ANNUAL TECHNICAL REPORT

1972-73

IMPROVING CAPACITY OF CUSUSWASH UNIVERSITIES FOR WATER MANAGEMENT FOR AGRICULTURE

REPORT NUMBER IV

COLORADO STATE UNIVERSITY

Grant No. AID/csd 2460
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COLORADO STATE UNIVERSITY 211(d) GRANT ANNUAL REPORT

Title: "Optimum Utilization of Water Resources: With Emphasis on Water Delivery and Removal Systems and Relevant Institutional Building"

Grantee: Colorado State University

Director: Dr. Maurice L. Albertson

A. STATISTICAL SUMMARY:

Period of Grant: 23 May 1969 to 22 May 1974

Amount of Grant: $750,000

Expenditures for Report Year $185,391 Accumulated $621,446

Anticipated for next year $128,554 (Final year of Contract)

B. NARRATIVE SUMMARY:

The area assigned to Colorado State University under the 211(d) Grant is entitled, "Optimum Utilization of Water Resources: With Emphasis on Water Delivery and Removal Systems and Relevant Institutional Development". This program involves participation by six departments: Agricultural Engineering, Agronomy, Civil Engineering, Economics, Political Science, and Sociology. Traditionally, engineers and agriculturists working in the areas of water delivery and removal systems have only a limited understanding of the related institutional structure which is required for the successful operation of water systems. Therefore, a primary purpose of this 211(d) Grant program is to improve the competence of the University by developing the knowledge and understanding not only in the technical fields but also by recognizing the concomitant need to analyze prevailing social systems as they affect water delivery and removal -- including the kinds of institutional changes necessary, the sources of resistance to change, and effective ways of dealing with various forms of social resistance to innovative forms of water delivery and removal. Thus, one of the

characteristics of the University's participation in the 211(d) Grant program is its inclusion of social, economic and cultural factors along with engineering, agricultural and other technological considerations. The results have brought about remarkable progress in the capabilities, dimensions of understanding and competence of the University in reaching the objectives of the Grant.

Because of the complex nature of the physical, financial, and technological constraints placed upon the optimal use of water delivery and removal systems, including relevant institutional structures, the participating disciplines feel that solutions may best be found through a comprehensive interdisciplinary approach. The various departments involved in the Grant program have strengthened and improved their activities with regard to and in support of the Grant objectives through:

- Adding faculty members who have expertise in water delivery and removal.
- Teaching courses in the subject areas to students in engineering, agriculture, economics, and the social sciences.
- Guiding the research activities of faculty and research assistants in the subject areas.
- Supporting and guiding the research assistants who are interested in the subject areas.
- Publication of technical reports.
- Developing linkages throughout the world on common areas of concern.

In general, the six participating departments are increasingly able to meet the requirements of the 211(d) Grant through:

- Close cooperation and coordination of their 211(d) activities with each other.
- A deeper understanding of the role of each department for the theme of the Grant program.
- Establishment by each department of benchmark data and literature applicable to the Grant objectives.

Developing capabilities within each department to respond to water delivery and removal problems through orienting and training students and faculty to the issues of development study of the larger questions of utilizing water and other natural resources for the achievement of planned change.

The Colorado State University accomplishments over the past four years of the Grant program have generated far greater entrainment effects and other benefits than was realized when looking at the program annually in a piece-meal fashion. As a consequence, the net accrued benefits have greatly improved the capability of CSU to achieve planned change and thus has made Colorado State University a better institution for foreign and national students to take up advanced and specialized studies in water delivery and removal systems including relevant institutional development.

The work of the faculty and research assistants in the six participating departments carried on during the reporting year is given in more detail in the following sections of this report. In addition, the four (4) year accumulated benefits, including entrainment effects and linkage growth, are brought into perspective in the Appendices D through K.

C. DETAILED REPORT

I. General Background and Purpose of the Grant

1. Background

Water management has been established as a critical and limiting factor in increasing agricultural productivity throughout the world. This is especially true in the case of developing countries. The need for more efficient use of water to increase agricultural productivity has not only been well stated in many reports and publications, but the necessity of introducing good delivery and removal systems is now widely accepted throughout the world. Attaining efficient water use in the United States, particularly in the west, occupies a high level of priority in specific U.S. Government organizations and in public and private water user organizations. The many national and international organizations and institutions in the world today dealing with water use for the purpose of increasing agricultural productivity is ample testimony to its importance in other countries as well.

Water management for agriculture is a complex subject embracing many individual arts and sciences involving such activities as protecting or reclaiming land from excess precipitation or flooding, husbanding or managing soil moisture, optimizing cropping practices to the moisture regime, impoundment of water, distribution and application of irrigation water supplies, coordinated management of watershed areas, and the development and maintenance of institutional capability necessary for support of water-related aspects of agricultural operations.

While all the CUSUSWASH universities have varying capabilities in the water management fields, extending the capacity for international service had to be coordinated, both for sharing research results and for optimum utilization of funding by the Agency for International Development. Based on these concepts and considering existing capabilities and interest

of the several universities, Colorado State University began activities in the field of optimum utilization of water resources with special emphasis on water delivery and removal systems including relevant institutional development. The following pages depict the type of activities undertaken by Colorado State University during the reporting period:

- Water supply development
- Structures for conveyance
- Delivery and drainage
- Impoundment and storage of water
- Control and measurement of water
- Control of erosion and sedimentation
- Use of wells
- Systems analysis for optimal utilization of water
- Economic allocation of water
- Acquiring and/or developing a concomitant understanding of social systems, culture and process of change to better accomplish a usually difficult and complex task of transferring technology and related institutional building to developing countries.

2. Purpose

The stated purpose of the CSU 211(d) Grant is to improve CSU's level of excellence with respect to planning, development, management and utilization of water resources with special emphasis on water delivery and removal systems and relevant institutional development related to the needs of the developing countries. This purpose is being realized by

increasing CSU's capabilities in:

- Improvement of teaching capability
- Increased research competence
- Increased capacity for consulting and service, and
- Increased involvement in international development programs.

Improving teaching ability, for example, involves not only specific knowledge of the state of technological advancement in foreign countries, but also awareness of their economic, social, cultural and educational conditions. Such knowledge is of great help to the professor in developing new courses, revising and up-dating old courses, teaching, and helping the foreign student to design his graduate program to be most useful to him when he returns to his home country.

During the past 4 years, CSU's competence and capabilities in international service has also greatly increased. CSU could not have reached this level of service ability, for example, as attained in the water management research project in Pakistan, had it not been for the 211(d) Grant program.

II. Objectives of the Grant

The objectives and scope, subject areas, and operational plan of the Grant program are briefly summarized below. However, the full text of the Grant Document, as related to the foregoing, may be found in Appendix A of this report.

1. Objectives and Scope

- Improving and expanding professional staff
- Expanding the number of graduate students
- Expanding research programs
- Expanding and improving course offerings
- Expanding special activities such as seminars, exchange programs, institutes, conferences, and publications
- Helping to alleviate the shortage of qualified professional personnel

- Expanding staff and institutional capability to serve in advisory and consulting capacities
- Improving understanding of the nature of the less developed societies
- Exchange of personnel and publications
- Programs of interaction with other groups and individuals
- Establishing linkages and lines of communication between CSU and the less developed countries.

2. Subject Areas Assigned

- Water supply and development
- Water storage
- Water conveyance and control structures
- Water delivery structures
- Water measurement
- Control of erosion and sedimentation
- Development and use of wells
- Drainage components and systems
- Social, political and cultural aspects of institutional development
- Processes of change
- Economic analyses of water systems
- Systems approach to analysis of water development and utilization
- Develop and analyze case studies of water systems.

3. Operational Plan

For the less developed countries:

- Assemble and analyze information on water delivery and removal systems
- Develop research programs which will increase knowledge of methods, techniques, and procedures for optimizing the utilization of water resources
- Increase the breadth and depth of teaching

- Solicit well qualified research assistants from both the U.S. and abroad
- Develop a program of student and faculty exchange
- Expand the library collection
- Plan, initiate and expand an interdisciplinary seminar on development and the interrelationship of the many factors involved in development--especially in the less developed countries.

These objectives, areas of study and operational plans for CSU do not stand by themselves, but they are part of an interlocking effort coordinating equally broad goals of the Water Management Research program and a variety of CUSUSWASH activities. In the tabulation, Fig. 1, is shown a general summary of the overlapping goals and objectives of the interrelated programs.

The lists in Fig. 1 not only indicate the interrelationship of goals in the variety of programs associated with the 211(d) Grant, but also serve as a framework for a better evaluation of specific objectives pursued, and of activities undertaken for their implementation.

4. Review of Objectives

With regard to the foregoing stated objectives, Colorado State University feels that these objectives served effectively as guideposts during the past four (4) years with respect to planning, development, management, and utilization of water resources as applied to water delivery and removal systems, and relevant institutional development. The six participating disciplines have provided the main intellectual stimulus and thrust to the program which in turn has attracted many graduate students and professors from other disciplines who are intrigued not only with the interdisciplinary approach but also with the international character of water management problems. Just as undergraduate and graduate students are required to take courses which in the beginning may be considered by some of them to be unrelated to what they wish to study, so the 211(d) program must

Fig. 1. INTERRELATIONSHIP OF GOALS*

A. Broad Goals of AID

1. Increased number and level of competence of manpower
2. Interdisciplinary approaches to research
3. Information and knowledge
4. To assist the developing countries

B. 211(d) Grant Goals

(In-house)

1. Expand professional staff
2. Expand graduate students
3. Expand research programs
4. Expand course offerings
5. Expand special activities
6. Expand qualified personnel in international matters
7. Expand advising and consulting
8. Understand nature of LDC's
9. Establish lines of communication between LDC and CSU

(Subject Areas)

1. Water supply and development
2. Water Storage
3. Water conveyance and control structures
4. Water delivery structures
5. Water measurement
6. Control of erosion and sedimentation
7. Development and use of wells
8. Drainage components and systems
9. Social, political and cultural aspects of institutional development
10. Processes of change
11. Economic analyses of water systems
12. Systems approach to analysis of water development and utilization
13. Development and analyze case studies of water systems

C. Water Management Research Program

Goals (On-campus)

1. Methods of skimming
2. Mineralogical analysis
3. Conjunctive use of groundwater and surface water
4. Farm turnouts
5. Use of saline water
6. Organization and administration of water management
7. Acceptance and use of water innovations

(Pakistan)

1. Land preparation
2. Use of saline groundwater
3. Classification of irrigation waters
4. Data limitations
5. Economic analyses

D. CUSUSWASH (Universities activities)

1. Determine technical needs of LDC's
2. Determine methods of meeting technical needs
3. Determine areas of interest
4. Conduct joint activities

(Council objectives)

1. Mobilize capabilities of members
2. Exchange and communication
3. Provide professional staff
4. Uniform procedures and coordination
5. Exchange of personnel
6. Represent common interests

*Partial list only

include a fairly wide range of related knowledge before successful transfer of such knowledge can be passed on to graduate students, professors and others. CSU believes that this approach has resulted in marked increase in University competence not only in water delivery and removal systems, including relevant institutional development, but in adding substantially to to the surrounding body of knowledge for agricultural development in the developing countries. For example, the Department of Economics, wishes to emphasize the plight of the small farmer and the meager resources he has (water is only one of a number). Sociology and Political Science also view the CSU Grant objectives on a broader basis. Yet these disciplines and the others have added much, and will continue to do so, to existing knowledge concerning water delivery and removal systems as well as making valuable new and fresh contributions towards solutions of age old problems of development in the less developed countries.

CSU is quite aware of the project constraints and the limitations of research work and other activities imposed by the Grant objectives and the necessity to remain in-bounds. Nevertheless, it should be noted that a too restricted viewpoint of the objectives tends to turn off the intellectual bombardment of problems which to date have not been solved and only recently have the Universities been asked for their input. In the light of experience garnered by both AID/Washington and the University during the past four (4) years, including other factors bearing on the foregoing brought on by the changing world, a review of these objectives and possibilities of extending the Contract period might well be considered.

III. Colorado State University Accomplishments

A primary thrust of the CSU program has been the improvement of the manpower resources, the information resources, and the institutional resources focused on an area study of water delivery and removal factors. CSU accomplishments in this area of Grant objectives involve a systematic approach to solving problems.

One approach which has been used by CSU is the development wheel. Briefly, this is based on the concept that man is motivated by his values and attitudes to take action and provide the thrust driving the developing wheel. Man acquires and uses information, processes and systems by working through institutional resources as vehicles. There is a variety of linkage mechanisms between stages of the development process with feedback to the various subsystems. For additional detail, see Appendix L.

Having briefly described the setting from which CSU accomplishments have materialized, the criteria used for measuring successful accomplishment should be examined.

1. Accomplishment Criteria

The criteria used for measuring successful accomplishment include: willingness of faculty to serve short or long terms abroad as advisors or consultants; attendance of all personnel at seminars and conferences; number and relevance of new courses developed, old courses revised and improved, and all courses taught; amount of student advising on water resource development; participation in research activities; service and consulting activities in and/or for developing countries; number and relevance of publications completed; linkages established; entrainment accomplished; and CUSUSWASH activities.

A primary thrust of the CSU program has been the improvement of the manpower resources, the information resources, and the institutional resources stressed in the foregoing pages which are needed for better and more efficient and effective development and utilization of the water resource

within the constraints of other natural resources, and the financial, legal, cultural and political resources (see the Development Wheel, Fig. 2). To this end, efforts have been concentrated on: improvement of faculty and staff, curriculum improvement, technical publication, library improvement, seminars, graduate students, meetings and travel, service, linkages, entrainment, and CUSUSWASH activities.

CSU has taken the position that improvement of faculty and staff can result from both adding new personnel, who already have most or all of the qualifications desired, and improving the knowledge, experience, and ability of existing staff. To this end, nineteen (19) new staff have been added and more than 40 existing staff members have improved their capability as a result of the 211(d) activities. Appendix F is a tabulation of these faculty and staff members.

2. Reporting Year Accomplishments

The six participating departments maintained close coordination with each other during the reporting year and were better able than ever before to meet the requirements of the Grant program and to respond to water delivery and removal problems through training of students and faculty to the issues of development as well as to the larger questions of utilizing water and other natural resources for the achievement of planned change.

a. Improvement of Faculty and Staff

Dr. Alan C. Early was recruited by the Department of Agricultural Engineering to start in September 1973. He will work on international aspects of water delivery and removal systems. His area of specialty focuses on water management in tropical agriculture and will provide new expertise to the University in areas needing further development through teaching, research and consulting and advisory services.

The expertise at the University, fostered and developed by the 211(d) Grant, qualified Dr. William E. Hart to participate as an invited speaker to a conference held at the University of Nigeria, Ibadan, October 23-27, 1972. The title of his paper was, "Prospects for Irrigation in West Africa". The conference was sponsored by the Ford Foundation, the L'Institute de Recherches Agronomeques Tropicales et des Cultures Vivrieres, and the International Institute of Tropical Agriculture. This conference focused on many aspects of irrigation including water delivery and removal systems. Dr. W. Doral Kemper, representing both the Agricultural Engineering and Agronomy Departments, was also present and presented a paper entitled, "Irrigation Agronomy". In this instance, only a small amount of 211(d) Grant funding was utilized to cover travel expenses.

During the report period, Professors Gaylord V. Skogerboe, Wynn R. Walker, and others, produced four (4) papers published in several scientific journals. The titles and authors are given in the following section b, "Publications", and also in more detail in Appendices D and E.

