator.

When comparing the catches of larger planktonic invertebrates, the Miller Sampler appears to be more effective. A comparison of the catches of the opossum shrimp, *Mysis relicta* (Loven), showed a ratio of nearly

100:1 in favor of the Miller Sampler when compared with the Multi-depth Plankton Indicator. In addition, a larger cross-section of size ranges from juveniles to adults was achieved with the Miller Sampler, while the Multi-depth Plankton indicator appeared to be selectively biased toward the smaller immature forms. Further studies comparing the relative catching power of these 2 instruments are indicated before more definitive statements can be made.

In general, the organisms seen in the Multi-depth Plankton Indicator tows consisted primarily of the group Copepoda with cladocerans as a groups being far less abundant. The usual ratio was approximately 30:1 in favor of the copepods. The cladocerans consisted largely of species of *Daphnia* while both *Bosmina coregoni* and *Bosmina longirostris* were intermittently present in the plankton. The preponderance of the copepods belonged to the genus *Diaptomus*. The cyclopoid copepods were far fewer in numbers, usually in a ratio approximately 20:1. Other regular contributors to the plankton included *Limnocalanus macrurus*, *Senecella calanoides* and *Epischura lacustris*.

The zooplankton of Lake Superior constitutes one segment of this lake's ecosystem which might be expected to undergo qualitative and quantitative transformations in populations as a response to enrichment of the waters. For this reason, it would appear desirable to study this group of organisms more intensively. Furthermore, it would be of special interest to determine whether or not detectable increases in biomass and differences in species composition occur in near shore areas of Lake Superior where localized regions of developing eutrophication may be anticipated. The investigations concerned with zooplankton biomasses may provide useful supplemental information on the relationship between productivity in open lake water conditions and the production in areas where moderate enriched zones may develop. The zooplankton data, together with other information already available, would provide a more complete picture of the lake's biosphere than is now available.

When the entire period of this study has been completed it is expected that the information can be related to practical and immediate problems such as pollution by tributaries and special waste contributions such as those made by industrial operations. The study will have its greatest value in establishing a baseline for the present period. One which can then be used for comparisons in evaluating potential advances in various types of eutrophication.

Project-related Publications:

- Johnson, J.M., T.O. Odlaug, T.A. Olson, and O.R. Ruschmeyer. June 1970. The Potential Productivity of Fresh Water Environments As Determined By An Algal Bioassay Technique. Bulletin No. 20. Water Resources Research Center. 101 p., 36 fig., 5 tab., 6 pl., 83 ref.
- Swain, W.R., R.W. Magnusen, J.D. Johnson, T.A. Olson, & T.O. Odlaug. 1970. Vertical Migration of Zooplankton. Mimeographed Report. 57 p., 18 fig., 1 tab., 26 ref.

Statements of Project Work Remaining to be Accomplished:

This is the first of a 3-yr. study; on the basis of this first season there seems to be no reason for a change in procedures. As indicated at the outset the research proposed will be more detailed than the earlier

background studies and will be restricted to the western arm of Lake Superior. Since a special effort will be made to relate the work to slight differences in water masses, three basic study areas will be selected. One of these just off the Duluth-Superior Harbor area represents a region which has received appreciable additions of St. Louis River water mixed with polluted water from the inner port areas and a considerable amount of industrial wastes originating far upstream. In the second area at Larson, which better represents the open water conditions, there is a region which has been under observation for more than 12 years. Past studies have dealt primarily with physical and chemical aspects of the water masses in that region. The data accumulated can be expected to provide a good background. The third sampling area will be in the Grand Marais- Isle Royale region which represents the clearest water found in Western Lake Superior. The latter station will be used for comparative purposes and the sampling program there will probably depend on Coast Guard cooperation and assistance. Tentative arrangements have been made but the final schedule will be based on the availability of Coast Guard vessels for such work.

In the studies envisioned, biomass determination and productivity measurements will be carried on throughout the open water season and total wet volume, organic matter of the biomass, enumeration and general identification of organisms and other pertinent determinations will be made on the samples. Samples will be taken by a variety of ways to insure the adequacy of the methodology. For this purpose Clarke-Bumpus Nets, Miller High Speed Samplers, Hardy Plankton Indicators and the C.P.R. will be used. If this is properly done it should be possible to profitably relate the work to the geographically more extensive C.P.R. studies already completed by us on the lake as a whole.

Supplementary studies which can be helpful in the interpretation of data and complementary to the main effort will include vertical phytoplankton profiles in selected areas and a limited number of associated pigment (chlorophyll) analyses. A report must be prepared.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

The summer and fall period is the time usually devoted to field work and sample collecting. On this basis it is expected that those analyses which without deterioration can be carried out at a later date, will be done during the winter period. It is expected that summer sampling will provide the basic materials to provide a body of data which is representative and meaningful and which will make it possible next year to arrive at a final research design which will permit the successful termination of the study.

MATCHING GRANT PROGRAM, NARRATIVE PROGRESS REPORTS (Form OW-1)

OWRR Project No.: A-023-Minn
Project Title: Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics

FCST Research Category: II-E
Name & Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1970 Scheduled Completion: June 30, 1972
Principal Investigator: C.L. Larson Degree: Ph.D.

Discipline: Agricultural Engineering
Project Progress Contemplated for the Remainder of the Current Calendar Year:

A number of small watersheds scattered throughout the U.S. in different geological and topographic areas will be selected for study. Compilation and processing of basic watershed runoff and rainfall data will be started. Some information concerning geology, topography, and channel characteristics will be assembled.

OWRR Project No.: A-024-Minn

Project Title: Mathematical Simulation of a Larger Watershed Using the Systems Approach to Quant. & Qual. Analysis
FCST Research Category: VI-A
Name & Location of University Where Project is Being Conducted:
Univ. of Minn., Minneapolis, Minn. 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973
Principal Investigators: C.S. Song & C.E. Bowers Degrees: Ph.D. & M.S.

Discipline: Hydraulic Engineering
Project Progress Contemplated for the Remainder of the Current Calendar Year:

The current literature pertaining to watershed mathematical models will be reviewed. Some progress will be made in selecting mathematical expressions to describe the surface and groundwater flow, the transport mixing and reaction of pollutants, the aeration process, etc. Data concerning the physical characteristics of the Minnesota river basin will be assembled.

OWRR Project No.: A-025-Minn
Project Title: Alleviation of Lake Pollution by Utilization of Aquatic Plants for Nutritional, Medicinal or Industrial Purposes.

FCST Research Category: V-E
Name & Location of University Where Project is Being Conducted:
Univ. of Minn., Minneapolis, Minn. 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973
Principal Investigator: E.J. Staba Degree: Ph.D.

Discipline: Pharmacognosy
Project Progress Contemplated for the Remainder of the Current Calendar Year:

Aquatic plants will be collected from various lakes throughout the State. Some of the plants will be identified, processed, and phytochemically screened for useful compounds.

OWRR Project No.: B-009-Minn

Matching Grant Agreement No.: 14-01-0001-1515

Project Title: Relation of Phosphorus in Lake-bottom Deposits & Pollutional History of Minnesota Lakes

FCST Category: V-C

Name & Location of University Where Project is Being Conducted:
Univ. of Minn., Mpls., Minn. 55455

Project Began: July 1, 1967 Scheduled Completion: June 30, 1970

Principal Investigator: Joseph Shapiro Degree: Ph.D.

Discipline: Zoology

| <u>Student Assistants:</u> | <u>Degree:</u> | <u>Discipline:</u> |
|----------------------------|----------------|--------------------|
| Stephen Tarapchak | M.S. | Limnology |
| Teresa Ewing | Undergrad. | Limnology |

Description of Research Performed and any Findings, Results or Conclusions Relating Thereto:

Phosphorus fractionation studies have continued, with emphasis on attempts to understand why some sediments release large amounts of phosphorus on reduction, while others release only small amounts. The intent of these studies is to utilize this knowledge in experiments directed at preventing sediments from releasing phosphorus under conditions of natural reduction. In analyzing phosphorus fractionation data, it became clear that the only fraction that seems to be mobile, i.e. that is likely to influence the productivity of lakes, is the acid soluble fraction, for it is only from this fraction that phosphorus is released upon reduction. In addition, not all of this fraction is mobile, the percentages varying from about 40% to 100%.