The Department of Agronomy continues to support the agricultural components that are significant to planning and development of irrigation projects. Emphasis continues to be placed on teaching and research that apply to water delivery and removal systems and related institutional development. Competence of the Agronomy staff has been increased by 1) attending and participating in the International Interdisciplinary Seminars sponsored by the 211(d) Grant program, 2) participating in College of Agricultural Sciences Seminars on Foreign Agriculture, and 3) research in water resource development. As a direct result of increasingly greater exposure to domestic and international water delivery and removal systems and related water resources development problems, the staff has been able to include selected examples of such problems in regular course work and has become far more proficient in advising students interested in foreign service.

Dr. John Reuss was in charge of the International Interdisciplinary Seminar for the 1973 winter quarter, which concerned itself mainly with the modeling of water supplies for irrigation projects. Dr. Robert Danielson assisted by discussing agronomic concepts of delivery - removal aspects of a model. The seminar in Foreign Agriculture in the College of Agriculture Sciences was conducted by the Associate Dean, Dr. William Thomas at no cost to the 211(d) Grant Program. However, staff members from the Department of Agronomy who were participants in the International Interdisciplinary Seminar, took primary responsibility in the sessions concerned with water resource development including water delivery and removal systems and relevant institutional development. Finally, research under the direction of Dr. Arnold Klute is being conducted to determine soil physical properties that influence the amount and chemical composition of the drainage water from irrigated land. Two research assistants, Mr. Jacob Dane, supported by 211(d) Grant funds, and Mr. T. K. Glas, supported by OWRR, are working on the project. The effort is interdisciplinary with the Department of Agricultural Engineering.

During the past year, Dr. Daryl B. Simons was chairman of the CUSUSWASH Executive Committee. He contributed much of his time to policy and high level decisions regarding CSU's participation in the 211(d) Grant program. He has been and continues to be a solid supporter of the 211(d) Grant program as well as other international programs at no cost to the Grant. Dr. Maurice L. Albertson, the Director of the Grant program at CSU, spent a great deal of time with the participating faculty in discussing and working out with each department head how best to meet Grant objectives with limited Grant funding. He also gave freely of his time to many research assistants who frequently needed his advice. As Chief of Party of a group of four (4) professors from CSU he gave a paper entitled, "Integrated Approach to Irrigated Agriculture" at an irrigation conference held at Ibadan, Nigeria. The other three (3) members also

also gave papers as indicated under department headings. In addition, he made a number of other valuable contributions to the cause of the 211(d) Grant program described in other sections of this report, thus increasing the entrainment effects of the Grant program. Dr. Everett V. Richardson has assisted in planning and organizing the work of research assistants and in research design supporting Grant objectives. Drs. Albert G. Mercer and Khalid Mahmood have also given their services -- mostly without Grant support -- to research assistants working on some aspects of water delivery or removal systems who are supported by Grant funds.

Last year it was reported that two new faculty members had joined the College of Engineering, Drs. Willis W. Shaner and John W. Labadie. Dr. Shaner continues to teach engineering courses directly related to water delivery and removal systems; developed a new course, "Water Resources Project Planning in the Developing Countries"; gave three seminars in economics of water resources; prepared an outline for the economic portion of a handbook on water resource systems engineering being organized by Dr. Labadie; and advises candidates for the M.S. and Ph.D. degrees. Dr. Labadie is not only working on the handbook, but also continues his work on the development of methodology and models to improve water delivery and allocation. He, like Dr. Shaner, contributes much of his time to planning and supervising the work of research assistants related to water delivery and removal systems and relevant institutional development. Substantial support from 211(d) Grant funding was essential for the initial period required for both men to be absorbed into the University system. Now only nominal Grant funding is required even though both men are contributing as much or more work for the Grant program than ever before. This is another example of the entrainment effect of the Grant program.

The Department of Economics continues to offer a number of graduate and undergraduate courses that are directly supportive of the 211(d) Program at no expense to the project. These courses are in the areas of: agricultural economics, development economics, and water and natural resources economics. These courses have been experiencing increased enrollments of non-economics majors. This fact is explained partially by the increased awareness that the optimal utilization of water resources requires an interdisciplinary, systems approach--a fact that has been emphasized by the International Interdisciplinary Seminar and the 211(d) Program. The 211(d) Grant program provided the opportunity for Dr. George E. Radosevich to become known both at home and abroad as an expert in legal and institutional constraints affecting water resources management. He also served as a consultant for USAID on a feasibility study of water resources development in Nigeria at no expense to the Grant, and later provided assistance in revising the water laws of Pakistan at the request of USAID. In December 1972, Dr. Radosevich was granted a year's leave from CSU to serve with the United Nations as Economic Affairs Officer, Resources and Transportation Department, Water Resources Division.

Dr. Huntley H. Biggs continued his research efforts on the technological and institutional constraints on resources management including delivery and utilization of water for small farm agricultural improvement in developing countries. He chaired a series of presentations on this subject for the International Interdisciplinary Seminar during the winter quarter 1973. He also went to Guatemala for purposes of consultation with the Minister of Agriculture, and supervise the thesis work of Christopher Dowswell, a research assistant. Dr. Ronald L. Tinnermeier participated in conferences and workshops dealing with the problem of the lack of credit institutions which forms a major constraint affecting the optimal utilization of resources and the introduction of new technologies on small farms. The 211(d) Program was the catalyst for much of his work since it provided sufficient released time for other university responsibilities for the

preparation of papers on small farmer credit institutions. This initial work set the stage for participation in other workshops on small farmer development strategies financed by the Agricultural Development Council and for heavy participation in the AID-Spring Review of Small Farmer Credit in 1973. Dr. Gene C. Wilken, Geography, worked on resources management on small farms including water resources development. It is his belief that there is much to be learned from current management practices on these low energy-using farming operations in devising strategies for increasing agricultural production efficiency. Only a small amount of Grant funds triggered the foregoing activities by these three professors.

Professor Henry P. Caulfield of the Political Science Department has an international reputation in the water resources field. He now teaches both graduate and undergraduate level courses, supervises the work of research assistants, and directs the International Interdisciplinary Seminar on water resources management (see Appendix D). Since joining CSU, he has been involved in numerous consulting assignments on water resources development throughout the world. Though initially heavily supported by Grant funds, he is much less so now as his academic services are being more and more absorbed into the University system.

Dr. Evan C. Vlachos of the Sociology Department has made significant progress in his Department to bring about an understanding and acceptance of the role of the sociologist in an essentially engineering field of water delivery and removal systems. Under his capable leadership, students and faculty have been oriented and trained in the problems of water development and an understanding of how natural resources, and their utilization and limitations affect the rate of development of many nations. Also, Dr. Vlachos is developing the capabilities within the Department to respond to water removal and delivery problems through research into the interface of water and society and an understanding of the dynamic processes involved in the interconnection between water supply, water control, water distribution, water utilization and water reclamation, and through faculty and staff participation in conferences and seminars. Though moderately supported by Grant funds, the entrainment and other effects generated include:

1. Adding a whole new educational dimension in the Sociology Department.

2. Receiving an appointment as a Sociology/Engineering Professor to inject the Sociologist's viewpoints to the Engineer in the field of Water Resources Development and Research.

3. An increasing use of his views, both on and off campus, as a Sociologist on the workability of the interdisciplinary approach to solving development problems. For added details see Appendix F.

b. Technical Publications

Most of these publications were prepared at little or no cost to the Grant program. However, a large part of the publication cost was Grant supported. Appendix B includes abstracts for each of the following reports and theses.

(1) During the reporting year, two (2) 211(d) Grant supported studies were published under CUSUSWASH covers. They are: The Puebla Irrigation Development Project, Publication No. 22 by Dr. H. H. Biggs, Economics Department; and Index for the Eight Near East-South Asia Irrigation Practices Seminars, Publication No. 24 by William Neal and Clifford Stockmyer, Political Science Department.

(2) Also during the reporting year, one (1) 211(d) Grant supported Ph.D. dissertation and three (3) M.S. theses were completed. They are: The Organization of Thai Irrigators, an M.S. thesis by Michael Schiefer, Civil Engineering Department, May 1973; A Laboratory Study of Bed Material Withdrawal in Farm Turnouts, an M.S. thesis by Ata Mohammad Nazar, Civil Engineering Department, May 1973; Optimal Parameter Identification of Nonlinear, Time-Variant Hydrologic System Models, a Ph.D. dissertation by Samuel Tuffuor, Civil Engineering Department, June 1973; and The Problem of Rural-Urban Water Competition, an M.S. thesis by Everett Meyers, Political Science Department, June 1973.

(3) During the reporting year, the following papers supported by 211(d) Grant funding were published in technical journals and acknowledgement made of support from Grant funding: The Green Revolution and Economic Development, by Huntley H. Biggs, Rocky

Mountain Science Society Journal, January 1973; Comparison of Bridge Backwater Relations, by G. V. Skogerboe, J. W. H. Barrett, W. R. Walker and L. H. Austin, Proceedings of ASCE, Journal of the Hydraulics Division, June 1973; Generalized Discharge Relations for Cutthroat Flumes, by G. V. Skogerboe, R. S. Bennett and W. R. Walker, Proceedings of ASCE, Journal of Irrigation and Drainage Division, December 1972; Slope-Discharge Ratings for Cutthroat Flumes, by G. V. Skogerboe, T. Y. Wu, R. S. Bennett and W. R. Walker, Transactions of ASAE, January 1973; Flow Measuring Flume for Wastewater Treatment Plants, by W. R. Walker, G. V. Skogerboe and R. S. Bennett, Journal of Water Pollution Control Federation, March 1973.

(4) The following paper was prepared by George E. Radosevich under partial support from 211(d) Grant funding: Institutional Arrangements for Local Water Control with Particular Reference to Adaptation in Pakistan.

(5) Papers prepared under Grant support and are being edited for possible use in an Irrigation Manual for West Africa are: Integrated Approach to Irrigated Agriculture, by Maurice L. Albertson; Socio-Economic Aspects of Irrigated Agriculture, by Evan Vlachos; Irrigation Agronomy, by W. D. Kemper (not supported by 211(d) Grant); Irrigation Engineering, by W. E. Hart.

(6) Papers prepared under other funding but which would not have been prepared were it not for the CSU 211(d) Grant program: The Impact of Small Farmer Credit in Peru, by Ronald L. Tinnermeier; Technology, Profit and Agricultural Credit, by Ronald L. Tinnermeier.

(7) Still in process are the following theses: An Analysis of the Helmand-Arghandab River Basin Development Program, by Philip A. Hosterman, Civil Engineering Department; Public Investments in Irrigated Agriculture: Mexico 1940-1960, by Larry Caswell, Economics Department.

c. Library Improvement

As reported in the 1971-72 annual report, one of the first steps taken at CSU to improve the cataloging system related to water resources development or management was to move the Project Office Library collection of approximately 1400 publications to the CSU Morgan Library. During the reporting year the following steps were taken to make the library materials more readily available. However, no Grant funds were utilized.

1. In July 1973 a professional librarian was hired and an office established in the Morgan Library for processing these materials;

2. Materials were checked in against a master list. A second "master list" was maintained as a location copy to record the final destination as well as the call numbers of these materials. Order cards were typed for each individual item. These cards were then checked against the CSU card catalogue to establish whether these items were already part of the collection. Titles already in the collection were checked against the shelf list to determine the number of copies held by the library. In cases where the library held only one copy, a second copy (copy 2) was added. If the library held 2 copies, a shelf check was made for missing copies to verify the actual number of copies held. After this was ascertained, remaining additional copies were sent with pertinent cataloging information to the Engineering Research Center reading room. Those materials which could be verified were submitted for original cataloging with suggested classification and subjects.

3. For each title new to the Library, an extra main entry card was created for future bibliographic purposes. Material falling under the category of Government Publications was searched in a similar manner. Those for which a Superintendent of Documents classification number could not be found were held while correspondence with GPO requesting classification could be carried out.

4. Material requiring original cataloging was reported to the National Union Catalog. In many cases, this proved Colorado State University was possibly the only school in the country to hold these titles. This material having been reported may prove a valuable source of information to other schools both in this country and overseas via Inter-Library Loan.

5. Reprints of journal articles were added to a special Engineering Research Center office reprint file in an attempt to keep these materials together. Also conference papers (i.e. pre-published proceedings) were added to the ERC reading room in a special file set up there for that purpose. These conference papers were already represented in the CSU Morgan Library as post-conference published proceedings.

d. Seminars

The International Interdisciplinary Seminar continues to be conducted under the leadership of Professor Henry P. Caulfield, Jr. During the reporting period, he served as Chairman of the Program Committee for the Seminar composed of seven faculty members representing different departments, implemented committee decisions, chaired the meetings, and guided discussion to meaningful conclusions. The Seminar continues to serve as a catalyst for the fusion of ideas on water resource management and the central theme of optimum utilization of water delivery and removal systems and related institutional development. These Seminars have greatly stimulated the thinking and actions of the participating departments, particularly in regard to the relationship of research to objectives of the Grant. Twenty-six presentations were made during the reporting period by the International Interdisciplinary Seminar on Water Resources Management revolving around a central theme, "Optimum utilization of water resources: with emphasis on water delivery and removal systems and relevant institutional development". Most of the presentations were given by CSU faculty and research assistants and the remainder from outside sources. Dr. Huntley H. Biggs served as organizer and coordinator of one series of presentations on Small Farm Agriculture during the winter quarter 1973. This list of presentations is included in the total list of presentations for the reporting period in Appendix C.

One new development included acceptance of a plan for regularizing the Seminar into the academic structure of the University. The attendance at this Seminar for the year was approximately 870. Many attended because of increasing interest created by 211(d) Grant activity. Also many Grant personnel, stimulated in part by the Grant, attended other seminars on related water resources development and management topics both on and off campus at no cost to the Grant.

e. Research Assistants

research assistants received support from 211(d) Grant funds ranging from three to six months' support (6 - 12 months at half-time) for each individual. The nature of studies supported by 211(d) Grant funds were directly related to some phase concerned with optimum utilization of water resources including water delivery and removal systems and related institutional development. All of these research assistants attend the weekly sessions of the International Interdisciplinary Seminar. The research assistants are:

Q. A. Khan, Agricultural Engineering
Jacob H. Dane, Agronomy
Ghulam Ahmad, Civil Engineering
Herbert Blank, Civil Engineering
S. Janakiram, Civil Engineering
Frederick Laufer, Civil Engineering
W. A. Lemma, Civil Engineering
Rashid Makhdoom, Civil Engineering
Ata Nazar, Civil Engineering
Michael C. Schiefer, Civil Engineering
Samuel Tuffuor, Civil Engineering
Christopher Dowswell, Economics
Everett M. Myers, Political Science
Bailey Wharton, Political Science
Forrest Deseran, Sociology

As indicated in Section b, Technical Publications, William L. Neal and Clifford Stockmyer, Political Science Department completed the index of the NESA Irrigation Practices Seminar Proceedings. This was done at the suggestion of Mr. O. L. Mimms of AID/Washington and accomplished under the direction of Garth N. Jones of CSU with support of 211(d) Grant funding. The report was published under a CUSUSWASH cover and provides a detailed alphabetical key to the contents of the eight volumes comprising the published proceedings of these seminars held from 1956 through 1970. Another Political Science Department contribution was an M. S. thesis by Everett Meyers entitled "The Problem of Rural-Urban Water Competition" (Abstracts - Appendix B).