Project-related publications:

- Shapiro, J., W. Chamberlain & J. Barrett. 1969. Factors Influencing Phosphate use by algae. Water Research 2:12 p.
Chamberlain, W. & J. Shapiro. 1969. On the biological significance of phosphate analysis: Comparison of standard & new methods with a bioassay. Limnology & Oceanography 14:921-923.
Chamberlain, W. & J. Shapiro. Methods for the measurement of biologically available phosphate. To appear in "Environmental Phosphorus Handbook" to be published by John Wiley & Sons.

Statements of Project Work Remaining to Be Accomplished: None

Additional Project Progress Contemplated for the Remainder of the Calendar Year: None

OWRR Project No.: B-012-Minn

Matching Grant Agreement No.: 14-01-0001-1914

Project Title: Development of a Mathematical Model to Predict the Role of Surface Runoff & Groundwater Flow in Overfertilization of Surface Waters

FCST Category: V-B

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., Mpls. Minn. 55455

Project Began: July 1, 1968 Scheduled Completion: December 31, 1970

Principal Investigator: C.P. Straub Degree: Ph.D.

Discipline: Public Health

Student Assistants: Degree: Discipline:
Jack Johnson M.S. Public Health

Description of Research Performed & any Findings, Results, or Conclusions Relating Thereto:

Over 600 water samples have been collected and analyzed for sediment, nitrogen, and phosphorus. These samples were collected at various locations on the 23 sq. mi. test watershed located at New Prague, Minn. The Watershed is quite typical in Minnesota and was selected on this basis. The data have been entered onto computer punch cards and have, through the computer, provided a printout for each sampling station. These printouts reflect the time sequence of mass flow; i.e., at the time the sample was taken the mass flow was X lbs./hr. of sediment, Y lbs/hr of phosphorus, and A lbs/hr of nitrogen. These data will, with some degree of extrapolation, provide the mass outflow from the drainage basin for a two year period. Sampling is continuing presently, but on a much reduced basis, consistent with the knowledge gained from last year's intensive sampling program. Two continuous recording streamflow gages are in operation and have provided continuous flow data. It was not feasible to obtain samples during every rising and falling of the hydrograph, but regression analysis with the computer entered data provided a sound basis for extrapolation of data to measured streamflow rates for which we had no chemical data. There are two point sources of streamflow and nutrients, one of these is the effluent from the sewage treatment plant for the city of New Prague, the other is the separate storm drain which also contains continual flow from industrial cooling water and processed water from milk drying. Both of these point sources have been monitored.

Maps of the area have been drawn, farm data have been collected, and we are presently attempting to define the mass balance for the entire watershed; i.e., the sum of the nutrients added to the watershed minus the sum of the nutrients removed by cropping and surface water outflow equals the sum of the nutrients in storage (soil, plant, and groundwater). Approximately 600 references have been or are being reviewed for possible data or mathematical models which can be utilized to make the model general in applicability. The model itself has not been developed, but should proceed at a reasonable pace from this point in the research. It is anticipated that the model will be general enough to be utilized by pollution control agencies to determine the relative magnitude of nutrient sources. This then will enable them to rank or place priorities on control measures, and such analysis can proceed on drainage basis basis.

Project-related Publications: None

Statements of Project Work Remaining to be Accomplished:

The mathematical model will be developed and tested with the data collected and analyzed for the New Prague Watershed.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

The model development, test, and publication of results is presently anticipated for completion by December 31, 1970.

OWRR Project No.: B-013-Minn

Matching Grant Agreement No.: 14-01-0001-1915

Project Title: Influence of Mist Irrigation on Moisture Stress, Growth Yields, and Quality of Potatoes & other Vegetable Crops

FCST Category: V-B

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., St. Paul, Minn. 55101

Project Began: July 1, 1968

Scheduled Completion: June 30, 1971

Principal Investigator: R.E. Nylund

Degree: Ph.D.

Discipline: Horticulture

Student Assistants:

Degree:

Discipline:

Douglas Sanders

M.S.

Horticulture

Edgards Quisumbing

M.S.

Horticulture

Ronald Schaefer

B.S.

Horticulture

James Brown

Undergrad.

Horticulture

Steven Kartack

Undergrad.

Forestry

Carolyn McWilliams

Undergrad.

Home Economics

Description of Research Performed & Any Findings, Results, or Conclusions Relating Thereto:

The influence of mid-day mist irrigation on the reduction of environmental water and temperature stresses and on growth & development of potato plant was studied for a second year. Air temperatures in the plant canopy, leaf temperatures, and soil temperatures were recorded daily principally between the hours 0700 and 2100. Soil moisture was recorded thrice weekly. Misting decreased air temperatures within the canopy 0.5 to 5°C with the temperatures of the upper and central portions being reduced more than that near the soil surface. Soil temperature was also decreased 0.5 to 3°C with the greatest reduction occurring at the 2.5 cm depth and lesser reductions to a depth of 30 cm. Further, leaf temperatures were decreased 1 to 20°C depending on the degree of leaf exposure to radiation. All temperatures were decreased more by misting when atmosphere stress was high. Reducing temperature and/or moisture stresses by mist irrigation resulted in increased tuber yields. Tuber defects such as hollow heart and secondary growths were also increased by misting. When water applied by misting resulted in excessive soil moisture, however, tube yields did not increase. Chipping quality of tubers was decreased but could be overcome by longer periods of reconditioning following low temperature storage.

The influence of mist irrigation on nutrient content of leaves, petioles, and tubers was also studied. Zinc concentration was found to be greatly increased in both leaves and petioles. Also, misted leaves contained more phosphorus, and tubers contained more phosphorus and calcium. In addition to the above study, a study was conducted in the growth chamber during the winter to determine the maximum time interval between mist applications that would effectively cool leaves and prevent their temperature from returning to "normal". Potato plants maintained at 2 levels of heat stress (30 & 40°C ambient air temperatures) were misted for 5 seconds at intervals of 5, 10, 15 and 20 min. Leaf temperatures were recorded at 4 sec. intervals during each mist-nonmist cycle. Preliminary analysis of the data indicates that under high ambient temp. (40°C) temp. differences between misted and unmisted leaves were greater than at lower ambient temp. (30°C). However, as leaf surfaces dried the temp. of misted leaves rose more rapidly under high ambient than under low ambient temperature

with the result that "normal" leaf temperature was attained in 15 min. on plants at 40°C ambient and in 20 min. under 30°C ambient.

The increases in yields of U.S. #1 grade tubers resulting when potato plants are mist irrigated indicate that this practice could have considerable value in commercial potato production. However, whether or not such a practice is economically justified from the engineering costs and water conservation standpoints still need to be studied.

Project-related Publications:

A Ph.D. thesis is in the process of being written. Two papers, representing part of the data contained in the thesis will be presented at the Potato Association of America annual meeting at Riverside, California, on July 27-30, 1970. These are:

- D.C. Sanders & R.E. Nylund. Studies on the influence of mist irrigation on the potato. I. Effects on micro-environment and leaf water relations.
- D.C. Sanders & R.E. Nylund. Studies on the influence of mist irrigation on the potato. III. Nutrient content of leaves.

Statement of Project Work Remaining to be Accomplished:

The data obtained in the above study is in the process of being analyzed and summarized in Ph.D. thesis form by D.C. Sanders. In addition to that mentioned above, these data include growth & developmental responses of the potato to mist irrigation and compositional changes in organic constituents of potato tubers. Also, changes in the micro-environment of the plant resulting from mist irrigation will be characterized.

Additional Project Progress Contemplated for the Remainder of the Calendar Year:

The information obtained in the growth chamber study will be used as a basis for conducting a field study on potatoes and on snap beans during the summer of 1970. Both species will be misted for 5 seconds every 15 minutes between the hours 1100 and 1500 on days when light intensity is above 1000 foot candles and temp. is above 26.7°C (80°F.) and then only if the "mechanical leaf" (a simulated leaf surface) indicates that the leaves are dry. This system should provide minimum water use with no reduction in stress-minimizing effectiveness. With the potatoes, this study will provide a comparison with the results obtained in the earlier study. With snap beans, the influence of mist irrigation on flowering and on pod yields and quality will be studied.

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 & Movement

FCST Category: II-G

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., St. Paul, Minn. 55101

Project Began: Jan. 1, 1969

Scheduled Completion: Dec. 31, 1972

Principal Investigator:

Degree: Ph.D. Discipline: Soil Science

George R. Blake

Student Assistants:

Degree: B.S. Discipline: Soil Science

Victor Fuentes

M.S. Soil Science

Lalit Arya

B.S. Soil Science

Jiwan Palta

Undergrad. Journalism

Vivian Lideen

Undergrad. Agric. Eng.