One (1) 211(d) Grant supported Ph. D. dissertation and two (2) M. S. thesis - - from the Civil Engineering Department - were completed during the reporting year. They are:

1. "The Organization of Thai Irrigators" by Michael C. Schiefer. This is an M. S. thesis which examines the problem of organizing Thai farmers for cooperative irrigation in Northeast Thailand and emphasizes the need for social and institutional development for better water delivery and removal efficiencies. See Abstracts - Appendix B.

2. "A Laboratory Study of Bed Material Withdrawal in Farm Turnouts" by Ata Mohammad Nazar. This study concentrated on the phenomenon of bed material withdrawal through a farm turnout. Depth of flow in the flume, discharge in the flume turnout elevation from the concrete bed of the flume, and the discharge through the turnout were the variables whose effect on the variation of sediment discharge through the turnout was determined.

3. "Optimal Parameter Identification of Nonlinear, Time-Variant Hydrologic System Models" by Samuel Tuffuor. This Ph. D. study focused on the important need for investigation of river basin characteristics. One of the major objectives of this study was the development of a hydrologic model for water delivery particularly suited for a developing nation. This dissertation was supported only in small part by 211(d) Grant funds. For further details see Abstracts - Appendix B.

Graduate Research Assistants in Agricultural Engineering co-authored in the following papers published in technical journals: J. W. H. Barrett, "Comparison of Bridge Backwater Relations"; R. S. Bennett, "Generalized Discharge Relations for Cutthroat Flumes"; T. Y. Wu and R. S. Bennett, "Slope-Discharge Ratings for Cutthroat Flumes"; and R. S. Bennett, "Flow Measuring Flume for Wastewater Treatment".

Larry L. Caswell, Department of Economics completed his M.S. thesis entitled, "Public Investments in Irrigated Agriculture in Mexico's Pacific Northwest".

Forrest Deseran of Sociology continued a bibliographic survey as to aspects of water and society and developmental issues related to the general problem of water delivery and removal, collecting data on population problems to be used as case studies for demographic constraints and the understanding of areas affected by proposed projects on water delivery and removal systems, and continuing work on a theoretical scheme integrating demographic data requirements and the interrelationship between population growth and water resource utilization with emphasis on water delivery and removal systems.

In process is an M.S. thesis: Philip A. Hostermann, Civil Engineering, "An Analysis of the Helmand - Arghandab River Basin Development Program". Mr. Hostermann has spent the last year in Afghanistan without 211(d) Grant support. His report focuses on sociological constraints hampering water delivery and removal systems including relevant institutional development within a particular river basin development program. Also, Christopher R. Dowswell, Economics, is working on "An Evaluation of the Irrigation Project for Small Farmers". Here, economic factors affecting a particular use group, i.e. restraints and problems connected with water delivery and disposal systems, are being evaluated in relationship to optimal agricultural production.

f. Meetings and Travel

Attending meetings and conferences abroad stimulates program activity through contact with other scientists, broadening viewpoints, and improving understanding of other cultures and economic and social problems which may inhibit transfer of knowledge. It appears essential that new professors and research assistants be exposed early

to such meetings in order to build interest. Also to allow the more experienced educator to attend meetings, participate, and forge linkages or to travel in a consultant capacity in order to maintain his interest and utilize his technical capacities in international activities. The following briefly describes travel performed in the interest of the 211(d) Grant program.

Foreign Travel

Details of financial support for foreign travel are given in Section IX, part 3, page 70.

Christopher Dowswell traveled to Guatemala City August 21, 1972, to conduct study on problems of small farmers on irrigated lands for his M.S. degree.

Dr. George Radosevich - through contacts made by M. L. Albertson, USAID/Nigeria requested the services of Dr. Radosevich to assist in developing a comprehensive feasibility study of an irrigation development plan for Nigeria. He was on this assignment from August 7 to August 25, 1972.

Dr. Maurice L. Albertson - an international trip October 1 to November 1, 1972, took him to Hawaii where he discussed water institutions in a meeting involving the University of Hawaii and the East West Center, and the potential collaboration of CSU and University of Hawaii in a new water management research program in Vietnam. In Tokyo, at no expense to the Grant, Dr. Albertson attended a regional irrigation seminar sponsored by FAO. From there he went to Thailand, Pakistan and Afghanistan where he was involved in discussion of plans for research involving water delivery and removal systems and educational and research programs. Having been invited to Kenya, he went there to discuss water delivery and removal systems and related institutional development of National Irrigation Plans. Following this, he went to Ibadan to help organize and to attend, by request, a seminar at Ibadan, Nigeria. In addition to Dr. Albertson, the party consisted of Drs. W. Doral Kemper, William E. Hart, and Evan C. Vlachos.

The seminar was sponsored by the International Institute of Tropical Agriculture (IITA), August 23-27, 1972. The main theme of the seminar was, "Prospects for Irrigation in West Africa". Each of those attending the seminar presented papers which were dove-tailed to cover a specific range of subject material and to fit within the theme of the seminar. This material is now being considered for possible use in development of an Irrigation Manual for West Africa. The participation of four CSU professors in this seminar came as a result of Dr. Albertson's attendance (as a representative from CUSUSWASH) of the IITA Soils Consortium Conference held at Ibadan, Nigeria in May 1972. Further linkages developed were: on his return to the U.S., Dr. Evan Vlachos' visit to Israel (at little cost to the Grant) at the request of Dr. Goldberg to see at first hand the national irrigation projects and to lecture and discuss the role of sociology and water institutions in water resources development. Also, enroute to the States, Dr. Hart stopped in Monrovia, Liberia to discuss with John Osguthorpe, USAID/West Africa Rice Development Association (WARDA), the implementation of their program. Contact was also made with Dean D. Shields, College of Agriculture and Forestry, University of Liberia as an additional part of the linkage program under 211(d) Grant objectives for possible future coordination and assistance.

Dr. Maurice L. Albertson - attended a conference of the SID in Costa Rica regarding rural development and social and political aspects of agrarian reform and their role in promoting social and political development, February 21-25, 1973.

Dr. Huntley H. Biggs - traveled to Guatemala in April 1973 to provide thesis guidance to Mr. Christopher Dowswell, graduate research assistant who was conducting thesis research and a study evaluating the irrigation program for small farms. While there, the Minister of Agriculture inquired into the possibility of CSU providing assistance to the new Institute of Agricultural Sciences in the areas of water resources management for agricultural development as well as graduate programs for Guatemalan students.

U.S. Travel

The following men, well known and qualified in the field of water resources development, conducted seminars at the International Interdisciplinary Seminar held each Wednesday during the academic year within the reporting period. The listed personnel are non-CSU personnel whose travel and other expenses were supported only in small part from 211(d) Grant funds:

Dr. Robert Lindsay - University of Minnesota

Dr. Nathan Buras - Technion, Israel Institute of Technology

Mr. Byron Palmer - Utah State University

Dr. John McNown - World Bank, Washington D. C.

Dr. A. Alagapan - United Nations, New York

Dr. D. R. Sikka - Secretary for Government Irrigation, State of Madha Pradesh, India

Dr. Wynn F. Owen - University of Colorado

Dr. John Coulter - Rothamsted Experimental Station, Harpenden, Herts, England

Dr. Garth Jones and George Smith traveled to Logan, August 24-26, 1972 to help finalize the Irrigation Management Program (IMP) report.

Dr. Maurice L. Albertson attended the ASCE, Irrigation and Drainage meeting in Spokane on September 27-29, 1972; also attended the SID meeting in Washington DC on September 30, 1972, to discuss the creation of an Agricultural and Rural Development Section within SID.

Dr. Maurice L. Albertson, George Smith, and Bonnie Frantz attended the CUSUSWASH meeting in San Francisco, January 2-5, 1973.

3. Summary of Accumulated Accomplishments

a. Improvement of Faculty and Staff

One new faculty member was recruited by the Department of Agricultural Engineering. His services will be available beginning September 1973. No 211(d) Grant funds were utilized for this purpose during the reporting year. One new course was developed in water resources development in the Engineering College. All participating departments have improved their courses through increasingly greater exposure to problems of both domestic and international water delivery and removal systems, and through selected samples of such problems in regular course work. The staff members are now far more efficient and effective in advising students in the technological aspects of international water problems.

Effective use of 211(d) Grant funds by all six participating departments provided the incentive and time for research activity, report writing, participating in domestic and international water conferences, graduate student advising, attendance at the International Interdisciplinary Seminars and other relevant seminars, development of linkages, and promoting entrainment effects.

A group of four (4) CSU professors presented keynote papers at a seminar sponsored by the International Institute of Tropical Agriculture (IITA) on the topic, "Prospects for Irrigation in West Africa". The seminar was held at Ibadan, Nigeria in October 1972. Each of these men learned a great deal about problems of irrigation in Africa through active participation at the seminar, and through private discussions. At the same time, valuable linkages were established with professionals from other countries which are continuing through correspondence and exchange of literature and information.

An Economics Professor made several trips abroad which improved his knowledge and understanding of water laws, water user organizations, and constraints and problems on a world-wide basis. On one trip, he served as a consultant for USAID on a feasibility study of water resources development in Nigeria. On another, he provided assistance in revising the water laws of Pakistan at the request of USAID. Other examples of increased staff competence through participation in both domestic and international seminars, conferences and committees are fully described in the foregoing sections of this report.

b. Technical Publications

During the reporting year two (2) Grant supported studies were published under CUSUSWASH covers; one (1) Grant supported (in part) Ph.D. dissertation and three (3) M.S. theses were completed; five (5) papers by staff personnel supported in part by Grant funds were published in technical journals; one (1) completed study under Grant support but not yet published; four (4) papers prepared under Grant support being edited for possible use in an Irrigation manual for West Africa; and two (2) papers prepared under other than Grant funding which could not have been prepared were it not for the Grant program.

c. Library Improvement

As reported in the 1971-72 annual report, the Project Office library collection of approximately 1400 publications was moved to the Morgan Library. During the reporting year, at no cost to the Grant program the following improvements were made: a professional librarian was hired and an office established in the Morgan Library to properly process these materials. During the cataloging and reporting to the National Union Catalog, it was found that CSU was possibly the only school in the country to hold certain titles. About fifty (50) publications were added to the library during the reporting year.

d. Seminars

Twenty six (26) presentations by the International Interdisciplinary Seminar were made. The titles of the seminars together with the names of the speakers and the organizations represented may be found in Appendix B of this report. The Seminar presentations fall under the three (3) general headings as follows:

(1) Major Constructed Water Development Projects Throughout the World

(2) Small Farming Problems in Less Developed Countries

(3) Interdisciplinary Modeling of Water Management Problems

e. Research Assistants

Fifteen research assistants received support from 211(d) Grant funding ranging from three (3) to six (6) months support (6-12 months half time). Three (3) of this number completed M. S. theses and one (1) completed a Ph. D. dissertation. The remainder are in the process of producing theses which may take from one (1) to two (2) years more to complete having just begun their studies. All studies are directed toward making a positive contribution to the body of knowledge surrounding the central theme of the 211(d) Grant program.

4. Proportion of Year's Expenditures Used for Each Area of Activity

The following table contains the same activity areas as appears in Table 1, Chapter IX of this report.

		Expenditure	Percent
1.	Salaries (Increased teaching competence)	$ 79,567	43
	Stipends (Research assistants)	52,426	29
	Travel	16,232	9
	Library and Publications	3,604	2
2.	*Other (Office expenses)	21,465	11
	CUSUSWASH Executive Director's Office Support	12,000	6
	Equipment	97	0
TOTAL		$185,391	100

1. Salaries include $350.00 consultation fees
2. *Breakdown:

Clerical costs	$13,305
Office expense (telephone, xeroxing, mailing, supplies, Western Union)	8,160
	$21,465

IV. Impact of Grant-Supported Activities in Developing Institutional Capabilities

As a direct result of increased faculty competence through 211(d) Grant funding in teaching, research, publications, seminars, conferences and consulting, the faculty and participating departments of CSU can now contribute even more effectively in projects and programs with developing country governments and international organizations in the broad aspects of optimum utilization of water resources development with special emphasis on water delivery and removal systems as well as related institution development.

Regarding these specific areas of increased capabilities, the participating faculty looks at the problem from a broad perspective by gaining a basic understanding of the process of technological change and the relating factors which critically affect the optimal use of water resources. The rationale governing this approach is the necessity of first understanding the basic institutional engineering, social and economic constraints which influence individual decisions, then designing the appropriate water delivery and removal system(s) which will assure an optimal use of water resources for increasing agricultural productivity. Research efforts have indicated that the availability of technology and credit institutions, together with resource management practices, can have an important bearing on the optimal use of water.

The International Interdisciplinary Seminar, has had an important impact on the faculty members and graduate assistants representing the participating disciplines in bringing about a better understanding of optimal development of water resources, particularly in water delivery and removal systems and related institutional development. The International Interdisciplinary Seminar has met for two hours each week throughout the academic year 1972-1973 under the direction of Professor Henry P. Caulfield, Jr., Department of Political Science. Though the terms of reference for the Seminar are quite broad, as

indeed they should be, for encouragement of faculty-student intellectual development, the seminar has been increasingly successful in creating an appreciation among faculty, research assistants, and others of the complex character and the diversity of factors involved -- including engineering, social and political, cultural, biological, and economic -- and thus, of the multidisciplinary and international nature of the problems inherent in increasing agricultural production in the world. As a result, the participating individual acquires a broader background and a basis for better comprehension of the complicated processes involved in successfully establishing in developing countries optimal utilization of water resources including water delivery and removal systems and related institutional structures. Thus, the Seminar has been useful in helping the participating departments to establish basic guidelines for interdisciplinary research activities related to the 211(d) Grant objectives.

More specifically, the Grant has made the following impacts in developing the Department of Agricultural Engineering's capability in the areas of water delivery and removal: increased staff competency -- the department now has increased numbers of staff (such as Professors Kemper, Hart, Clyma, Skogerboe and Walker), who have developed linkages in the developing countries, are aware of problems in developing countries, have an interest in these problems and have significant capability to provide technical assistance for the solution of these problems. Graduate students have been trained who are interested in working in or with the developing countries and have helped to establish linkages in these countries, have worked in developing countries, have significant contacts there and have thus increased CSU's linkages. Courses directly and indirectly related to water delivery and removal and relevant institutional development have been developed (see Appendix G) and are being taught to students and staff from many

departments of the campus. In addition, existing courses have been focused more toward the solutions of problems in developing countries.

Various design manuals have been and are being prepared which can be used to provide needed technology to the developing countries in the field of water delivery and removal systems. The Water Management Technical reports No. 9 "Check-Drop-Energy Dissipator Structures in Irrigation Systems" and No. 19 "Installation and Field Use of Cutthroat Flumes for Water Management" have been well received by numerous engineers based upon return correspondence, as well as comments from foreign engineers and soil scientist participants in the Irrigation Practices Training Course (sponsored by USDA) conducted at CSU each summer who have repeatedly stated the value of these manuals in their work. It is anticipated some of these will be translated into Spanish or other languages to increase their usability. Each of the areas described above have built upon CSU's existing capabilities and the staff and students have become more aware and responsive to the needs in developing countries. Interest has been expressed to the investigators to give short courses in Pakistan and Central America regarding improved water delivery systems. In fact, an advisory mission to Pakistan by Professors Skogerboe and Walker concerning flow measurement and irrigation systems structures is anticipated.

The 211(d) Grant program has created a greater awareness on the part of the Department of Agronomy to the needs of developing countries in the solution of problems in water resource management. It has been responsible, in part, for developing courses designed to inform and train both undergraduate and graduate students for foreign assignments in water resource management especially in water delivery and removal systems, irrigation management, and related institutional development situations. In addition, the Department provides academic

and program advisors for non-degree foreign students enrolled in the International School for Water Resources Environmental Management. The 211(d) program also has increased the competence of CSU staff actively involved as advisors for the CSU/USAID project in Pakistan. For example, the services of Dr. W. R. Schmehl, Dr. W. T. Franklin and Mr. C. W. Robinson were requested by the Mission for consulting and program planning on the water management project during the reporting year.

The 211(d) Grant program has made it possible for the Department of Civil Engineering to: improve faculty and staff capability for advising foreign students in the field of optimum utilization of water resources and more specifically, in water delivery and removal systems and related institutional structures; increase the competence of staff and faculty; developing a greater awareness of the priority needs of developing countries in the solution of water resource management problems, specifically in water delivery and removal systems and related institutional development; improving the design and content of courses for undergraduate and graduate students emphasizing water delivery and removal systems and related institutional structures; and increased number, capabilities and desire of faculty and staff to serve overseas. Grant funding made it possible for a team composed of Drs. M. L. Albertson (team leader), W. Doral Kemper, William Hart, and Evan C. Vlachos, to develop and present papers at an irrigation seminar held in Ibadan, Nigeria last fall. The initial contact with the IITA was made as a result of Dr. Albertson's attendance at the Soils Consortium meeting in Ibadan in May 1972 at which time he was asked to help organize the program and to provide 4 keynote speakers.

The Civil Engineering Department has also made progress on several publications which will be completed during the coming year. New courses have been added in water systems engineering, and linkages have been established with engineers, scientists and public officials in Nigeria, Ivory Coast, Kenya, Uganda, Senegal, Liberia, Tanzania, Afghanistan and Pakistan.

The approach of and the impact on the Department of Economics in the 211(d) Grant program has involved as many young faculty members as possible in research and teaching in the problems of the developing countries, with special focus on understanding the constraints (technological, financial and legal) which influence the optimal use of water resources. Accomplishment of the Grant objectives by faculty members and research assistants has been increasingly realized through a number of activities, including teaching, research, publications, conferences and consulting. For example, due to the broadening and development aspects of the 211(d) Grant program, George E. Radosevich, among other consulting trips taken during the reporting year, was selected by AID/Washington to serve as a legal and economics advisor to assist in preparing a feasibility study of a river basin in Nigeria, Africa. As a direct result of increased faculty competence in these areas through 211(d) Grant funding, the Department of Economics can now participate even more effectively in projects and programs with developing countries. Beginning several years ago, research efforts have gradually been focused more and more on the small farmer. This reflects the conviction that if developmental efforts are to have an impact on the majority of the world's impoverished peoples they must be focused on this group. Currently, it is the technical, financial and legal constraints confronting the small farmer that have largely limited the effectiveness of water delivery and removal systems, and relevant institutional achievement in developing countries. It is anticipated that even greater attention will be given to this problem area in the future by the Economics Department.

The impact of the 211(d) Grant program on the Department of Sociology resulted in the creation of a group within the department entitled, "RDM" (Research in Demography and Modernization), which was established with the explicit purpose of providing a forum and a concrete means for the study of the general problems of the project. This group of faculty members and graduate students (four faculty members contributed time without

211(d) Grant funding) attempted to extend and understand problems of water delivery and removal in the context of a more systematic undertaking of the designing and establishment of a set of data banks related to demography and modernization with emphasis on water delivery and removal; investigation of original surveys and other field studies which may provide the training ground for research assistants in problems of water and development; collection of an initial library and material reflecting aspects of water and the larger questions of both quantity and quality problems in water delivery and removal. Like the other disciplines involved in this 211(d) Grant program, it was early decided that as a first step in studying water delivery and removal systems it was necessary to gain an understanding of the large parameters of problems of water management and organization.

V. Utilization of Institutional Resources in Development

Increasing agricultural productivity throughout the world to a major degree is dependent upon making the proper use of water -- effecitvely and efficiently coordinating water use with other agricultural inputs. Since this is a tremendously large and complicated problem, Colorado State University is assigned, through the 211(d) Grant program, the improvement of its competency in optimum utilization of water resources with emphasis on water delivery and removal systems and related institutional development. Six disciplines are actively involved and the International Interdisciplinary Seminar acts as a catalyst for a fusion of coordinated ideas leading to a better understanding of the CSU 211(d) Grant theme.

This interdisciplinary approach leads to connections with all the departments of the University and their personnel participating in the program, and other faculty members and research assistants interested in the general subject, as well as outside institutions, both government and private concerned with various aspects of water resources development. Within the campus, the six participating departments (Agronomy, Agricultural Engineering, Civil Engineering, Economics, Political Science and Sociology) receiving Grant support have developed meaningful ties with each other. Also, ties were continued with CUSUSWASH and during the year contacts, linkages, and communication were established or continued and strengthened with off campus institutions in the United States and abroad. Examples of the utilization of institutional resources in development appear on the following pages.

The importance of water control, including the timing of deliveries and maintaining constant discharges, is well recognized as a necessity for achieving improved irrigation efficiencies. The Department of Agricultural Engineering has long been working on water delivery systems together with other investigators funded from the U.S. Environmental Protection Agency to improve water delivery, farm, and drainage subsystems. This has provided CSU investigators - Professors Gaylord V. Skogerboe and Wynn Walker - with considerable laboratory and field research experience concerned with achieving improved water management practices. Funding from the 211(d) Grant also made it possible for Dr. W. E. Hart to prepare and give a seminar sponsored by the International Institute of Tropical Agriculture in Nigeria concerning irrigated agriculture in tropical and semi-arid regions. While in Nigeria, Dr. Hart visited with a number of African educators, researchers and Government officials resulting in a free flow of information which is continuing by letter communication. Dr. D. B. McWhorter and Professor G. V. Skogerboe taught the Irrigation Practices Short Course under the sponsorship of the USDA. Eighteen participants from around the world had an opportunity to interact with the CSU faculty and to obtain intensive instruction as well as to tour irrigation developments in the Rocky Mountain Region. Though no 211(d) Grant funds were involved, this irrigation course was very supportive of the Grant objectives.

The increased utilization of institutional resources made possible by the 211(d) Grant has permitted the Agronomy Department to make a major contribution to the development of the CSU/AID/csd 2162 water management research project in Pakistan at no cost to the 211(d) Grant Program, also to permit three Agronomy staff members - Dr. W. R. Schmehl, Dr. W. T. Franklin and C. W. Robinson - to

serve as advisors for the CSU/AID Water Management Project and as water management consultants for other Pakistani institutions. In addition, Dr. R. S. Whitney, Department Head, and Dr. W. T. Franklin were advisors for an Economics project evaluating the impact of the quality of water delivered to an irrigation project based on the economic returns from the crops produced. The results will have general application to problems of irrigation development in developing countries where irrigation water supplies are at low to marginal quality.

Graduate students of the Department of Agricultural Engineering who have chosen to come to CSU, because of interest in development of water delivery and removal systems, and the institutions needed for the development of these systems in their home countries, are as follows (no support from 211(d) excepting one as noted):

Name	Nationality (Citizenship)	MS/Ph.D.	Funding
Zewdie Abate	Ethiopia	Ph.D.	AFGRAD
Robert Chandler	Canada	MS	WMR
Chuntse Cheng	Republic of China	MS	Private
Ken-Tsai Huang	Republic of China	MS	Experiment Station
Qurban Ali Khan	Pakistan	MS	211(d) Grant
Leck Jindasanguan	Thailand	MS	AID
Humberto Lam	Peru	MS	LASPAU
Pongsak Limjaroenrat	Thailand	MS	Private
Mohamad Mahmoodian-Shooshtari	Iran	MS	AFME
Giacomo Paniagua	Nicaragua	MS	AID
Mahmood Shariatmadar-Teleghani	Iran	Ph.D.	WMR
Jose Luis Trava	Mexico	Ph.D.	CNCT Sch.
Ter-Fung Tsao	Republic of China	Ph.D.	Experiment Station
G. S. Vijaya Raghavan	India	Ph.D.	Experiment Station
Jernan Yow	Republic of China	Ph.D.	Experiment Station

Experience gained by the Civil Engineering faculty, staff, and research assistants through participation in the 211(d) Grant program has, over the past several years, noticeably increased this department's competence, ability, and willingness to respond to such requests. Utilization of the institutional resources of the Civil Engineering Department and the University as a whole through 211(d) Grant participation has made it possible to provide competent personnel and persuade University officials to permit the use of University equipment, laboratory facilities, and library facilities for such overseas projects as the AID/csd 2162.

An example of response to overseas requests is the participation of 4 CSU Professors in a seminar sponsored by the International Institute of Tropical Agriculture (IITA) in Ibadan, October 1972, on Prospects for Irrigation in West Africa. The initial contact was made with Dr. Albertson in May 1972 when he was asked to help plan and organize the seminar. Later, he suggested that Utah State University participate, but they were unable to do so.

Another example of responding to an overseas request is the team of CUSUSWASH specialists which went to Nigeria at the request of the AID Agriculture Officer in Lagos, who was following the suggestion made by Dr. Albertson during his visit there in May 1972.

The 211(d) Grant program has stimulated and heightened the Department of Economics' utilization of institutional resources in many ways with very little Grant funding. Following are examples of the utilization of this institution's human resources in development.

As a direct result of Dr. George E. Radosevich's meeting with the leading Spanish authority on water law in the fall of 1972, an International Conference on Water Law will be held in Valencia, Spain during the summer of 1974. Dr. Radosevich will play a major role in that conference. On the same trip, he met with a German lawyer for the United Nations to obtain needed information on the international legal aspects of the Indus Basin project and, in Pakistan, consulted with national and AID officials concerning the need for structuring organizational mechanisms for improving the efficiency of water use in the country at no cost to the Grant program. During late summer of 1972, Dr. Radosevich served as the legal and economics advisor to a special USAID three-man team to Nigeria to assist in the preparation of a feasibility study of the Do-Anambra River Basin, at no expense to the Grant program. At present, Dr. Radosevich is on leave from CSU acting as a United Nations Economic Affairs Officer for the Water Resources Division at the Resources and Transportation Department. His return to CSU next December will add measurably to this institution's utilization capacities in development.

At the request of the Guatemalan Minister of Agriculture, Dr. Huntley H. Biggs went to Guatemala last April under Grant funding to discuss CSU's capabilities in the areas of water resources management for agricultural development. While there, he also provided thesis guidance to Mr. Christopher Dowswell who was conducting his thesis research under Grant funding. In his discussions with the Minister, there was revealed the possibility of a Guatemalan request to CSU for technical assistance to the new Institute of Agricultural Sciences.

The 211(d) Grant program provided no funds but did provide the stimulas for the following type of utilization of institutional resources by encouraging Dr. Ronald L. Tinnermeier to be actively involved in studying and evaluating the experiences of the less-developed countries in promoting agricultural credit institutions to small farmers. First, a paper on small farmer credit was prepared for a workshop on Small Farmer Development Strategies in 1972. As a result of this workshop,

Dr. Tinnermeier then organized a workshop on Small Farmer Credit, financed by the Agricultural Development Council, which provided much of the rationale and the general guidelines for the later, and larger, AID-Spring Review on Small Farmer Credit. Dr. Tinnermeier was also very active in the Spring Review. He prepared a study of the Colombian Bank's small farmer credit activities as one of the some 60 country papers prepared for the Review. Then, he was asked to prepare a paper on credit and technology summarizing the experiences around the world. This paper and some fifteen others served as points of discussion for three-day, regional workshops held in Latin America, Asia, the Middle East, and Africa. Dr. Tinnermeier participated as a resource person in each of those workshops.

The 211(d) Grant program (though no Grant funding was utilized) also inspired Dr. Gene C. Wilken to organize and chair the first session on Peasant Farming ever offered to the Annual National American Association of Geographers in April 1973. This session will now become a part of future annual meetings. During 1972-73, there were a number of students from developing countries enrolled in graduate programs in economics. Typically, the major areas of interest are: water resources economics, agricultural economics, and development economics. The selection of CSU and these courses reflect the growing interest in the economic aspects of water resources management and in other areas supported by the 211(d) Grant. In addition, a number of non-economics students are now taking courses in these areas. Quite a few economics faculty members serve on graduate committees for CSU non-economics graduate students from developing countries. Below is a list of the graduate students enrolled in the graduate program in economics. Each of these students is a candidate for the Masters of Science degree; however, some of them will continue into the Ph. D. program in the future:

NAME	COUNTRY	SPECIALIZATION	FUNDING
Aitell, Tariq	Jordan	Ag. Econ., Stat.	FAO
Chaann, Serewuddh	Cambodia	Econ	Fulbright-Hayes
Kamram, M. Hussain	Afghanistan	Ag. Econ.	Private
Khan, Ahmad Saeed	Pakistan	Ag. Econ. Dev.	211(d)
Khan, Mohammad Jameel	Pakistan	Ag. Econ., Nat. Res., Dev.	211(d)
Mesfin, Mebrahtu	Ethiopia	Ag. Econ., Nat. Res.	USAID
Muttamara, Sumali	Thailand	Ag. Econ.	USAID
Neghassi, Habte Miriam	Ethiopia	Ag. Econ.	AFME - RA
Tekie, Million	Ethiopia	Ag. Econ., Dev., Stat.	USAID
Tiv, Thean Po	Cambodia	Econ.	Fulbright-Hayes
Sarwar, Mohammad	Afghanistan	Dev., Nat. Res.	Private
Satiroglu, Kadir	Turkey	Dev., International	Private
Usman, Mohammad	Afghanistan	Ag. Econ.	Private

The Department of Sociology, through the 211(d) Grant has been provided the opportunity to develop firm ties with the participating departments on campus in the area of optimum utilization of water resources including water delivery and removal systems and particularly in related institutional development activities. During the year, communication was also established with other social scientists working in the field of natural resources, especially water, in such institutions as Michigan State University and Brigham Young University. However, once again, it is imperative to re-emphasize that the general thrust of the utilization of the institutional resources has been one of increasing the general sensitivity for the presence of sociology in the area of water resources rather than of specific task accomplishment. The importance of continuing such sociological activities should not be underestimated.

As a direct result from the accumulated impact of the 211(d) Grant, a number of spin-off activities have been generated. For example:

1. A request by the World Bank as to the interest of CSU in providing expatriate consultants to aid in the preparation of Mexico's National Water Plan. Subsequently, CUSUSWASH became interested and the resources of the Consortia of Universities were offered to the Government of Mexico. As a result, a World Bank official and two highly placed Mexican officials came to the CSU campus and were met by 22 CSU scientists.

2. A letter of intent signed between the University of Coahuila, Saltillo, Mexico, and CUSUSWASH in a collaborative arid zone research and development proposal.

3. As a direct result of Dr. Maurice L. Albertson's trip to Nigeria, May 23-30, and through his contacts with personnel of the International Institute of Tropical Agriculture (IITA) in Ibadan, Colorado State University received an invitation to participate in a seminar sponsored by IITA on Prospects for Irrigation in West Africa. This seminar was held from the 23rd to the 27th of October, 1972. Colorado State University responded by sending to Nigeria, four scientists, Drs. Maurice L. Albertson, W. Doral Kemper, Evan C. Vlachos, and William E. Hart, each of whom presented papers at the seminar. Also, Dr. George Radosevich, at the request of AID Washington was sent to Nigeria to help on the DoAnambra River Basin Study.

4. Development of an outline of principles as a result of a visit by Professor Emanuel Guggino, representing the Polytechnic Foundation of the Mediterranean, Italy, to Colorado State University in the area of water resources -- at no expense to 211(d).