James Johnson

Undergrad. Chemistry

Ronald Hudson

Undergrad. Chemistry

Mary Lathrop

Description of research performed & any findings, results, or conclusions relating thereto:

Practical implications of thixotropic changes in sheared soil were explored in some detail by Mr. Arya. Experiments were conducted to test the hypothesis that freshly formed aggregates in field soils stabilize over a period of time after formation. Three categories of freshly formed aggregates were studied. These included, 1) natural aggregates from field soils collected immediately after plow-shearing, 2) simulated earthworm casts produced by extruding kneaded soil through sieve with 2mm round holes, and 3) aggregates produced by coalescence of dry soil particles around a droplet (herein called as water-drop aggregates). In all cases, aggregates were aged at constant water content and wet sieved at different times to investigate whether the stability increased with time.

Natural aggregates from field soils showed an increasing stability with time. The rate of increase was high during the first 10 to 12 hours of aging, but decreased as the aging period increased beyond this. Stability was still increasing even after 72 hrs. of aging. This feature of the phenomenon is characteristically the same for the 4 soil types studied. Stability attained in 72 hours of aging varied between soil types.

Extruded soil threads simulating earthworm "casts" were obtained at varying water contents by extruding moist kneaded soil at varying water contents. These were stored at constant water contents and wet sieved soon after and approximately 24 hours after extrusion. Soil threads increased in stability with aging time as did shear generated aggregates. Water-drop aggregates were prepared at 0.27, 0.29, 0.47, and 0.49 g water per g soil. These water contents were held constant during aging and aggregates were wet sieved at various times after formation. The initial stability at all water contents was near zero, but increased slowly as the aging progressed. Both initial and final stabilities were lower than for plow-shear generated aggregates or simulated earthworm casts.

The time-dependent increase in relative stability of freshly formed aggregates is believed to be related to thixotropic properties of soil-water systems. The initial condition of aggregates at the time for forma-

tion is considered one of non-equilibrium in which interparticle forces are not satisfied. Because of this, aggregates are initially relatively unstable. As the equilibrium is approached particles in the aggregates attain more stable configurations and show higher stability. The process is time-dependent because equilibration of inter-component forces is not instantaneous.

There are important practical implications of these results. Newly generated aggregates are relatively unstable and can be easily puddled. This suggests that after plowing secondary tillage should not be carried out until aggregates can withstand further shear forces placed upon them. The data indicate that the waiting period should be at least 10 to 12 hours. There are, of course, climatic conditions when the danger of cloddiness may be greater than the danger of aggregate destruction from an earlier secondary tillage. It also suggests that rain soon after plowing will do a greater damage to soil structure than at a later time when intra-aggregate bonds have strengthened.

Recording matrix potential equipment was described in 1969 annual report for precisely measuring thixotropic effects on soil moisture tension in pressed briquets on aging. A large number of measurements were made with this equipment. A summary of the results shows that at low water contents soil matric suction showed a rapid decrease with aging time. At intermediate water content, 0.25 by weight, matric suction remained constant with time. At water contents over 0.26 matric suction increased with time. Only in the wetter samples could reversibility be shown on repressing the soil sample indicating a clear thixotropic effect. The data are being summarized into a thesis by Mr. Fuentes and explanations of the various phenomena are being applied on the basis of pure clay mineral studied reported in the literature.

Mr. Palta has measured the in situ hydraulic properties of Hubbard sandy loam and Zimmerman fine sand with and without asphalt moisture barriers at 24 in. depth in the soils. Basis for the conservation of water by barriers and its extent were determined and are being summarized for a thesis.

About 75 to 80% of all precipitation is cycled into the soil, interacts with clay and other soil particles, evaporates or transpires back into the atmosphere. Seepage losses are small. The 20% or so that does not enter the soil is, of course, an important part. In this project we are dealing with maintenance of soil structure in such a way as to maximize infiltration, storage and retention in the soil profile and thus increase usage efficiency. Formation and stabilization of shear-generated aggregates and an understanding of clay-water interaction contribute directly to maintaining matrix characteristics that contribute to these end. The increased storage retention by asphalt in pilot field studies has been demonstrated.

Project-related Publications:

L.M. Arya. Dec. 1969. Stabilization of shear-generated soil aggregates. M.S. Thesis, Univ. of Minn., Dept. of Soil Science. 63 p., 14 tab., 8 fig., 48 ref.

Chyi-sheng Hwang. Oct. 1969. Wet strength of silica-diluted synthetic soil aggregates. M.S. Thesis. Univ. of Minn., Dept. of Soil Science. 48 p., 9 tab., 12 fig., 38 ref.

L.M. Arya, G.R. Blake. June 1970. Stability of sheared-generated soil aggregates. 17 p., 2 tab., 6 fig., 15 ref

Statements of Project Work Remaining to be Accomplished:

Three aspects of this project are continuing. Effectiveness of asphalt and other soil profile discontinuities in increasing the capacity of the soil reservoir will be further studied particularly with respect to its practical applications in crop production. A statistical study of the probability of drouth reduction is under consideration. The pattern of extraction of water by soybean plants under field studies has been recently undertaken and will continue in the field during 1970 and 1971 and under controlled climate conditions during winter months. Literature pertaining to the theoretical aspects of clay-water thixotropy is now being reviewed and subproject plans will be developed.

Additional Project Progress Contemplated for the Remainder of the Calendar Year:

A thesis will be completed on soil matric suction changes with time in pressed soil briquets. A thesis will be completed on hydraulic characteristics of soil profiles with and without asphalt moisture barriers. Two papers will be written on porosity of soil aggregates.

OWRR Project No.: B-020-Minn

Matching Grant Agreement No.: 14-31-0001-3095

Project Title: Pollution & the Ecology of Nearshore Periphyton of Lake Superior

FCST Category: V-A

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., Mpls. Minn 55455

Project Began: July 1, 1969

Scheduled Completion: June 30, 1972

Principal Investigator:

Degree: Discipline:

T.A. Olson

Ph.D. Public Health

Student Assistants:

Degree: Discipline:

Jenathan Vomachka

Undergrad. Public Health

Description of Research Performed and Findings, Results, or Conclusions Relating Thereto:

A number of recent Lake Superior water quality studies have established certain baselines which in the future can be utilized for the recognition of advancing eutrophication. These studies have dealt with physical, chemical, and biological criteria which were directly related to the quality of Lake Superior water and its future potential as a natural resource. During the months Aug. to Sept., 1969, a survey was undertaken of filamentous green algae growing along the North Shore of Lake Superior (between Duluth, Minn., and the Canadian border). Growth of filamentous green algae were collected from 27 sampling stations, established at the following points along the shore: (The sampling sites are numbered 1 through 27 and descriptions are given for each one)

1. Beyond mouth of Pigeon River on the Canadian side of border;
2. Between the Pigeon & Reservation Rivers;
3. At mouth of Reservation River;
4. Approx. 4.5 mi. south of Reservation River;
5. At mouth of Brule River;
6. Approx. 2.5 mi. south of the Brule River;
7. At mouth of Devil Track River;
8. Grant Marais Sewage Treatment Plant (STP);
9. Near first way-side stop south of Grand Marais;
10. At mouth of Cascade River;
11. Near endpost of fence south of Cascade Lodge;
12. At mouth of Poplar River-Lutsen Resort;
13. At mouth of Baptism River;
14. At Silver Bay (STP) Outfall;
15. At mouth of Beaver River;
16. Near King's Landing;
17. At mouth of Split Rock River;
18. Between Split Rock & Gooseberry Rivers-at Madonna Ice;
19. At mouth of Gooseberry River;
20. At Castle Danger;
21. Two Harbors STP Outfall;
22. At mouth of Knife River;
23. Approx. 2 miles south of Knife River near yellow cabins;
24. At mouth of French River;
25. Near Duluth water treatment plant;
26. At mouth of Lester River;
27. On rocks near entrance to Duluth Harbor.

A total of 241 samples of filamentous green algae were collected over the 5 month sampling period. One sampling trip was made each month. During the intervals between sampling trips the following analyses were performed: 1) the samples of filamentous green algae were identified; 2) total and fixed residue determinations were made on selected samples; and 3) the predominant species was determined. The predominant organism was the filamentous green algae, Ulothrix zonata, which was the characteristic organism at 19 of the 27 stations.