VI. Other Resources for Grant-Related Activities

The Irrigation Practices Training Course was again given at Colorado State University, conducted by Gaylord V. Skogerboe and Wynn R. Walker of the Department of Agricultural Engineering and others. The course is not supported by Grant funds. It is sponsored by USDA and is primarily conducted for foreign engineers and soil scientists. Other resources for Grant-related activities allocated to the Department of Agricultural Engineering include: Irrigation Practices, Return Flow Salinity and Crop Yield -- Environmental Protection Agency; Improvements in Sprinkler Irrigation Systems -- Office of Water Resources Research; Consolidation of Irrigation Systems -- Office of Water Resources Reasearch; Systems of Management for Optimal Water Use -- United States Bureau of Reclamation.

Under the direction of Dr. W. T. Franklin, Department of Agronomy, a cooperative research project between the State Colorado project No. 192 and AID/csd 2162 was conducted to evaluate the effect of water quality and method of irrigation on the salt content of return flows back into the irrigation system. As part of the study a computerized chemical model was formulated for Pakistan conditions. This project will be tested in 1973-74. In addition another project is underway between AID/csd 2162 in cooperation with the State of Colorado project No. 127 to evaluate the influence of soil fertility on plant growth when the crop is irrigated with saline irrigation water. The results so far indicate that some of the detrimental effects of saline return-flow water can be overcome by judicious fertilization.

The participating departments have provided faculty support for an ongoing institute at CSU called the International School of Water Resource-Environmental Management. This school is sponsored by CSU's Department of Civil Engineering to provide one-year training

programs for persons from developing countries. Many of these students take engineering, economics, and sociology courses in water resources development. Faculty from the six participating departments serve in an advisory capacity for a number of these students at no cost to the 211(d) program. Most of the students are funded by such International organizations as: AID, FAO, UNDP, and WHO. Additionally, the Department of Civil Engineering, in cooperation with the Colorado State Experiment Station, is presently doing water research work in the following projects: Irrigation Flow Measurement; Hydraulics; Water Resources Optimization; and Groundwater Resources. Cooperative studies are also undertaken with such organizations as: Bureau of Reclamation; Office of Water Resources Research; and U.S. Geological Survey.

The Department of Economics is heavily involved in funded research dealing with economic aspects of water resources. Many of these projects directly support the areas of concern to the 211(d) Program. Among the general areas of research concern that support the 211(d) Grant Program are: the economics of water quality, systems management for optimum water utilization, legal and economic problems in the consolidation of irrigation systems, water quality, regional use of water resources, and efficiency in on-farm water use. Below is a list of the titles of these projects and the agencies providing funding.

Title	Sponsors
Economic and Institutional Analysis of Water Quality Standards and Management	Experiment Station and Office of Water Resources Research (OWRR)
An Economic Analysis of Water Use in Colorado's Economy	Experiment Station, Colorado Water Conservation Board and OWRR
Economic Analysis of Water Use in Boulder, Larimer and Weld Counties	Bureau of Reclamation, USDI

Consolidation of Irrigation Systems: Economic Aspects	OWRR
Consolidation of Irrigation Systems: Legal Aspects	OWRR
Economic Analysis of On-farm Input Use With Reference to Achieving an Efficient Allocation of Water Use in Pakistan	Agency of International Development, State Department
Systems of Management for Optimum Water Utilization	Bureau of Reclamation, USDI
Finance in Public Water Resource Use and Development	OWRR
Economic Effects of Salinity in the Colorado River	Bureau of Reclamation, USDI
Systems of Management for Optimum Water Utilization	Experiment Station

In addition, Dr. Gene C. Wilken was awarded two research grants for the purposes of studying "Resource Management and Peasant Farming Systems in Middle America" over the next two years. The sources of funding are: the National Science Foundation and the Foreign Area Fellowship Program. Dr Wilken was granted a sabbatical leave from CSU to spend 1973/74 in Mexico. He will return to CSU in 1974 for an additional year to complete his research.

Similar to Economics and the other participating departments, some of the other resources for Grant-related activities in the Political Science Department would include: the Office of Water Resources Research, Resident Instruction Funds and the State of Colorado.

One of the major resources utilized by the Department of Sociology (beyond the immediate funding of graduate students) has been the volunteered time of a number of faculty who were guided by the general interest and concern for the area of water management research. Also extensive use was made of the computer facilities of the University (also no cost to 211(d)) in the context of both training and research in order to develop the general capabilities of graduate students.

VII. Next Year's Plan of Work and Anticipated Expenditures

The fiscal year 1973-74 is intended to consolidate and bring together all of the progress that has been made through the Grant thus far. Specifically, special emphasis is to be placed on publications which will bring out the new information that has been gained during the Grant and to summarize certain existing information which needs to be made readily available; to establish ways for continuing the team activities which are already underway even beyond the end of the Grant; to try to find ways of supporting (beyong the Grant period) the new staff which has been brought to CSU as a result of the Grant; and to round out the research and study activities.

Specific publications which are expected to be produced during this Grant period are:

1. The Ultimate Irrigation Water Supply Potential of the Indus Basin, Pakistan, which is an analysis of the present water delivery system and a projection, using systems analysis of the ultimate potential, using all sources and conveyance systems optimally.

2. Water Resource Management of Small Farms in Developing Countries, which is a collection of 10 papers giving an inter-disciplinary approach to the subject.

3. Improving the Water Resources Management Institutions in Pakistan, which will present a summary of existing institutional arrangements, examine the available models, and show how a combination of models might be used to improve the institutional structure in Pakistan.

4. Optimal Conjunctive Use Model for the Indus Basin, which considers the optimal combined use of ground water and surface water to maximize agricultural production.

5. Sediment Problems in Rivers, Canals and Watercourses in the Punjab, which will examine the existing situation and measures which might be taken to improve it.

6. Water Delivery and Removal Systems in the Developing Countries, which will be a volume containing a series of papers relating water supply and conveyance, conjunctive use of ground water and surface water, reuse of excess water, sediment problems, quality control, seepage, and water resource institutions, to improve delivery and removal systems -- all aimed at reducing the cost of irrigation water to the farmer and making it available to him at the time and place and in the quantities that he needs with as little maintenance and operational expense and difficulty for him as possible.

7. Aquifer Recharge for Optimal Conjunctive Use of Surface and Ground Water Resources in Pakistan, which will consider seepage and the lining of canals as well as salinity control and general management of the underground reservoir which has been shown to be much less expensive than reservoirs above ground.

8. Flood Control Measures in Pakistan, which will examine the recent floods, the damage they have caused to water delivery and removal systems, and measures which might be taken to prevent or minimize such damage in the future.

9. Control of Sediment at Farm Turnouts, which will report the results of laboratory and field experiments on methods and designs for controlling the sediment which enters a farm turnout and is deposited in the farmers ditch or field.

10. Development Planning, a book which presents a model on input-output techniques, which can be used to analyze such development problems as: forecasting, optimization, international trade, and technological (this is not supported by 211(d)).

11. Incorporation of Working Capital in Project Analysis, which includes such factors as water application and fertilizers.

12. Underlying Assumptions for the Rate of Return Analysis, which applies to water resources analysis as used by the World Bank.

13. Prospects for Irrigation in West Africa which includes the socio-economic aspects of institutional development for water delivery systems and on-farm irrigation systems.

During the coming year, new courses will be added, such as "Fundamentals of Irrigation and Drainage" which will be taught in the Agricultural Engineering Department for non-engineers such as economists, lawyers, sociologists, agronomists and political scientists. The primary emphasis will be for the expansion and upgrading of existing courses -- especially those which have been added through the help of the 211(d) Grant.

Research will continue and be reported on:

1. water conveyance layout,
2. design and management for small irrigated farms,
3. pumping groundwater underlaid by saline aquifers,
4. small irrigation structures for water delivery and removal,
5. movement and accumulation of salt in the soil and the necessary removal systems,
6. institutional arrangements for water delivery and removal systems,
7. conjunctive use of surface water and groundwater, and
8. techniques for reducing the cost of water to the farmer.

CSU is continuing to expand joint and cooperative activities with the other CUSUSWASH Universities, both in the U.S. and in the developing countries such as Mexico, Iran and Nigeria.

The participating departments' plan of work for next year and anticipated expenditures are as follows:

Dr. William E. Hart, Agricultural Engineering, will direct the research efforts of two graduate students supported by 211(d) Grant funds. One student is Stephen W. Smith, who recently received his B.S. in Agricultural Engineering from New Mexico State University. The other student is Okezie Abarikwu from Nigeria. Dr. Hart met Mr. Abarikwu on his trip to Africa. Both Mr. Smith and Mr. Abarikwu will work on water conveyance designs suitable for distribution to small (1-5 acres) plots on rolling land in Africa as well as a management scheme for the system.

Dr. Alan C. Early, a new recruitment for Agricultural Engineering, will arrive on campus in September and will develop and teach a water conveying, delivery and irrigation course for non-engineers. It is anticipated this course will be popular for sociologists, economists, lawyers, political scientists, and others who are interested in social institutions related to water delivery and conveyance systems.

The design manuals (see CUSUSWASH Water Management Technical Reports No. 9 and 19) have been well received by numerous engineers based upon return correspondence and comments from visiting engineers and foreign students. The world-wide implications of this work are many fold. First, water delivery and measurement problems are areas of specific interest to irrigation planners in the developing countries, and thus, this material has wide general interest and design procedures have been collected into a few presentable sources. Consequently, a potential exists for developing additional useful design manuals, as well as preparing short courses which would facilitate rapid dissemination of project results in other countries. Finally, the principal investigators feel that their technical competence has reached a level where their expertise should now be channeled towards problem evaluation and solution in developing countries.

In order to properly take advantage of previous work and continuing interest, the objective of the coming year is to prepare material on flow measurement, irrigation structures, and the role of water delivery in salinity control for possible short courses and miscellaneous presentations. In addition, as a part of the effort to initiate involvement in developing countries, Mr. Qurban Ali Khan, a Research Assistant, will conclude his study on small irrigation structures used in Pakistan. From this thesis, the specific structures requiring further evaluation will be identified and present designs can be upgraded. Also, anticipated field visits to Pakistan by the investigators will allow the development of realistic designs for Pakistan conditions.

The anticipated man-months and budget are:

	Man-Months	Budget
Staff and Faculty	7.5	$11,427
Research Assistants	10	7,413
		$18,840

The Department of Agronomy will continue the research project, "Salt Transport in Soil Systems", under the direction of Dr. Arnold Klute. It is emphasizing the movement and accumulation of salt in the soil as a function of the soil, the quality of water delivered, and the effectiveness of the removal systems. The staff will continue to attend and contribute to the International Interdisciplinary Seminar and Dr. John Reuss will serve on the Planning Committee for the Seminar. Other members of the Agronomy Department will continue to be active in research planning and student training in international water resource management with emphasis on water delivery and removal systems and supply consultants for developing country projects.

The anticipated man-months and budget are:

	Man-Months	Budget
Staff and Faculty	1	$1,508
Research Assistants	9	5,130
		$6,638

The Civil Engineering Department has made great progress on several publications which will be completed during the coming year. New courses have been added in water systems engineering, and linkages have been established with engineers, scientists and public officials in Nigeria, Ivory Coast, Uganda, Senegal, Liberia, Tanzania, Botswana, Afghanistan and Pakistan.

As a result of the 211(d) Grant, arrangements were made during the past year to have Dr. Warren A. Hall join the engineering faculty of CSU. He is currently Director of the Office of Water Resources Research in Washington, D.C. and will become a resident member of the CSU faculty in September, 1974. Dr. Hall pioneered the subject of, and has written a book on, Water Resources Systems Engineering -- which is directly related to water delivery and removal systems as well as the institutions involved in the development, utilization, and management of water systems.

The Civil Engineering anticipated man-months and budget are:

	Man-Months	Budget
Staff and faculty	16	$29,863
Research Assistants	24	13,900
		$43,763

Only two persons in the Department of Economics will be funded under the 211(d) Program for the coming year: Drs. Biggs and Tinnermeier.

Dr. Huntley H. Biggs will continue to serve as a member on the Planning Committee for the International Interdisciplinary Seminar. He expects to participate and attend these seminars. His major activity will be to serve as editor of a book entitled, "Institutional and Technical Aspects of Resource Management on Small Farms in Developing Countries". In this endeavor, Dr. Biggs will only be partially supported by Grant funds. The book will cover those aspects of water delivery, removal and relevant institutional development in appropriate sequence with other subject material. This book will be a collection of 10 readings, of which Dr. Biggs will contribute two and Dr. Tinnermeier one, by faculty members from agricultural engineering, anthropology, economics, geography, and sociology. The emphasis of the book is on analyzing the institutional and technical constraints that influence the development of a strategy for raising the levels of production on small farms. Dr. Biggs will also be completing work on development planning. This book presents a model, based on input-output techniques, which can be used to analyze such development problems as: forecasting, optimization, international trade and technological change.

Dr. Ronald L. Tinnermeier will continue focusing on small farmer development strategies, with special emphasis on credit and credit institutions and their relationship to the introduction of new water management and other technologies. Water availability has been identified as an important variable for successful small farmer credit programs. On the other hand, further research is needed to more clearly understand the need for credit where new delivery systems, water management techniques, and other practices are introduced. Dr. Tinnermeier will also continue to participate in the International Interdisciplinary Water Seminar this coming year. And, as mentioned above, an article will be prepared for Dr. Biggs' editied work on small farms.

The Economics anticipated man-months and budget are:

	Man Months	Budget
Faculty and staff	4	$6,795
Research Assistants	1.5	688
		$7,483

Professor Henry P. Caulfield, Department of Political Science will continue his work in the development, and conduct of the International Interdisciplinary Seminar. He is attempting to obtain full support for the Seminar from sources other than the 211(d) Grant. The Department will also attempt to supplement its support of three graduate research students whose course of studies will focus on the political science aspect of water delivery and removal systems including relevant institutional structures.

The Political Science anticipated man-months and budget are:

	Man Months	Budget
Faculty and staff	2	$4,996
Research Assistants	3	780
		$5,776

During the year, the Department of Sociology completed a general cycle of sensitization to both problems of water delivery and removal systems and to the larger questions of the relationship between water and development. Intended for next year, is a more specific writeup of activities reflecting the concern with irrigated agriculture, and especially the component reflecting water delivery and removal systems. As such, a major paper is prepared dealing with socio-economic aspects of irrigated agriculture in order to provide a background document as well as a training device for both faculty and graduate students participating in the program.

The major expenditure for next year involves essentially the time of a faculty member whose purpose will be to write the documents reflecting the general concern with the socio-economic aspects of irrigated agriculture as well as coordinate the nonfunded activities of other faculty members and supervise the work of one research assistant. The research assistant is expected to utilize the theme of relating population growth to problems of water delivery and removal systems. It is believed that this plan will help improve the competence of sociology with relationship to the requirements of the Grant and will also provide for the emergence of capabilities for applied research in this area.

The anticipated Sociology man-months and budget are:

	Man-Months	Budget
Faculty and staff	3	$5,100
Research Assistants	4.5	2,970
		$8,070

VIII. Entrainment Activities

The impact of Grant-supported activities in helping to develop and strengthen institutional capabilities, the utilization of these institutional resources in development including other resources for Grant-related activities have all made major advances during the reporting year in coordinated unison. The purpose of the Grant, under Title 211(d) was to increase the University's capability to perform assigned functions in the training of professionals at home as well as from the developing countries in the broad fields making up the developmental process. At CSU the impacts of the Grant program at no cost to the Grant have extended throughout the University, particulary with all activities in connection with international education, development and foreign assistance.