The project, which deals with the growth of Ulothrix zonata and other filamentous green algae along the North Shore of Lake Superior and the effects of nutrients introduced into the environment on these algae, is therefore well under way and our original guess that Ulothrix zonata

would be the predominant form has been substantiated. For biomass estimates total residue and fixed residue determinations were made on filamentous green algae samples brought in from the field after preliminary preparation of the samples in the laboratory. The methods for conducting the total residue and fixed residue determinations were those called for in Standard Methods for the Examination of Water and Wastewater, 12 Edition, 1965, APHA.

Samples of U. zonata collected from rocks along the North Shore of Lake Superior in the vicinity of Castle Danger (sampling sta. No. 20) were exposed to lake-water treated with 0.1 ml of 1 $\mu\text{g}/\mu\text{l}$ p, p'-DDT and an untreated lake-water control. Samples were exposed approximately two days in a walk-in low temp. room (34° F) under two 15-watt fluorescent lamps. The objective of this experiment was to check the pesticide concentrating capabilities of the alga. This experiment has not been completed and is still in its preliminary phase.

Aquarium tanks were set up for the purpose of culturing U. zonata. Several aquarium tanks were cleaned and rinsed 5 times with tap water and 5 times with distilled water. Several pounds of aquarium gravel were rinsed in a similar manner and equal portions were placed in each tank. The tanks with gravel were rinsed a few times with lake water and filled to the 4 liter mark. In each of the 3 experiments two aquarium tanks were used. In each experiment one tank was used as a control. Two to three autoclaved rocks from the North Shore of Lake Superior, and 1 liter of a viable, 4 mo. old culture of U. zonata were added to the control and experimental tanks. In addition, the following chemical compounds were added to the experimental tanks: KCl, $(\text{NH}_4)_2\text{SO}_4$, NaH_2PO_4 , and CaCO_3 . Since U. zonata requires very low temperatures for growth, the tanks were placed in a walk-in low temperature room (34° F) under 40 watts of illumination. Temperature and pH of the lake water in each of the tanks were periodically checked and recorded.

Attempts were made to culture U. zonata in aquaria with slow and fast circulating Lake Superior water during the winter and spring of 1969-70. Chemical nutrients including $(\text{NH}_4)_2\text{SO}_4$, KCl, NaH_2PO_4 , and CaCO_3 were added after seeding with U. zonata. All aquaria were kept at 34° F under 40 watts of illumination. A small yield of U. zonata was obtained in an experimental aquarium with slowly circulating Lake Superior water, approx. one month after it was started.

Although much has been written concerning the effects of pollution on water quality in the Great Lakes there is, with the exception of certain Canadian studies, relatively little knowledge of the role which filamentous algae growing along the shore may have in the eutrophication phenomenon. Hopefully one outcome of this study will be the implementation of a rapid method for the evaluation of the extent of a body of water based on shoreline characteristics of the filamentous periphyton.

Project-related Publications:

W.R. Swain. 1970. Crustacea of Lakes Superior, Michigan, and Huron as determined by the Continuous Plankton Recorder technique. At press.

Statements of Project Work Remaining to be Accomplished:

The work will be continued in the following directions: 1. to establish the optimal growth requirements of U. zonata and other filamentous

algae found along the North Shore; 2. to determine whether or not pesticides can be concentrated by U. zonata and other filamentous forms; 3. to make a comparison of the concentration of selected pesticides which can be taken up by U. zonata and other filamentous green algae under varying environmental conditions; 4. to determine the influence of various nutrients such as raw sewage, sewage treatment plant effluents, agricultural runoff, mining wastes, etc. on growth of filamentous algae; 5. to determine the effects of seasons on filamentous growth along the North Shore; 6. to determine the role of other organisms in the Ulothrix bio-coenose; 7. prepare a report.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

The field activities related to the project work outline earlier should be completed this summer together with adjunct laboratory experiments relating to and necessary for the proper implementation of such field studies. During the winter period culture experiments and other work which can be held in abeyance will occupy the time of the investigation.

OWRR Project No.: B-031-Minn

Matching Grant Agreement No.: 14-31-0001-3096

Project Title: Participatory Ecology: A Study of Citizens Groups Involved at the Grass Roots to Improve the Water Resources Environment

FCST Research Category: VI-B

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., Mpls., Minn. 55455

Project Began: July 1, 1969

Scheduled Completion: June 30, 1972

Principal Investigator:

Degree:

Discipline:

L.P. Gerlach

Ph.D.

Anthropology

Student Assistant:

Degree:

Discipline:

Allen Pierce

M.S.

Anthropology

Description of Research Performed and Findings, Results, or Conclusions

Relating Thereto:

Research was conducted on the ecology-water resources movement using a 5-factor model developed in previous research. The research is comparative and was conducted primarily in Minn. and Southern Florida, with surveys in Tennessee, the West Coast and Boston. Data was collected through participant observation, interview and questionnaire, and recorded in writing, film and tape recordings. It has been determined that movement in social organization parallels the segmentary, polycephalous, and reticulate structure noted in other movements. An ideology of ecology-water resources is developing, as yet there is no broad based commitment process. A 16 mm sound/color film, 32 min. in duration, entitled "People-Eco Action" was produced and shown to a large audience in Mpls.

Project-related Publications:

Gerlach, L.P. May 1970. Eco-Gemini: Two for the Teach-In. Natural History

Gerlach, L.P. June 1970. Eco-Valuator: A Questionnaire. Natural Hist.

Gerlach, L.P. Feb. 1970. Participatory Ecology: An Embryonic Social Movement to Improve the Quality of Man's Environment. Mimeographed paper read at Agric. Research, 1980 Planning Conference.

Gerlach, L.P. and V.H. Hine. 1969. Participatory Ecology: The Genesis of a Social Movement. Mimeo. paper read at 1969 meeting of American Anthropology Assoc.

Statements of Project Work Remaining to be Accomplished:

Continue Study of the movement development in selected areas. This will include a survey of study of conflict between movement and established order. Develop a second film and a film strip, and a book.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

a) Processing data collected from monitoring of mass media, especially newspapers, b) conducting a field study by the principal investigator in South Florida and Minnesota on conflict between movement and established order, and c) developing a book summarizing the findings of this research.

OWRR Project No.: B-032-Minn

Matching Grant Agreement No.: 14-01-0001-3097

Project Title: Mississippi River Ecology Associated with Heated Power
FCST Category: V-C (Plant Effluent)

Project Began: July 1, 1969

Scheduled Completion: June 30, 1972

Name & Location of University Where Project is Being Conducted:

St. Cloud State College, St. Cloud, Minn. 56301

Principal Investigator:

Degree:

Discipline:

Alfred J. Hopwood

Ph.D.

Limnology

Student Assistants:

Degree:

Discipline:

R.O. Morgenweck

B.A.

Limnology

J.D. Ott

B.A.

Limnology

H.P. Scherer

M.A.

Limnology

Description of Research Performed and Any Findings, Results, or

Conclusions Relating Thereto:

Forage Fish: Work commenced on the definition of forage fish populations and natural history principally of the minnows (Cyprinidae) inhabiting the Mississippi River above and below the NSP-Monticello Nuclear Generator. A general survey of species was begun during the fall of 1969 from which the following species were identified: Etheostoma nigrum, Hybognathus hankinsoni, Hybopsis biguttata, Notemogonus crysoleucas, Notropis cornutus, N. dorsalis, N. spilopterus, N. stramineus, Percina caprodes, Pimephales notatus, P. promelas, Rhinichthys atratulus, R. cataracte. For determining habitat requirements of the forage fish, several study plots were defined by the placement of steel rods at the 4 corners of each area. Care was taken to match as closely as possible, the apparent characteristics of upstream and downstream study plots. Specific analyses in each study plot included observations on substrate types, vegetative cover, water depth and current velocity in addition to fish species composition and population density. Analysis of forage fish samples included age determination by opercular and scale analysis, length, weight, qualitative and quantitative analysis of stomach and intestinal contents by microscopic and gravimetric methods.

Other Fish: Work which was started in 1968 continued on the determination of migratory activity, population sizes, species composition and physical condition of fishes other than minnows and occasionally encountered residents. 5 study zones extending from 1.1 mi. above to 4.5 mi. below the power plant discharge were delineated. Fish in each zone were captured by electrofishing, measured for length, weighed, tagged, and returned to the approximate location of capture. Scales were removed for later analysis of age in the laboratory. Except for the walleye, which is a strongly migratory species, the fish tended to remain in the same area during the summer months. Concentrations of fish, especially carp, were noted in backwater areas during spring flooding. A summary of fish species composition is given in Table 1. Data on the physical condition of the most numerous game fish and rough fish are given in Tab. 2.

Aquatic plants: A plant survey was initiated in May 1969 to ascertain species composition, population density and associated factors of substrate, depth and current velocity in areas where plants were present and absent. Vegetation in much of the 5.6 mile study area was sparse and diffuse. Species of underwater plants observed were: Potamogeton ampli-

Table 1. No. of fish captured by electrofishing and % of ea. species in total catch, Mississippi River, Monticello, Minnesota.

| | Northern Redhorse | Carp | Silver Redhorse | Black Crappie | White Sucker | Small Mouth Bass | Walleye | Bull-head | Rock Bass | Burbot | Northern Pike |
|------------------------|-------------------|------|-----------------|---------------|--------------|------------------|---------|-----------|-----------|--------|---------------|
| Sector A | | | | | | | | | | | |
| Total | 474 | 287 | 73 | 48 | 44 | 18 | 20 | 7 | 3 | 1 | |
| % | 48.6 | 29.4 | 7.4 | 4.9 | 4.5 | 1.8 | 2.0 | 0.7 | 0.3 | 0.1 | |
| Sector B | | | | | | | | | | | |
| Total | 159 | 43 | 24 | 1 | 12 | 5 | 5 | 1 | | | |
| % | 64.1 | 17.3 | 9.6 | 0.4 | 4.8 | 2.0 | 1.2 | 0.4 | | | |
| Sector C | | | | | | | | | | | |
| Total | 70 | 29 | 8 | 33 | 4 | 8 | 2 | 1 | 2 | | 1 |
| % | 44.3 | 18.3 | 5.0 | 20.8 | 2.5 | 5.0 | 1.2 | 0.6 | 1.2 | | 0.6 |
| Sector D | | | | | | | | | | | |
| Total | 68 | 29 | 5 | | 6 | 3 | 3 | | | | |
| % | 59.6 | 25.4 | 4.3 | | 5.2 | 2.6 | 2.6 | | | | |
| Sector E | | | | | | | | | | | |
| Total | 96 | 55 | 2 | 25 | 2 | 12 | 5 | 1 | 2 | | |
| % | 48.0 | 27.5 | 1.0 | 12.5 | 1.0 | 6.0 | 2.5 | 0.5 | 1.0 | | |
| Total of all Sectors | 667 | 443 | 112 | 107 | 68 | 46 | 33 | 10 | 7 | 1 | 1 |
| % of all Fish captured | 51.2 | 26.1 | 6.6 | 6.3 | 4.0 | 2.7 | 1.9 | 0.5 | 0.4 | .05 | .05 |

Table 2. Data indicating physical condition of dominant rough fish & game fish in the Mississippi River near the NSP-Monticello Nuclear Generator, 1969. No's. in parentheses for each species are total population estimates. Age expressed in year (1 indicates fish in its first yr.), lengths in mm, wts. in grams.

| Northern Redhorse (33,376) | | | Carp (21,666) | | | Silver Redhorse (3,576) | | | Walleye (1,609) | | | Smallmouth Bass (1,359) | | |
|----------------------------|--------|--------|---------------|--------|--------|-------------------------|--------|--------|-----------------|--------|--------|-------------------------|--------|--------|
| Age | Length | Weight | Age | Length | Weight | Age | Length | Weight | Age | Length | Weight | Age | Length | Weight |
| 1 | 234.8 | 154.5 | 1 | | | 1 | | | 1 | 318.0 | 318.0 | 1 | 228.5 | 272.0 |
| 2 | 262.5 | 235.7 | 2 | 363.0 | 862.0 | 2 | 107.0 | 107.3 | 2 | 334.0 | 318.0 | 2 | 270.8 | 387.0 |
| 3 | 335.1 | 525.3 | 3 | 402.2 | 1024.8 | 3 | 394.0 | 816.0 | 3 | 273.6 | 209.1 | 3 | 313.4 | 589.6 |
| 4 | 437.8 | 940.8 | 4 | 452.5 | 1359.2 | 4 | 462.0 | 1270.5 | 4 | 325.7 | 320.7 | 4 | 351.5 | 612.5 |
| 5 | 454.9 | 1056.9 | 5 | 472.8 | 1484.7 | 5 | 479.9 | 1355.3 | 5 | 391.3 | 861.7 | 5 | 375.8 | 884.4 |
| 6 | 464.6 | 1142.5 | 6 | 488.2 | 1614.4 | 6 | 507.2 | 1546.1 | 6 | 537.0 | 1406.0 | 6 | 437.0 | 1330.3 |
| 7 | 468.4 | 1134.0 | 7 | 485.8 | 1582.1 | 7 | 499.6 | 1510.7 | 7 | | | 7 | | |
| 8 | 457.0 | 1270.0 | 8 | 544.0 | 2493.8 | 8 | 514.0 | 1723.6 | 8 | 552.0 | 1814.0 | 8 | 470.0 | 1678.0 |
| | | | 9 | 584.0 | 2812.0 | 9 | | | 9 | | | | | |
| | | | 10 | 552.0 | 2087.0 | 10 | 526.7 | 1762.4 | 10 | | | | | |
| | | | | | | | | | 11 | 673.00 | 3901.0 | | | |

folius, P. crispus, P. pectinatus, Elodea canadensis, Ceratophyllum demersum. Juncus sp. a rush was observed, in profusion on much of the low riverbank. During May and June 1969, these emergent plants were underwater and thus, directly contributed to the ecology of the river at that time. Several beds of P. amplifolius were observed above the power plant discharge. Very few plants occurred in the 0.75 mi. zone immediately below the power plant discharge. This is probably due to a reduction in suitability of the habitat for plant growth. This zone is just below the confluence of two large channels of the river. The velocity volume and depth of this stretch is greater than that of areas where plants have been observed. The substrate of boulders, rubble and coarse gravel is unsuitable for the attachment of rooted aquatic vegetation. The greatest density of plants was observed from 2 to 4 miles below the discharge of the power plant. It is clear from this survey that the paucity of aquatic plants in the study area is due primarily to the scarcity of habitats with finely divided sediments and slowly flowing, shallow water.

Invertebrates: An intensive study of macroinvertebrate fauna in the vicinity of the power plant has been conducted continuously since June 1968. A total of 524 artificial substrate samplers were used at 2 control and 6 experimental stations. (Fig. 1). These yielded 25 genera of invertebrates, mostly immature caddisflies, mayflies, and stoneflies. At each station, current velocity, depth and temperature were recorded every 30 days. Samples from the artificial substrates were classified, enumerated, preserved, wet weighed and dry weighed. A qualitative survey of river invertebrates resulted in the identification of 11 orders, 32 families and 66 genera. Marked differences were noted in the species composition of the swift part of the river inhabited by caddisflies and mayflies compared to backwaters, slow shallows and the shoreline where dipterans, isopods, bugs and beetles occurred in larger numbers.

Water quality: Water quality has been observed every 2 weeks at 4 stations in the study area since 1968. Water samples were analysed for dissolved oxygen; biochemical oxygen demand; alkalinity; total, inorganic and organic solids; and phosphate. Bottom temperature has been monitored continuously since July 1969 with the aid of a thermograph at each of the 2 stations above and 7 below the power plant discharge. 3 principal variables in the river habitat which impinge on the living community there are temperature, current velocity, and water depth, therefore, with the exception of temperature, these parameters were measured precisely at biological sampling sites rather than at fixed intervals along the flow within the study area.

Turtles: An analysis of the turtle population in the vicinity of the power plant commenced in July 1969. Hoop nets, surface traps and bottom traps were used to capture specimens. Trionyx mutica, T. spinifera and Chelydra serpentina were the only species captured. Direct observation of turtles with the aid of binoculars were negative for other species of turtles. Each captured turtle was measured for length and width, weighed, and tagged or notched, then released in the area of capture. Between July 7 and Sept. 3, 1969, traps and nets were set 28 times yielding 23 captures, one of which was the recapture of a tagged specimen. Many specimens died in the traps. The stomach contents of these turtles were examined during autopsy. Trionyx stomachs contained crayfish. The single observed Chelydra stomach contained a leaf from an aquatic plant and

some carp scales. Turtles could be captured in one area for 3 or 4 trap-net sets. Further trapping in that area yielded negative results. Movement of the traps to another area produced successful catches. It is concluded either that the turtles became trap-shy or that population naturally feeds in an area for a time, then moves on. In this situation an accurate population estimate would be difficult to obtain.