As pointed out previously in an annual report, this process of extending benefits, developing and maintaining interest on-campus in foreign affairs, and increasing the capabilities and accomplishments at the University beyond the prescribed limits of the Grant, may be summed in one word "entrainment." The entrainment effect of the Grant program at CSU cannot be over-estimated. Most of the participant professors are key men in six out of eight colleges of the University. The philosophy of these men, their attitudes and actions have extended downward and upward through many channels to other professors, to graduate and undergraduate students and to administration as well. The net results as seen today have been very beneficial. Far more so than has been indicated in any of the past Grant reports. Last year several of these faculty members brought about a reorganization of the International program at CSU resulting in establishing an Office of International Education, elevating responsibility for strengthening and continuing the International program on-campus to the level of the Academic Vice President. The President himself is Internationally minded -- last year

he spent several weeks at Yugoslavia and in Thailand on technical assistance projects involving educational programs -- and fully supports the International programs on campus.

During the past several decades, CSU has performed many foreign training and advisory services and its competence to successfully complete international technical assistance tasks has measurably improved particularly during the last 5-year period, due, in large part, to the entrainment effects of the 211(d) Grant program. Thus, the Grant program has had and continues to exert a stimulating effect on building and maintaining a strong and stable base for both on campus international affairs and overseas activities.

As a consequence of the greatly increased staff capability and the entrainment effect throughout the university, there has been an increase in support for water resources research from other sources. This is illustrated by the list of some of the new contracts and grants obtained during the period of this 211(d) Grant, see Appendix I. The total number is 64 and the total funding is $2,192,858. Although a large part of the funding is in engineering, a really significant part of it is in the other departments and colleges which are cooperating in the 211(d) program.

IX. Report of Expenditures

1. The expenditures as shown in Table I and Table II state the expenditures for fiscal year July 1, 1972, through June 30, 1973, the period under review. The amount shown in Expenditures to Date represents the actual amounts spent in each line item since the beginning of the Grant, July 1, 1969. The projected budget for FY 1974 represents the total funds available for the last year of the 5-year Grant period in the 211(d) Grant Program and is outlined in Section VII, Next Year's Plan of Work and Expenditures.

The Report of Expenditures as shown in Table I is as follows:

Line Item I, Teaching, gives the salaries plus the CSU fringe benefits paid to faculty. In many cases a faculty is paid only one or two months salary for such purposes as initiating and teaching a new course or serving as an advisor for a graduate student. This has had the effect of stimulating other programs and research for Grant-related activities at minimal cost with an expanding or entrainment effect.

Line Item II is the amount paid to graduate students for research stipends. A student is required to work at least 20 hours per week in support of his research project, and to qualify for Grant funding. A list of research assistants supported by 211(d) funds for periods from three to six months is given on page 28.

The Line Item III on travel represents all international travel and also travel within the United States. See pages 31 and 70 for details on foreign travel. Some travel support was provided for faculty to attend 211(d) seminars and Grant-related conferences for presentation of papers and increasing their knowledge and competence in the Grant area.

Library and publications expenses, Line Item IV, cover the cost of books purchased out of 211(d) Grant funds requested by the various faculty, staff and graduate research assistants connected with the program in order to improve the CSU and CUSUSWASH library covering

the areas of the research program as outlined in the Grant objectives. These books are catalogued and placed in the CSU Morgan Library for use in all water resources programs and by other disciplines through inter-library loans. Many other libraries can and do draw upon these materials. Also, covered in these expenditures is the cost of printing and publishing the theses and dissertations by graduate students on their research activities including papers and reports by CSU faculty and mailing expenses for these publications.

Line Item V also includes the costs of consultants to support the programs of the Interdisciplinary Seminar. Many consultants served in the capacity at no expense to Grant funds.

With regard to Line Item VI, since the Grant funds have been responsible for spin-offs in other research, there was little need to purchase equipment as most of the equipment was provided by non 211(d) Grant funds.

Line Item VII, Other and Office Expenses, shows the amount spent for clerical assistance for office administration, for the CSU contributed share of the CUSUSWASH Executive Director for administration of the Grant, and for the funds allocated to the three (3) colleges and six (6) departments. Other office expenses cover such items as telephone, miscellaneous office supplies, and xeroxing.

The line items as listed in Table II conform with the budget in the Grant Document, while Table I shows a general distribution of funds in the area of activity.

Table I

Expenditure Report
(Actual and Projected)

Under Institutional Grant AID/csd-2460

Review Period 1 July 1972 to 30 June 1973

(List all Grant-related activities)	Expenditures to Date		Projected Expenditures (Final Year of Contract) FY 1974	Non 211(d) Funding Amount
	Period under Review	1 July 69-30 June 73 Cumulative Total		
I Teaching	79,217	267,261	67,024	97,000
II Research	52,426	166,280	30,881	165,000
III Travel	16,232	59,315	12,000	25,000
IV Libraries and Publications	3,604	23,670	3,397	10,000
V Consultation	350	10,018	1,000	
VI Equipment	97	3,428		50,000
VII *Other	33,465	91,474	14,252	
TOTAL	185,391	621,446	128,554	347,000

*Breakdown on Other Direct Costs:

Clerical Expense	13,305
Office Espense (telephone, Xeroxing mailing, supplies, Western Union)	8,160
CUSUSWASH Executive Director's Office (CSU contribution)	12,000
	33,465

1 September 1973
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Table II

Expenditure Report
(Actual and Projected)

Under Institutional Grant AID/csd-2460

Review Period 1 July 1972 to 30 June 1973

(List all Grant-related activities)	Expenditures to Date: Period under Review	Expenditures to Date: 1 July 69-30 June 73 Cumulative Total	Projected Expenditures (Final year of Contract) FY 1974	Projected Five-Year Total
Salaries	79,217	267,261	67,024	334,285
Stipends	52,426	166,280	30,881	197,161
Travel	16,232	59,315	12,000	71,315
Equipment	97	3,428	-0-	3,428
*Other (Office Expenses)	33,465	91,474	14,252	105,726
Library and Publications	3,604	23,670	3,397	27,067
Consultation	350	10,018	1,000	11,018
TOTAL	185,391	621,446	128,554	750,000

*Breakdown on Other Direct Costs:

Clerical expense	13,305
Office expense (telephone, Xeroxing, mailing, supplies, Western Union)	8,160
CUSUSWASH Executive Director's Office (CSU contribution)	12,000
	33,465

1 September 1973
dw

FOREIGN TRAVEL

DESCRIPTION			DOLLAR AMOUNT PER TRIP
A brief narrative statement listing the name and title of the individual, purpose and results of the trip, duration and the total amount charged to the Grant including partial funding, is indicated below:			
GRA			
Christopher Dowswell - 3 months - Guatemala To establish a research program for an M. S. degree and to gain linkages with the Ministry of Agriculture coordinating this study and activities with USAID.	ticket actual expenses	none 470.00	$470.00
FACULTY			
Dr. George Radosevich - 1 month Comprehensive feasibility study in the area of irrigation development.	ticket excess baggage actual expenses	914.00 283.00 711.00	$1,908.00
Dr. Maurice L. Albertson - Costa Rica Rural Development - Social and Political Aspects of Agrarian Reform and their role in promoting Social and Political Development.	ticket expenses	485.00 264.00	$749.00

FOREIGN TRAVEL

FACULTY - continued		DOLLAR AMOUNT PER TRIP	
Dr. Huntley H. Biggs - 1 week - Guatemala City Thesis research supervision (Christopher Dowswell) and to further strength the linkages of Mr. Dowswell with USAID and Ministry of Agriculture.	ticket expenses	334.00 355.00	$689.00
Dr. Maurice L. Albertson - Ibadan, Rome IITA, Nigeria seminar on "Prospects for Irrigation in West Africa". Consult with FAO officials in Rome.	ticket excess baggage expenses	1,050.00 250.00 466.00	$1,802.00
Mr. Evan Vlachos IITA, Nigeria seminar on "Prospects for Irrigation in West Africa". Includes approved linkage stopovers.	ticket excess baggage expenses	1,050.00 250.00 629.00	$1,929.00 (partial)
Dr. William B. Hart IITA Nigeria seminar on "Prospects for Irrigation in West Africa". Includes approved linkage stopovers.	ticket excess baggage expenses	1,050.00 250.00 1,021.00	$1,271.00 (partial)
Dr. W. Doral Kemper IITA Nigeria seminar on "Prospects for Irrigation in West Africa".	--------- --------- expenses	 157.00	$157.00 (partial)
Dr. Maurice L. Albertson - Kabul, Afghanistan Strengthen linkage between CSU/USAID Mission. Follow up with research on the Helmand Valley Project.	ticket expenses	313.00 78.00	$391.00

APPENDIX A

Grant Document

(without special provisions)

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

OFFICE OF
THE ADMINISTRATOR

Mr. William E. Morgan
President
Colorado State University
Logan, Colorado

Dear Mr. Morgan:

I am pleased to inform you that pursuant to the authority contained in Section 211(d) of the Foreign Assistance Act of 1961, as amended, Grant No. AID/csd-2460 in the amount of $750,000 is made hereby to Colorado State University. This grant is for the purpose of implementing the project "Optimum Utilization of Water Resources with Emphasis on Water Delivery and Removal Systems", as set forth in the final proposal, dated April 23, 1969, and agreed to by A.I.D. and Colorado State University.

The grant funds are obligated as of the date of this letter, and shall apply to costs incurred in furtherance of the project for five years.

This grant is made by A.I.D. to Colorado State University on condition that the Grantee shall administer the funds provided under this grant in accordance with the terms and conditions set forth in the final proposal, Special Provisions and Administration of A.I.D. Grants attached hereto and made a part hereof.

Please acknowledge this grant by signing the original and six (6) copies of this letter and one copy of the Assurance of Compliance. Please return all documents to the Grant Officer.

Sincerely yours,

/s/ John A. Hannah
John A. Hannah

Attachments:
1. Final Proposal
2. Assurance of Compliance
3. Special Provisions
4. Administration of A.I.D. Grants
5. Budget

ACCEPTED
BY
TITLE

Final Proposal

For

AID Institutional Development Grant

I. Title: Optimum Utilization of Water Resources: with special emphasis on Water Delivery and Removal Systems and Relevant Institutional Development

II. Name of Applicant: Colorado State University

III. Program Director: Maurice L. Albertson
Linwood L. Hodgdon, Associate Director

IV. Duration: Five years from date established by the Grant

V. Amount of the Grant: $750,000

VI. Action Officer:

Summary:

This Proposal is one of three being submitted by each of three universities on different aspects of water resources utilization. This Grant will strengthen the already existing competence of Colorado State University in water delivery and removal systems and in development of institutions which are relevant to the various aspects of optimum utilization of water resources.

The competence of Colorado State University in these subjects exists in several departments whose staff members constitute the basic capability and interest. The Grant will be used to expand both the depth and breadth of this capability in its application to the less developed countries. Specifically, the grant would be used to support the salary of staff members and graduate students, and their travel and other expenses related to this activity.

As a Land Grant University, Colorado State University has a long tradition of research, education, and service for agricultural areas and their needs both in the United States and abroad. This Grant will help to expand these activities more effectively into and for the less developed countries.

Background

This proposal is one of three being submitted by each of three universities (University of Arizona, Colorado State University, and Utah State University), which are coordinating their efforts through the Council of U. S. Universities for Soil and Water Development in Arid and Sub-Humid areas -- later referred to as Council. These three universities are among the most competent in the field of water management in the United States.

Colorado State University will emphasize the development of its competence with special emphasis on "water delivery and removal systems and relevant institutional development", Utah State University in "on farm water management" and the University of Arizona, "water shed management". This devision of emphasis reflects their respective current special competencies and major field of interest in United States' water management problems. In addition, each of these universities has special geographic experiences and interests in less developed countries. Utah State University is active in several Latin American countries; Arizona is working for AID in Brazil; and Colorado State University is active in Pakistan and Southeast Asia. All three of the universities have contacts and experience in several other locations throughout the less developed world and have general interests in water management problems in less developed countries.

Activities under the Grants to these three universities will be coordinated through the Council in order to maximize development of competencies under the Grants and to facilitate usefulness of these competencies to AID and other appropriate agencies.

Because irrigation agriculture is concentrated in relatively few states, special U.S. competence in irrigation water management is limited to relatively few U. S. universities. However, irrigation is of extreme importance to the agriculture of a large proportion of the less developed countries. Therefore, the increased competence in water management to be created through these Grants for conditions found in the less developed countries, will be of central importance to optimum agricultural development in many of the less developed countries of all the major continents of the world.

Capacity and Commitment

Shortly after the Land Grant Act was signed by President Lincoln, the Land Grant College for Colorado was created in Fort Collins to work with the people in the rural areas through its extension service programs, and to provide higher education for the common man. The Colorado Agricultural Experiment Station was also created at Fort Collins as an integral part of the college to conduct research and experiments on problems confronting the farmer. Colorado State University thus has a long-standing interest in and commitment to the problems of development--particularly in arid agricultural areas where water resources are in short supply or not yet fully developed.

This very practical beginning for what is now Colorado State University has continued to be the central theme, a strong program in research, education, and service. The primary aspect of this program is in Water Resources Development, including agriculture, engineering, watershed management, geology, and various aspects of biological and social sciences. The various water resources programs of research and education at Colorado State University constitute the largest such graduate programs in the world, and a number of these programs are heavily involved in various types of foreign activities, such as the Asian Institute of Technology in Bangkok, and a research program on Water Management in Pakistan.

Well over 100 faculty, and more than 300 graduate students from both the United States and abroad, are now involved in the foregoing programs in the various departments of Colorado State University.

Colorado State University has developed within its institutional structure a Center for Natural Resources, an Office of International Programs and a Center for Latin American Studies. Each of these centers and offices will assist in the development of this project and will be strengthened by their involvement in assisting in the addition of faculty, students, courses, and service activities to broaden the scope of the water resources program at the University as it relates to the less developed countries. These offices and centers have been and are now involved in projects or programs that focus on the professional and technical needs of the less developed countries including specific geographical areas; Latin America, South and Southeast Asia, and Africa.

Colorado State University also has a tradition of working on research, education, and service activities related to water resources with many different agencies of the United States Government and various state agencies, such as:

1. U.S. Geological Survey
2. U.S. Bureau of Public Roads
3. U.S. Agricultural Research Service
4. U.S. Economic Research Service
5. U.S. Soil Conservation Service
6. U.S. Forest Service
7. U.S. Rocky Mountain Forest and Range Experiment Station

8. U.S. Bureau of Reclamation
9. U.S. Bureau of Sport Fisheries and Wildlife
10. U.S. Public Health Service
11. Colorado Water Conservation Board
12. Colorado Cooperative Wildlife Research Unit
13. Colorado Game, Fish, and Parks Department
14. Colorado State Forest Service

Colorado State University has a large number of courses related directly or indirectly to water resources. These courses have been expanded steadily to meet additional requirements in each of the many departments which are interested in the optimum utilization of water resources.

When AID and SEATO were interested in establishing a graduate school in Southeast Asia ten years ago, with special emphasis on water resources, they came to Colorado State University which has taken the responsibility for the initial design of the School and the coordination of the United States contribution ever since that time. The School is located in Bangkok, Thailand and is now known as the Asian Institute of Technology with a continually expanding scope of activities.

Many of the Colorado State University faculty are serving periodically as consultants to various governments, agencies, and other organizations abroad with regard to water resources problems.

Colorado State University has been expanding, at an ever increasing rate, its level of support, both in breadth and in depth, in the various aspects of water resources. Furthermore, it expects to continue this expansion in the future. In addition, in support of this Grant, the University will provide:

1. The office, classroom, laboratory, and library space for faculty, students, and foreign visitors.
2. The basic facilities and equipment required for research, instruction, and service--such as analog and digital computers and certain basic laboratory equipment.
3. The usual administrative and technical supervision and counsel by the various administrators.
4. The advise and assistance of faculty and other staff throughout the University who have special competence which bears on the needs of the program.

Objectives and Scope of Proposed Program

With the funds from the Grant, Colorado State University will improve its level of excellence with respect to planning, development, management, and utilization of water resources with special emphasis on water delivery and removal systems and relevant institutional development related to the needs of the less developed countries. This will be accomplished through the following steps:

1. Expand its professional staff in the various departments of the University which are now involved, or which would like to be involved, in water resources activities related to the needs of the less developed countries.

2. Expand its number of graduate students in these departments from, or interested in, the less developed countries.

3. Expand its departmental research programs and activities related to the needs of the less developed countries.

4. Expand its course offerings in these departments --- including interdisciplinary courses --- which are related to the less developed countries.

5. Expand special activities, and initiate new ones, in the United States and abroad which are related to research, teaching, and service -- e.g. seminars, exchange programs, institutes, conferences, and publications which are concerned with the less developed countries.

6. Help to alleviate the critical shortage of qualified professional personnel with international interests, experience, and expertise, and with cross-cultural insights.

7. Expand its capability to serve in advisory and consulting capacity to various individuals, government agencies, industries, business, and other organizations who have an interest in activities abroad. It would be understood, however, that substantial specific services in this area will be funded by AID and any other sponsoring agencies under separate contractual arrangements.

8. Improve its understanding of the nature of the less developed societies, and find ways and means of assisting them to resolve crucial problems relating to water resources development and management.

9. Develop an exchange of personnel and publications, and other programs of interaction, which will help to establish steady and effective lines of communication between Colorado State University and the less developed countries.

The subject areas of specialization include the following as related to the needs of the less developed countries:

1. Development of water supplies from various sources.

2. Conveyance, delivery, and drainage of water in open and and closed conduits, including rivers, canals, irrigation ditches, tunnels, and pipelines.

3. Storage and use of water in reservoirs, both above and below ground.

4. Control and measurement of water in storage, and water being conveyed either for delivery or for drainage.

5. Control of erosion and sedimentation with respect to storage.

6. Use of wells as a source of water or for storage of water underground.

7. Use of systems engineering for development of optimum solutions to problems of water resources utilization.

8. Understanding social, economic, political, and cultural factors in technological change, and the processes of developmental change.

9. Analysis of prevailing social systems, their structural-functional characteristics within specific less developed countries to determine:

   a. The kinds of structural changes necessary for maximizing water resource development and management, including the use of necessary new inputs.

   b. The sources of resistance to these necessary changes, and

   c. Effective ways of dealing with social resistance

10. To analyze specific organizational and administrative structures for agricultural development in specific less developed countries to determine needed changes for better water utilization in maximizing agricultural production.

11. To conduct economic analyses, including input response studies, and including the analysis of delivery and removal systems, to achieve efficient and economic allocation of water for agricultural purposes in selected areas of the less developed countries.

12. By use of systems analysis, develop case studies analyzing and documenting the above relationships in selected areas of the less developed countries for instructional research, and training purposes in a multidisciplinary setting.

Operational Plan

The details of the operational plan will be developed with the help of an interdisciplinary advisory committee from several departments and areas of administration. The broad aspects of the plan, however, are as follows:

1. Assemble and analyze existing information on water delivery and removal systems related to the less developed countries.

2. Assemble and analyze existing information on development of institutions relevant to optimum utilization of water resources in the less developed countries.

3. Prepare plans for additional research programs which will increase the knowledge of methods, techniques, and procedures for optimizing the utilization of water resources in the less developed countries.

4. Increase the breadth and depth of teaching and educational materials for the subjects of this proposal and for the situations in various less developed countries.

5. Solicit especially well qualified graduate research assistants, from both the United States and the less developed countries, who expect to work in some aspect of international development upon completion of their training.

6. Expand the library collection, especially with respect to the problems of the less developed countries.

7. Develop a program of student and faculty exchange with certain less developed countries.

8. Plan, initiate, and expand an interdisciplinary seminar on development and the interrelationship of the many factors involved in development--especially in the less developed countries.

9. Conduct short courses, institutes, seminars, and other activities to stimulate other personnel to become more deeply and actively involved, and to help in continuing education for those already involved in various aspects of international developemnt.

The first year of this program will be devoted to analysing and developing the details of the total program, integration of on-going programs, selection and orientation of new staff and graduate students, and establishing the interdisciplinary components of courses, seminars, research projects, and service activities. It is expected that approximately 16% of the total grant will be spent the first year, and that this percentage will gradually increase to more than 20% the fourth and fifth years. Throughout the period of the grant the proportion spent for each line item will remain approximately the same from year to year.

Following the submission of the annual technical report, AID will initiate a review of the acitvities under the Grant. Such a review will include an evaluation of progress, administrative and financial considerations, and plans for the coming year. The discussion will include ways in which the accomplishment may be utilized in the AID program and other areas where technical assistance may be needed.

Date of Application: 21 April 1969

The Special Provisions of the Grant Document are not included here.

Appendix B

Appendix B contains the following ABSTRACTS:

Biggs, Huntley H. The Puebla Project: Progress and Problems. CUSUSWASH Technical Report No. 22. (Fort Collins: Colorado State University), July 18, 1972.

ABSTRACT

In 1967 the Puebla Project was initiated in Mexico under the direction of the International Maize and Wheat Improvement Center. The program was designed to raise maize yield on small, rainfed farms. A team of experts devised a technological package which would substantially raise yields. One of the key innovative aspects of the program was the integration of the research and extension effort. Agronomic experiments were carried out on farmers' plots with the assistance of the farmers themselves. In addition, new approaches to the extension function were conceived, such as the formation of producer groups for the effective dissemination of technical knowledge. The first part of the paper reviews the history of the project. Despite early successes, by 1970 there was great concern expressed concerning the future levels of farmer participation in the project. The majority of this report is based upon the author's personal observations during a brief stay in Mexico in June, 1972. In it, he attempts to identify three sets of interrelated problems which must be approached if further progress is to be achieved: technical-production problems, organizational and institutional problems, and farmer decision making considerations. This report points out difficulties that should be anticipated by development planners who are contemplating similar programs aimed at small farmers in other developing countries of the world.

Neal, William L. and Clifford Stockmyer. Index For the Eight Near East-South Asia Irrigation Practices Seminars. Introduction by: A. Alvin Bishop and O. L. Mimms, AID/Washington. CUSUSWASH Water Management Technical Report No. 24. (Fort Collins: Colorado State University) August 1972.

ABSTRACT

This index of the Regional Near East-South Asia Irrigation Practices Seminar Proceedings prepared with support of 211(d) Grant Funds under the direction of Dr. Garth Jones, Colorado State University, provides a detailed alphabetical key to the contents of the eight volumes comprising the published proceedings of these seminars.

Under the sponsorship of the Agency for International Development and predecessor agencies, the biennial seminar series had its beginning in Izmir, Turkey, in 1956, followed by seminars in Tehran, Iran, 1958; Lahore, Pakistan, 1960; Ankara, Turkey, 1962; New Delhi, India, 1964; Amman, Jordan, 1966; Lahore, Pakistan, 1968 and Kabul, Afghanistan, 1970.

In the aggregate the eight volumes contain over 2500 pages of information including 180 technical papers, numerous panel reports with recommendations and country reports regarding the irrigation situation in the 17 countries represented at one or more of the seminars.

Approximately 3000 copies of each volume have been printed and distributed throughout the world to USAID Missions, to organizations having to do with irrigation development, to universities and educational institutions and to the Library of Congress and its subscribing libraries.

The comprehensive alphabetical indexing of the seminar proceedings listing the countries, names, technical topics and places by volume and page numbers will provide the users of the proceedings an easy access to the information contained.

Schiefer, Michael C. The Organization of Thai Irrigators.
M.S. Thesis, Civil Engineering, Colorado State University, Fort Collins.

ABSTRACT

This thesis examines the problem of organizing Thai farmers for cooperative irrigation in Northeast Thailand. Cooperative irrigation requires more elaborate organization than rural Thai have been accustomed to. Consequently, local water user organizations have not developed as an automatic reflex to the construction of dams and irrigation canals.

Investigations in this study indicate that where Thai irrigation systems are structured such that they reinforce the development and persistence of satellite village structural type of communities irrigators have had more success in organizing for irrigation. The reason for this is thought to be the structural changes needed in social relationships. When organizational requirements for irrigation systems reinforce the satellite village structural type of community, new and increased demands come to bear directly upon traditional organization. This causes traditional organization to become technically underdeveloped and functionally maladjusted for exploiting opportunities at hand. At the same time, however, suitable avenues are created for structural change to take. These two conditions are believed to provide both the impetus and direction for the structural change upon which success in organization depends.

Nazar, Ata Mohammad. A Laboratory Study of Bed Material Withdrawal in Farm Turnouts. A M.S. Thesis, Civil Engineering, Colorado State University, Fort Collins.

ABSTRACT

The phenomenon of bed material withdrawal through a farm turnout was studied in an indoor laboratory flume. Depth of flow in the flume, discharge in the flume, turnout elevation from the concrete bed of the flume, and the discharge through the turnout were the variables whose effect on the variation of sediment discharge through the turnout was to be determined.

The statistical analysis of the data (Eq. 5-1) indicates that the sediment discharge through the turnout is almost directly proportional to the sediment concentration in the flume. Data taken at two different turnout elevations confirmed (Fig. 5-3) that most of the sediment load was transported close to the bed of the channel and the variation in sediment concentration at higher elevations from the bed of the channel was not significant.

Based on a series of special runs plus visual observation, it was found that the amount of sediment discharge through the turnout was significantly affected by the bed form movement in the flume. A collapse of sharp peak or unstable bed formation which was irregular in time and space in the vicinity of the turnout would increase the sediment discharge through the turnout considerably. The analysis of data shows that the scour pit formation near the turnout remains geometrically similar under different conditions of flow in the flume and the turnout. It was also found that the depth of scour pit increases with an increase in the discharge ratio.

Tuffuor, Samuel. Optimal Parameter Identification of Nonlinear, Time-Variant Hydrologic System Models. Dissertation, Civil Engineering Department, Colorado State University, Fort Collins, June 1973.

ABSTRACT

Investigation of river basin characteristics is important to river basin planners, engineers, atmospheric scientists, mathematicians, statisticians, and agriculturists.

This study focuses on the important need in river basin investigations for development of mathematical models that describe hydrologic system response to rainfall. In particular time variant, nonlinear simulated models for runoff and a predictive model for evapotranspiration are presented. One of the major objectives of this study is in the development of a hydrologic model for water delivery particularly suited for a developing nation, though general in application. Emphases are placed on using what is available in the best possible way. The proposed model is evaluated with respect to total computation time required and ease of understanding and utilization. Solution procedures are evaluated with respect to speed of convergence to optimal solutions of computed runoff and parameters; and general accuracy and efficiency.

Two models are developed: first and second order nonlinear differential equations. From the results obtained, the first order nonlinear differential equation proves to be a better monthly model for river basin response simulation. This conclusion is based on computed runoff using the models, and the predicted seasonal and annual evapotranspiration losses.

The river basin clearly demonstrates nonlinear characteristics. Linear models, developed for comparative purposes with the proposed nonlinear models, consistently predict low evapotranspiration values and comparatively poorer computed runoff values. An optimization procedure is carried out with the objective function being the sum of the squared difference between the observed and computed runoff. The constraints on the objective function are based on the parameters or coefficients of the differential equations; and these are further based on the physical realities of the hydrologic system--the river basin.

Two solution approaches used were based on the above objectives. Quasilinearization and gradient (steepest descent) techniques were utilized. Quasilinearization proved to be an ineffective algorithm as far as the proposed models are concerned, and diverged in solving all the various models. The gradient technique proved to be a good algorithm and could be modified to handle time dependency of parameter values. All the parameters, except

one, varied very little and their corresponding average seasonal values were successfully used. The time dependent parameter α, referred to in this study as the sensitivity parameter, is responsible for the prediction of the evapotranspiration losses.

These models were applied to an actual river basin in a developing country in order to verify them and gain insight into them through experimental methods. On the basis of these, conclusions drawn can be useful to planners of water resources development, agriculturists, hydrologists and even theoreticians.

Myers, Everett. The Problem of Rural-Urban Water Competition. An M.S. thesis, Political Science Department, Colorado State University, Fort Collins, June, 1973.

ABSTRACT

The numerous issues and problems involved in rural-urban water transfer are prima facie evidence of the need for comprehensive water planning. The Las Animas water sale illustrates how even local, state, and regional planning can be thwarted. The axiomatic importance of water means that its allocation can no longer rest on a laissez-faire basis. It is a scarce commodity that attracts many competing interests. Therefore, it is in the public interest that all decisions regarding this scarce commodity be made by our informed and planned choice--not by happenstance or default.

Biggs, Huntley H. The Green Revolution and Economic Development. Rocky Mountain Social Science Journal, X (January 1973), 15-24.

ABSTRACT

While the development of high-yielding varieties of food grains raised the hopes of the developing countries for solving food production problems, there are many social science problems that must be solved before the miracle seeds will be effective in generating long-term development. This paper reviews briefly the history of the research effort which lead to the discovery of the high-yielding varieties of wheat and rice. The majority of the paper is devoted to a discussion of fundamental problems which must be solved in order for the developing countries to capture the full potential of the new production technologies for raising the living levels of a large segment of their populations. Among the issues discussed are: the provision of agricultural inputs to the majority of farmers, particularly fertilizer, water, seeds and pesticides; domestic and international marketing; foreign exchange impacts; income distribution; mechanization; and employment.

Skogerboe, Gaylord V., J. W. Hugh Barrett, Wynn R. Walker, Lloyd H. Austin. Comparison of Bridge Backwater Relations. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, Colorado State University, Fort Collins.

ABSTRACT

A need exists to compare methods of analyzing bridge backwater relations and to determine the interrelationships among the various methods, thereby disclosing any advantages or disadvantages of one technique in comparison with the other techniques. This paper evaluates these currently existing methods of predicting the effects of a bridge construction on stream flow, as compared to the method of subcritical flow analysis.

Skogerboe, Gaylord V., Ray S. Bennett and Wynn R. Walker. Generalized Discharge Relations for Cutthroat Flumes. Journal of the Irrigation and Drainage Division, ASCE, Colorado State University, Fort Collins.

ABSTRACT

Water measurement is essential to water resources management. Flowing water must be measured to determine the amount received from a source and to control the amounts distributed to various uses in conformance with legal requirements or water supply contracts. The flume is the most widely accepted and used device for measuring open channel flows. Of the flumes in present day use, the most common is the Parshall flume (2) developed by Ralph Parshall.

The Cutthroat flume (4) is a new flume designed to measure flows in flat gradient streams. The flume was originally limited to one length with width as a variable. The different sized flumes were therefore not geometrically similar. This study presents groups of flumes which are geometrically similar.

Skogerboe, Gaylord V., Wynn R. Walker, Tsu-Yang Wu, Ray S. Bennett. Slope-Discharge Ratings for Cutthroat Flumes. Soil and Water Division of ASAE, Colorado State University, Fort Collins.