These studies represent a preoperational baseline against which river ecology may be compared after operation of the NSP-Monticello Nuclear Generator begins operation.

Project-related Publications:

- Hopwood, A.J. 1970. Monticello Ecological Monitoring Program: Progress Report Covering 1969. N.S.P. Co. Minneapolis. 119 p.
McConville, D.R. 1969. Macroinvertebrates of the Mississippi River in the Monticello region. Master's Thesis. St. Cloud State College. 85 p.
Scherer, H.P. 1970. A Fish population study in the Mississippi River at Monticello, Minn. Master's Thesis. St. Cloud State College.

Statements of Project Work Remaining to be Accomplished:

Further work will include continuation of the studies designated Water Quality, Invertebrates, Forage Fish, Other Fish (Macrofish) and Aquatic Plants. A study of birds in the vicinity of the plant, conducted in 1968, will be matched as a postoperational survey in 1971. Much time must be devoted to preparation of complete reports on all phases of the project.

Additional Project Progress Contemplated for the Remainder of Current Calendar Year:

During the summer months work will be concentrated on fish and aquatic plant sampling. Other phases of the project will continue on their normal semi-monthly schedule through the winter.

OWRR Project No.: B-042-Minn

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

FCST Category: VI-B

Name and Location of University Where Project is Being Conducted:

Gustavus Adolphus College, St. Peter, Minn. 56082

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

Principal Investigator: Degree: Discipline:

R.T. Moline Ph.D. Geography

Project Progress Contemplated for the Remainder of the Current Calendar Year:

A thorough review will be made of the literature dealing with environmental perception, specifically perception of water resources and problems. A questionnaire will be prepared for mailing to a stratified sample of persons living in the study area. Personal interviews will be conducted with a selection of people in south central Minnesota.

OWRR Project No.: B-044-Minn

Project Title: Area Financing of Water Resource Development

FCST Research Category: VI-B

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., St. Paul, Minn. 55101

Project Began: July 1, 1970 Scheduled Completion: June 30, 1972

Principal Investigator: Degree: Discipline:

W.R. Maki Ph.D. Agricultural Economics

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Existing financing procedures for water resource development in a west central Minn. 14-county environmental area will be recorded. The spatial distribution of the present financing burdens for water resource development and the present development beneficiaries will be estimated.

OWRR Project No.: B-047-Minn

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

FCST Research Category: VI-E

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., Mpls. Minn 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

Principal Investigator: Degree: Discipline:

R.E. Rickson Ph.D. Sociology

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Industries in Minn. will be selected for analysis according to different technologies of waste treatment, size and location. A case study of 5 firms will be made to allow a full and intensive exploration of industrial water use. Interviews will be conducted with at least 2 executive policy-makers in each of the industries. Instruments for the measurements of technological variables will be constructed and pre-tested.

OWRR Project No.: B-049-Minn

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

FCST Research Category: VI-B

Name & Location of University Where Project is Being Conducted:

Bemidji State College, Bemidji, Minn. 56601

Project Began: July 1, 1970 Scheduled Completion: Sept. 30, 1972

Principal Investigator: J.P. Ludwig Degree: Ph.D.

Discipline: Ecology

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Base-line data relevant to the project area will be obtained through standard sources and compiled. A population and land use survey will be started. Present statutes and ordinances in effect in the project area relating to water use, sanitation regulations and zoning will be compiled. Questionnaires concerning attitudes towards the present status and potential redevelopment of the Mississippi River will be prepared and mailed.

New Courses Developed

University of Minnesota

Me Ag 106. Agricultural Waste Management
Ag En 10. Water Supply, Sanitation and World Food Production

CE 5-421. Water Resources Systems (4 cr). Introduction to water resources systems engineering, includ. the basic concepts, socio-political-legal features and economic objectives; review of mathematical tools such as the differential calculus method, method of steepest ascent, linear programming and dynamic programming; application of systems analysis to water resources systems with reference to water use and allocation, water conveyance systems, reservoirs, systems, and ground water systems.

CE 5-430. Lake, Reservoir and Ocean Hydrodynamics (3 cr.). The hydrodynamics of large 3-dimensional bodies of water are considerably different from those generally associated with rivers and channels. Formation of stratification due to density gradients is but one of the differences.

The course touches upon the following subjects: Heat budget of a large body of water, formation of density stratification, 2-layered stratified flows, multi-layered stratified flows and continuous stratification, design of selective withdrawal and discharge facilities, density currents, wind generated currents and waves, internal waves and internal mixing and exchange processes.

The treatment of these subjects is partly descriptive and partly quantitative. The goal is to provide some understanding of the complex physical and hydrodynamic processes which control transport of mass, energy, and momentum in large bodies of water.

St. Cloud State College

433-533 Aquatic Plants. Taxonomy & ecology of aquatic plants, including vascular plants, mosses and selected algae and fungi. Laboratory.

4 cr. First offered July-Aug., 1969.

434-534 Freshwater Algae. Morphology, taxonomy & ecology of algae of lakes, ponds, streams, bogs and soils. Lab. 4 cr. 1st offered June-July, 1970.

452-552 Water & Sewage Microbiology. Indicators of pollution, determination of numbers and kinds of micro-organisms, standards of pollution, purification of water, microbiology of sewage disposal. Lab. Fall 1970.

4 cr.
649. Limnological Methods. Theory & practice in limnological sampling and analysis, emphasis on plankton, physical and chemical parameters. Lab. 3 cr. Summer 1971.

652 Pollution Biology. Classification of pollutants and their effect on water and air quality, biota, and socio-economics. Remedial methods. Lab. Spring 1971. 3 cr.

660 Fisheries Biology. Natural History, ecology, recreational and

commercial aspects, and special methods. Lab. Fall 1970. 4 cr.

669 Advanced Limnology. Readings and discussions of No. American and international papers. Winter 1970. 3 cr.

New Staff Members Added:

University of Minnesota

B.O. Krogstad, Ph.D. (summer session) School of Public Health
Jack Borchardt, Ph.D. (visiting lecturer) School of Public Health
M. Barton, Watershed Scientist, (visiting lecturer), U.S. Forest Service Lab., Ely, Minn., School of Public Health
P. Goodrich, Ph.D. (Asst. Prof.-Water Quality and Agric. Pollution) Dept. of Agricultural Engineering.
P. Gast, Ph.D. (Clay Mineralogy and Physical Chemistry of Soils) Dept. of Soils Science.

St. Cloud State College

Keith M. Knutson, Ph.D., Limnology, was added to staff in Jan. 1970.

New Research and Training Facilities Other Than Research Equipment Items:

Univ. of Minn.

Two 3,000 gal. flow-through pools have been constructed in the rocky shore area at Castle Danger near Duluth to provide a field facility in which the effect of various pollutants may be studied in terms of their effect upon periphyton exposed to altered Lake Superior water pumped from the lake at the experimental site.

A new rain-simulation facility 8 x 12 ft. in area has been constructed in the Dept. of Civil Engineering and Hydraulics as a teaching aid. It is anticipated that this will permit the demonstration of the effect of rainfall intensity, duration, and patterns on the runoff hydrograph.

INTERDEPARTMENTAL, INTERUNIVERSITY OR REGIONAL AGREEMENTS
CONSUMMATED WITH RESPECT
TO IMPROVED RESEARCH AND TRAINING CAPABILITIES

The Center and the University will enter into written agreements with Gustavus Adolphus College and Bemidji State College to permit those Institutions to participate in the Center's activities. The memorandums of Agreement given below will be executed in connection with approved Fiscal Year 1971 Matching Grant Projects.

MEMORANDUM OF AGREEMENT BETWEEN REGENTS OF THE UNIVERSITY OF MINNESOTA AND
 GUSTAVUS ADOLPHUS COLLEGE

WHEREAS: The Regents of the Univ. of Minn. wish the collaboration of Gustavus Adolphus College with the Water Resources Research Center, Univ. of Minn., in conducting the research project entitled "Spatial Variation in the Perception of Water Resources & Water Problems in South Central Minnesota."

AND

WHEREAS: Gustavus Adolphus College is willing to cooperate with the Univ. of Minn. Water Resources Research Center in carrying out this research.

THEREFORE: Subject to the award of grant funds from the U.S. Dept. of the Interior, Office of Water Resources Research in support of this study, the collaboration between the parties to this agreement during the period from July 1, 1970 to June 30, 1973, will be governed by the terms and conditions as follows

1. Integration of the research with that of the Center: In keeping with the spirit of the law under which the Center was established, the proposed program has been selected for inclusion in the activities of the Center upon the recommendation of the Center Director, in consultation with the Advisory Committee of the Center. Further Planning and work performance in connection with the study will be coordinated through the Center Director's Office.
2. Institute responsibility for the planning, work performance, and reporting of the project: The Center Director or his authorized representative will conduct periodic site visits to consult with the principal investigator and furnish such advice and assistance as will best promote the purposes of the Center program. Gustavus Adolphus College, pursuant to its vouchers, on a quarterly basis only in such amounts as are required to liquidate liabilities connected with the research due and payable during the time period to which the voucher pertains. Expenditures of grant funds shall be made in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

GUSTAVUS ADOLPHUS COLLEGE

REGENTS OF THE UNIVERSITY OF MINNESOTA

 Signature

 Signature

 Name & Title of Official

 Name & Title of Official

 Date

MEMORANDUM OF AGREEMENT BETWEEN
REGENTS OF THE UNIVERSITY OF MINNESOTA & BEMIDJI STATE COLLEGE

WHEREAS: The Regents of the Univ. of Minn. wish the collaboration of Bemidji State College with the Water Resources Research Center, Univ. of Minnesota, in conducting a research project entitled "A Survey of Attitudes towards the Mississippi River as a Total Resource in Minnesota."

AND

WHEREAS: Bemidji State College is willing to cooperate with the Univ. of Minn. Water Resources Research Center in carrying out this research.

THEREFORE: Subject to the award of grant funds from the U.S. Dept. of the Interior, Office of Water Resources Research in support of the study, the collaboration between the parties to this agreement during the period from July 1, 1970 through June 30, 1972, will be governed by the terms and conditions as follows:

1. Integration of the research with that of the Center: In keeping with the spirit of the law under which the Center was established, the proposed program has been selected for inclusion in the activities of the center upon the recommendation of the Center Director in consultation with the Advisory Committee of the Center. Further planning and work performance in connection with the study will be coordinated through the Center Director's Office.
2. Institute responsibility for the planning, work performance, and reporting of the project: The Center Director, or his authorized representative will conduct periodic site visits to consult with the principal investigator and furnish such advice and assistance as will best promote the purposes of the Center program.

Bemidji State College will provide the Univ. of Minn. with annual progress and financial reports and other periodic reports as required in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

Grant funds will be forwarded to Bemidji State College, pursuant to its vouchers, on a quarterly basis only in such amounts as are required to liquidate liabilities connected with the research due and payable during the time period to which the voucher pertains.

Expenditure of grant funds shall be made in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

BEMIDJI STATE COLLEGE

REGENTS OF THE UNIV. OF MINN.

Signature

Signature

R.D. Decker, President

Name & Title of Official

Date

Student Enrollment in Water-related Fields During Period July of Last Year (Summer Term) Through June of This Year (Spring Term).

University of Minnesota

| | <u>No. Enrolled</u> | | <u>No. Graduating</u> | |
|---------------------------------|---------------------|--------------------------|-----------------------------|--------------|
| | | <u>With OWRR Support</u> | <u>Without OWRR Support</u> | <u>TOTAL</u> |
| Juniors | not applicable | --- | --- | --- |
| Seniors (B.S. degree candidate) | 20 | 4 | 15 | 19 |
| Master's degree students | 30 | 2 | 10 | 12 |
| Doctoral degree students | 21 | 3 | 8 | 11 |
| Postdoctoral degree students | 0 | 0 | 0 | 0 |

No. of Students Using Equipment & Supplies Purchased Wholly or in Part with P.L. 88-379 Funds:

University of Minnesota

| <u>Category of Students</u> | <u>Number Using Equipment, Supplies, etc.</u> |
|-----------------------------|---|
| Undergraduates | 14 |
| Master's Students | 41 |
| Doctoral Students | 24 |
| Postdoctoral Students | 1 |

No. of Students Receiving Employment Through The P.L. 83-379 Program

University of Minnesota

| <u>Category of Students</u> | <u>No. by Scientific Disc. or Major Field of Study</u> | |
|-----------------------------|--|---|
| Undergraduates | Agricultural Engineering | 1 |
| | Chemistry | 2 |
| | Civil Engineering | 1 |
| | Forestry | 1 |
| | Home Economics | 1 |
| | Horticulture | 1 |
| | Journalism | 1 |
| | Limnology | 1 |
| | Public Health | 1 |
| | Soil Science | 2 |
| Master's Students | Agricultural Economics | 2 |
| | Botany | 1 |
| | Civil Engineering | 3 |
| | Ecology | 1 |
| | Horticulture | 1 |
| | Limnology | 2 |
| | Soil Science | 2 |
| Doctoral Students | Agricultural Engineering | 1 |
| | Anthropology | 1 |
| | Civil Engineering | 3 |
| | Horticulture | 2 |
| | Limnology | 2 |
| | Public Health | 2 |
| | Soil Science | 1 |
| | Zoology | 1 |

Employment Status of Majors in Water-related Fields Who Graduated During the School Year Ending About June

University of Minnesota

| <u>EMPLOYMENT STATUS</u> | <u>CATEGORY OF SCHOOL YEAR GRADUATES BY DEGREE OBTAINED</u> | | | |
|--|---|----------------------------------|---------------------------------|---------------------------------------|
| | <u>Bachelor's Degree</u> | <u>Master's Degree</u> | <u>Doctoral Degree</u> | <u>TOTAL</u> |
| <u>No. employed in water related positions in:</u> | | | | |
| Federal Agencies ----- | $\frac{1}{2}$ | $\frac{2}{4}$ | $\frac{3}{6}$ | ----- |
| State Agencies ----- | $\frac{0}{2}$ | $\frac{0}{2}$ | $\frac{0}{4}$ | ----- |
| Colleges & Universities----- | $\frac{0}{0}$ | $\frac{1}{0}$ | $\frac{1}{0}$ | ----- |
| Other-Such as Private----- | $\frac{0}{2}$ | $\frac{0}{1}$ | $\frac{0}{3}$ | ----- |
| No. graduates returning to school for advanced degrees ----- | $\frac{1}{4}$ | $\frac{0}{0}$ | $\frac{1}{4}$ | ----- |
| No. going into military service ----- | $\frac{0}{0}$ | $\frac{0}{0}$ | $\frac{0}{0}$ | ----- |
| No. unemployed or working in other fields ----- | $\frac{0}{0}$ | $\frac{0}{0}$ | $\frac{0}{0}$ | ----- |
| No. status unknown----- | $\frac{4}{15}$ | $\frac{0}{0}$ | $\frac{0}{0}$ | $\frac{4}{15}$ ----- |
| TOTALS----- | $\frac{4}{15}$ | $\frac{2}{10}$ | $\frac{3}{3}$ | $\frac{9}{33}$----- |

Note: Graduates who received OWRR support above dotted line, and those who received no financial support from OWRR below dotted line.

Type of Employment of Those School Year Graduates Known to Have Gone Into Water-Related Positions.

University of Minnesota

| No. of Graduates engaged in water related work in: | CATEGORY OF SCHOOL YEAR GRADUATE BY DEGREE OBTAINED | | | |
|--|---|-----------------|-----------------|-------|
| | Bachelor's Degree | Master's Degree | Doctoral Degree | TOTAL |
| <u>University or College:</u> | | | | |
| Teaching Primarily----- | 0 | 0 | 0 | 0 |
| Research Primarily----- | 0 | 0 | 0 | 0 |
| Research & Teaching----- | 0 | 1 | 1 | 1 |
| Agency or Private Water Resources Research----- | 0 | 1 | 1 | 1 |
| Operations & Management----- | 0 | 0 | 0 | 0 |
| Planning----- | 0 | 1 | 1 | 1 |
| Other Water Resources Work: | | | | |
| Unknown----- | 4 | 1 | 0 | 5 |
| | 15 | 0 | 2 | 17 |
| TOTALS----- | 4 | 1 | 3 | 8 |
| | 15 | 6 | 8 | 29 |

Note: Graduates who received OWRR support above dotted line and those who received no financial support from OWRR below dotted line.

Identify by name & discipline and briefly describe instances, if any, in which the institute program, in the past year, has resulted in individuals, other than students, doing research or teaching in the water resources field who, previously, were not involved in water work.

None

Cite any instances you know in which individuals who previously served as student research assts. on P.L.88-379 projects, are now serving as professional investigators of P.L. 88-379 projects following graduation. Do not include individuals reported in this category last year or before.

None

PROJECT-RELATED REPORTS & THESES PUBLISHED DURING FY 1970

Reports

Anon. 1969. Inventory of Water Resources Research Conducted in Minn., 1963-65. Univ. of Minn., Water Resources Research Center. Bull. 12

Anon. 1969. Water Pollution by Nutrients-Sources, Effects & Control. Univ. of Minn., Water Resources Research Center. Bull. 13.

Anon. 1969. Graduate Education in Water Resources at the Univ. of Minn. Univ. of Minn., Water Resources Research Center. Bull. 15.

Anon. 1969. Fifth Annual Report of Water Resources Research Center. Univ. of Minn., Water Resources Research Center, Bull. 16.

Anon. 1970. Information Concerning Water Resources Research Center Projects, 1965-70. Univ. of Minn., Water Resources Research Center. Bull. 19.

Arya, L.M. & G.R. Blake. 1970. Stability of Sheared-generated Soil Aggregates. Agronomy Jour. 17 p., 6 fig., 2 tab., 15 ref.

Baker, D.G. 1970. Winter Soil Temperatures at St. Paul, Minn. Proc. of the Soil Sci. Soc. of Amer.

Bowers, C.E., A.F. Pabst & S.P. Larson. 1970. Computed Program for Statistical Analyses of Floods by Log-Pearson Type II Method. St. Anthony Falls Hydraulic Laboratory Computer Program. No. 1. 20 p.

Chamberlain, W. & J. Shapiro. 1969. On the Biological Significance of Phosphate Analysis: Comparison of Standard & New Methods with a Bioassay. Limnology & Oceanography 14:921-923.

Fox, J.L., T.O. Odlaug and T.A. Olson. 1969. The Ecology of Periphyton in Western Lake Superior. Part I - Taxonomy and Distribution. Univ. of Minn., Water Resources Research Center. Bull. 14. 127 p., 87 fig., 24 tab., 79 ref.

Gerlach, L.P. May 1970. Eco-Gemini: Two for the Teach-In, Natural History.

Gerlach, L.P. June 1970. Eco-Valuator: A Questionnaire. Natural History.

Johnson, J.M., T.O. Odlaug, T.A. Olson, and O.R. Ruschmeyer. 1970. The Potential Productivity of Fresh Water Environments as Determined By an Algal Bioassay Technique. Univ. of Minn., Water Resources Research Center. Bull. 20. 101 p., 36 fig., 5 tab., 6 pl., 83 ref.

Megard, R.O. 1969. Algae & Photosynthesis in Shagawa Lake, Minn. Univ. of Minn., Limnological Research Center. Interim Report No. 5. 20 p., 5 fig., 10 tab., 8 ref.

Megard, R.O. 1969. Phytoplankton, Photosynthesis & Phosphorus in Lake Minnetonka, Minn. Limnology & Oceanography. 44 p., 20 fig., 10 tab.

Parkos, W.G., T.A. Olson & T.O. Odlaug. 1969. Water Quality Studies on the Great Lakes Based on Carbon-14 Measurements on Primary Productivity. Univ. of Minn., Water Resources Research Center. Bull. 17. 121 p., 38 fig., 35 tab., 72 ref.

Stokes, L.W., T.A. Olson & T.O. Odlaug. 1970. The Photosynthetic Pigments of Lake Superior Periphyton and Their Relation to Primary Productivity. Univ. of Minn., Water Resources Research Center. Bull. 18. 150 p., 110 fig., 26 tab., 168 ref.

Theses

- Arya, L.M. Dec. 1969. Stabilization of Shear-generated Soil Aggregates. Univ. of Minn., Dept. of Soil Science. M.S. Thesis. 63 p., 14 tab., 8 fig., 48 ref.
- Chyi-Sheng Hwang. Oct. 1969. Wet Strength of Silica-diluted Synthetic Soil Aggregates. Univ. of Minn., Dept. of Soil Sci., M.S. Thesis. 48 p., 9 tab., 12 fig., 38 ref.
- Johann, D. 1970. A New Fluorescent Technique for the Determination of Changes in Selected Phytoplankton Populations in Lotic Aquatic Ecosystems. St. Mary's College, Biology Dept. M.S. Thesis.
- Gibson, U.P. June 1970. Integrating Water Quality Management into Total Water Resources Management in Minn. Univ. of Minn., School of Public Health. Ph.D. Thesis. 376 p., 53 fig., tab. 14, ref. 112.
- McConville, D.R. 1969. Macroinvertebrates of the Mississippi River in the Monticello Region. St. Cloud State College, Biology Dept. M.S. Thesis 85 p.
- Scherer, H.P. 1970. A Fish Population Study in the Mississippi River at Monticello, Minn. St. Cloud State College, Biology Dept. M.S. Thesis.
- Wei, T.C. June 1970. Effects of Areal & Time Distribution of Rainfall on Runoff Hydrographs. Univ. of Minn., Dept. of Agricultural Eng. Ph.D. Thesis. 195 p., 31 fig., 28 tab., 71 ref.

FISCAL YEAR 1970 BUDGET

Annual Allotment Program

| | <u>Budget Fed. Funds</u> |
|--|--------------------------|
| <u>Center Director's Office</u> | \$ 23,370 |
| <u>Projects Continuing from FY 1969</u> | |
| Primary productivity of selected Minn. Lakes - Wright, Limnological Research Center (A-016-Minn) | \$ 11,950 |
| Effects of areal & time distribution of runoff supply on watershed hydrographs - Larson, Dept. of Agric. Engineering (A-017-Minn). | \$ 7,200 |
| Methodology for integrating water quality management with management of the total water resources in Minn. - Straub, School of Public Health (A-018-Minn). | \$ 14,400 |
| Economics of Water Quality Control in the Upper Mississippi River, Minnesota, - Waelti, Dept. of Agricultural Economics (A-019-Minn) | \$ 13,550 |
| Evaluation of Selected Computer Programs in Hydrology - Bowers, St. Anth. Falls Hydr. Lab. (A-020-Minn) | \$ 7,767 |
| <u>New Projects</u> | |
| Water Resources Administration in Minnesota, - Walton Graduate School (A-021-Minn). | \$ 12,763 |
| Zooplankton Biomass and Incipient Eutrophication in Lake Superior - Olson, School of Public Health (A-022-Minn). | <u>\$ 9,000</u> |
| <u>Annual Allotment Program</u> | TOTAL |
| | <u>\$100,000</u> |

Matching Grant Program

| | <u>Federal</u> | <u>Budget</u> <u>Non-Fed.</u> | <u>Total</u> |
|---|----------------|----------------------------------|--------------|
| | <u>Funds</u> | <u>Funds</u> | |
| <u>Projects Continuing from FY 1969</u> | | | |
| Relation of phosphorus in lake-bottom deposits & pollutional history of Minn. Lakes-J. Shapiro Limnological Research Cntr. (B-009-Minn) | \$ 17,091 | \$ 17,451 | \$ 34,542 |
| Development of a mathematical model to predict the role of surface runoff and ground-water flow in overfertilization of surface waters - Straub, School of Public Health (B-012-Minn) | \$ 10,064 | \$ 13,205 | \$ 23,269 |
| Influence of mist irrigation on moisture stress, growth, yields and quality of potatoes and other vegetable crops - Nylund, Department of Horticultural Science (B-013-Minn) | \$ 11,989 | \$ 11,989 | \$ 23,978 |
| Characteristics of the soil matrix that affect water storage & movement - Blake, Dept. of Soil Science (B-015-Minn) | \$ 16,607 | \$ 17,384 | \$ 33,991 |
| <u>New Projects</u> | | | |
| Pollution & the Ecology of nearshore periphyton of Lake Superior - Olson, School of Public Health, (B-020-Minn) | \$ 16,199 | \$ 16,199 | \$ 32,398 |
| Participatory Ecology: A study of citizen's groups involved at the grass roots to improve the water resources environment - Gerlach, Dept. of Anthropology (B-031-Minn) | \$ 6,321 | \$ 9,061 | \$ 15,382 |
| Mississippi River Ecology Associated with Heated Power Plant Effluent - Hopwood, Dept. of Biology, St. Cloud State College (B-032-Minn) | \$ 18,423 | \$ 16,923 | \$ 35,346 |
| <u>Matching Grant Program Total</u> | \$ 96,694 | \$102,212 | \$198,906 |