ABSTRACT

Frequently, flow measuring flumes placed in unlined channels settle at the flume exit due to scouring action. Usually, the settlement is not corrected. Therefore, the discharge will be affected and corrections to the discharge coefficient varies and discharge increases as the flume floor slope increases.

The most significant findings resulting from this study are that both the free flow and submerged flow exponents have a unique value for each flume length. These exponents are not affected by throat width or flume floor slope.

The above findings have allowed the effect of flume floor slope to be analyzed in terms of the free flow coefficient and submerged flow coefficient. These coefficients are uniquely related to the flume floor slope for each flume length, but are independent of throat width. Thus, generalized slope-discharge relations could be developed for Cutthroat flumes by extending these studies to longer flume lengths.

Skogerboe, Gaylord V., Wynn R. Walker, Va-Son Boonkird. Culverts for Flow Measurement in Irrigation Systems. Soil and Water Division of ASAE, Colorado State University, Fort Collins.

ABSTRACT

This study has shown that the submerged flow analysis used for flow measuring flumes and weirs can be applied to free surface outlet control flow in culverts. Also, discharge ratings for horizontal culverts can be graphically shown on a single plot. Such a plot covers the three flow conditions investigated in this study, which are inlet control, free surface outlet control, and submerged outlet control.

The results of this study have clearly shown that culverts can definitely be used as flow measuring structures in irrigation systems. Thus, existing culverts could be utilized for providing discharge measurements. Also, small culverts could be employed as portable flow measuring devices.

The assumption that $n_1 = 1.5$ was used to simplify the analysis. Further study should be undertaken to remove this assumption from the flow analysis. Then, generalized discharge ratings could be developed for a wide variety of inlet, barrel, and outlet culvert geometries.

Appendix C

INTERNATIONAL INTERDISCIPLINARY SEMINAR ON WATER RESOURCE MANAGEMENT (GS 797)

Purposes of Seminar

A. To develop appreciation among participants--faculty and graduate students--of the diversity of factors--including engineering, cultural, biological, economic, social and political--and thus, of the multidisciplinary nature, of water resources management.

B. To gain basic intellectual understanding among all participants of the concerns, concepts, methods and contribution of each academic discipline concerned with water resources management.

C. To foster construction of interdisciplinary models for the solution of water management problems through the joint efforts of faculty and graduate students representing the disciplines relevant for the solution of such problems.

D. To evaluate interdisciplinary models for the solution of water management problems from all points of view including those of experienced practitioners and observers of water resources management.

E. To appraise the successes and failures of water management efforts throughout the world, especially in less developed countries, in meeting human needs.

F. To enable participants from all academic departments to gain, in successive terms and years of their participation, greater and greater resolution in their knowledge of water resources management; and thus

G. To contribute to the achievement of increased levels of competence in water resources management among faculty and graduate students of Colorado State University.

Academic Credit

As of the fall term, 1972, the seminar is offered as a credit course, GS 797; and it is open to any interested graduate student.

Academic credit for attendance and participation in the weekly seminar is one credit per term. Satisfactory participation in a field trip of ten days or longer, such as that to the Lower Balsas River Basin, Mexico, in 1971, would also entitle a graduate student to one credit. In addition, one to three credits would be granted for making a major contribution to the seminar through preparation alone, or in a group, of a seminar paper requiring a substantial amount of work.

Place and Time

The seminar is held regularly once each week on Wednesday from 3:00 p.m. to 5:00 p.m. in a room in the Student Center. Notices of meetings are sent each week to all faculty and graduate students (i.e. whether they are taking the course for credit or not) who are on the Seminar mailing list.

Seminar Administration

The Seminar is a function of the Graduate School. A Program Committee composed of a chairman and faculty representatives of academic departments interested in having their faculty and graduate students involved in the Seminar Program establish Seminar policy and develop the Seminar's annual program within established guidelines. One or more graduate students from each participating academic department participate in the deliberations of the Program Committee as advisory members.

The current faculty members of the Program Committee are:

Henry P. Caulfield, Jr.	Chairman
Maurice L. Albertson	Ex-Officio
Huntley H. Biggs	Economics
Clarence Carlson	Fishery and Wildlife Biology
Linwood L. Hodgdon	Sociology
David B. McWhorter	Agricultural Engineering
Albert G. Mercer	Civil Engineering
John O. Reuss	Agronomy
John Straayer	Political Science

The Chairman of the Program Committee is appointed by the Dean of the Graduate School and is responsible for implementing the policies and program of the Program Committee. The tenure of the Chairman is limited to one term of five years. He is not to be the representative of his academic department during his tenure as Chairman. The present Chairman is Henry P. Caulfield, Jr., Professor of Political Science.

Seminar Program for 1972-1973

The general plan developed by the Program Committee for conduct of the International Interdisciplinary Seminar on Water Resources Management in 1972-1973 called for seminar presentations falling under the following three general headings:

1. Small Farming Problems in Less Developed Countries--Because much irrigated farming in less developed countries is on small farms and promises to remain so, attention will be focused upon the factors that are critical in making such small farms economically, socially and politically viable.
2. Major Constructed Water Development Projects Throughout the World--Evaluation of their Planning Procedures, Experience During Construction, and Operations and Effects to the Present. Emphasis in this series will be placed upon learning from apparent past mistakes. Also, efforts will be made to discern whether there is any difference in "mistake-making" if the projects are planned by public agencies in a country, by private engineering firms of the country or foreign, or by university planning teams.
3. Interdisciplinary Modeling of Water Management Problems--This part of the program will continue the emphasis upon modeling in previous years. The topics to be covered during the coming year have not yet been selected.

Seminar Program for Fall, 1972

September 27	National Water Plan of Israel--Nathan Buras, Associate Professor and Dean, The Lowdermilk Department of Agricultural Engineering, Technion-Israel Institute of Technology, Israel.
October 4	State of Madha Pradesh (India)--Water Use and Developments--D. R. Sikka, Secretary, Control Board, Major Projects; Dy. Secretary for Government Irrigation, State of Madha Pradesh, India.
October 11	Some Planning and Implementation Problems for Irrigation Projects With Latin American Examples--Dr. Byron C. Palmer, Professor of Irrigation Engineering, Field Director of USU's Water Management Research Project, Utah State University, Logan, Utah.
October 18	Water Resources Developments in Ethiopia--Presentation by Panel: Dr. Willis W. Shaner, Associate Professor, Department of Mechanical Engineering, Chairman; Zewdie Abate, Graduate Student, Department of Agricultural Engineering; Tadesse Kibreab, Graduate Student, Department of Agronomy; W. A. Lemma, Graduate Student, Department of Civil Engineering; Habte Neghassi, Graduate Student, Department of Agricultural Engineering, CSU.
October 25	Observation on Water Management in Yugoslavia--Henry P. Caulfield, Jr., Professor of Political Science, CSU.
November 1	Observations on Water Developments in the Less Developed Countries--Dr. Gilbert White, Professor of Geography and Director of Behavioral Sciences Institute, University of Colorado, Boulder.
November 8	A United Nations Perspective: An Appraisal of Effects of Water Developments to Date in Less Developed Countries, and the Water Development Role of International Agencies--Dr. A. Alagappan, Chief, Water Resources Section, Resources and Transport Division, United Nations, New York.
November 15	Observation on Water Management in Nigeria and Other African and Asian Countries--Dr. Maurice L. Albertson, Program Director for Water Management Research Project and 211(d) Institutional Grant, CSU. Capitalizing on the Water Resources of Southeast Asia and Pakistan--Dr. W. Doral Kemper, Project Director for Water Management Research Project, CSU.
November 29	Water Management Practices and Opportunities in Pakistan--Dr. W. Doral Kemper, Project Director, Water Management Research Project, CSU.

Seminar Program for Winter, 1973

Small Farm Agriculture in Developing Countries--Emphasis in the series of presentations in Winter, 1973, is to be identification of factors (including specific technologies) appropriate to small farm agriculture in developing countries. This emphasis is based on the assumption that small scale agriculture "is here to stay" in the foreseeable future.

January 10	The Significance of Small-Scale Farming in Developing Countries--Dr. Huntley H. Biggs, Assistant Professor of Economics; and Dr. Ronald L. Tinnermeier, Associate Professor of Economics.
January 17	Traditional Agricultural Resources Management--Dr. Gene Wilken, Associate Professor of Geography.
January 24	Primitive and Peasant Economies: Cultural Implications of Directed Social Change--Dr. John Schultz, Assistant Professor of Sociology and Anthropology.
January 31	The Role of Small Farms in the Development Process--Wyn Owen, Professor and Director of Economics Institute, University of Colorado, Boulder.
February 7	Extending New Technologies to Small Farms: The Puebla Project--Dr. Huntley H. Biggs, Assistant Professor of Economics.
February 14	Credit for Small Farmers--Dr. Ronald L. Tinnermeier, Associate Professor of Economics.
February 21	Adoption of New Agricultural Inputs by Indian Peasants--Dr. Linwood L. Hodgdon, Professor and Acting Chairman of Sociology and Anthropology.
February 28	Technology in Relation to Scale of Farming Operation and Education of Farmer-- Dr. W. D. Kemper, Project Director, Water Management Research Project.
March 7	Topic Related to Trip to India, January 1973--Henry P. Caulfield, Jr., Professor, Political Science.

Seminar Program for Spring, 1973

Except for certain special programs, the Seminar will emphasize during Spring, 1973, interdisciplinary modeling of water management problems.

March 28	National Water Grid of India--World's Biggest Water Project Proposal: Ganga-Cauvery Link Canal--S. Janakiram, Graduate Student in Water Resources Systems Engineering;

	Discussant, Henry P. Caulfield, Jr., Professor of Political Science.
April 4	Food for the World--Public Policy Dilemmas Especially in Relation to Water Resources Management--Dr. Howard R. Cottam, North American Representative of the Food and Agriculture Organization (FAO).
April 11	Mathematical Modeling of Surface Water Flows for Water Resources Planning and Management--Dr. Jean Cunge, Visiting Professor of Civil Engineering, Grenoble, France.
April 18	Interdisciplinary Modeling as a Decision-Making Device--Dr. Donald A. Jameson, Professor of Range Science, CSU.
April 25	Development of Dynamic Simulation Models Using Interdisciplinary Teams--Dr. George Innis, Associate Professor of Mathematics; and Director of Modeling for the Natural Resources Ecology Laboratory, CSU.
May 2	Water Resources Development in the USSR with Special Reference to Irrigation Developments in Arid Regions--Harald Peterson, Counselor for Water Resources, Embassy of the USSR, Washington, D.C. This meeting of the Seminar held at Colorado University in Boulder.
May 9	An Interdisciplinary Model for Urban Flood Plain Management, Atlanta, Georgia--Dr. Duane Hill.
May 16	Optimal Control of Large Scale Combined Sewer Systems--John Labadie, Assistant Professor of Civil Engineering, CSU.
May 23	Optimizing Conjunctive Use of Indus Basin Waters--Dr. Albert G. Mercer, Associate Professor of Civil Engineering; Rashid A. Makhdoom, candidate for master's degree, Civil Engineering; M. Talib Chaudhry, candidate for Ph.D. degree, Civil Engineering; Fang Hong Wu, candidate for Ph.D. degree, Civil Engineering.

The International Interdisciplinary Seminar has given 97 seminars during the past four years resulting in CSU achieving higher levels of competency each year in water resources management among faculty and graduate students.

Appendix D

Research Assistant Activities

The following are examples of research activities under preparation by research assistants supported in part or wholly by Grant funds:

Q. Ali Khan — Pakistan's irrigation water distribution system and its operation and management.

This research will serve as a model system for application of the research already performed by Professor Skogerboe under the 211(d) Grant. The application of these techniques to the Pakistani situation will improve my competence and develop the university's capability in water delivery and drainage.

Jacob H. Dane — Interactions of water and salt movement in soil profiles.

The research being conducted relates to the quality of the water leaving the soil profile. The salt content of the irrigation return flow will be affected by the amount and timing of the irrigation water application in combination with the soil profile properties. Hence, the research activity will contribute information useful in the design and management of irrigation water delivery and removal systems. The information will be useful and could possibly be utilized in less developed countries which may be constructing irrigation systems.

Herb Blank — Optimal use of surface and ground water in Botswana.

The study is in the beginning stage. It will compare possibilities for development in Botswana with similar situations in other developing countries.

W. A. Lemma — Methodology for selection and timing of water resources projects.

The objective of the study is to develop a methodology that uses vigorous analytical procedures for the optimal selection and timing of water resources projects to enhance comprehensive national planning for economic development.

R. A. Makhdoom — Soil and water salinity for the Northern Indus Plain in Pakistan.

Study of this problem is important from the viewpoint of proper water management and crop growth. It is also of fundamental importance in connection with the water delivery and removal system. In problems involving drainage application of the leaching irrigation water and the optimal use of the groundwater reservoir, the salinity considerations have to play a major role. This study will be helpful for carrying out further research on various aspects of the water resources systems in countries with less developed economics.

Chris Dowswell — Evaluation of irrigation projects for small farmers in Guatemala.

This research is designed to evaluate the impact of four irrigation projects on economic development. It is anticipated that this type of evaluation will be useful in designing future irrigation projects.

Bailey F. Wharton — Cooperation and disagreement between the nation members of the Mekong Committee.

This project could ostensibly help lesser developed countries by elucidating problem areas within the field of political communication. The relative success of the Mekong Committee illustrates that political differences between rival nations can be overcome. An understanding of this talent exhibited by the Committee could be utilized by lesser developed countries seeking political cooperation on mutual development projects.

S. Janakiram — Development of water institutions: motivations and values.

This study probes into the origins of water institutions, the need for such institutions, their functions, and their development.

Appendix E

Publications

Publication of technical reports and papers and developing design manuals supported in part or fully by Grant funds concerning water delivery and removal systems and related institutional development and considered to be of high priority by developing countries for the past four (4) years include: (1) a total of 12 CUSUSWASH publications with 8 more underway; (2) 8 technical papers published in scientific journals; and (3) 10 Ph.D. dissertations and/or M.S. theses completed.

1969-70

Dissertation:

"Water Management in West Pakistan", by Robert F. Schmidt, June 1970.

1970-71

CUSUSWASH Publications:

1. "Check-drop Energy Dissipator Structures in Irrigation Systems", by Gaylord V. Skogerboe, Venus T. Somarau, and Wynn R. Walker, May 1971.

2. "The Effect of Data Limitations on the Application of Systems Analysis to Water Resources Planning in Developing Countries", by Luis Ernesto Garcia-Martinez, May 1971.

Technical Papers:

1. Bibliography, by Garth N. Jones, Shaukat Ali, Richard Barber and Jim Chambers. Published in Planning, Development and Change: Bibliography on Development Administration, 1970.

2. Accounting and Budgeting Reform in Pakistan for National Development; Reconsideration of Fundamentals, by Saiyid M. Hamid, Co-author. Published in National Institute of Public Administration Journal, 1970.

3. Public Problems and Non-Decision Making, by John A. Straayer. Published in Natural Resources Journal, July 1970.

1971-72

CUSUSWASH Publications:

1. Effect of Settlement on Flume Ratings, by Tsu-Yang Wu, August 1971.

2. Width Constriction in Open Channels, by J. W. Hugh Barrett, November 1971.

3. Cutthroat Flume Discharge Relations, by Ray S. Bennett, March 1972.

4. Culverts as Flow Measuring Devices, by Va-son Boonkird, February 1972.

5. Installation and Field Use of Cutthroat Flumes for Water Management, by G. V. Skogerboe, Ray S. Bennett, and Wynn R. Walker, March 1972.

6. Dualism in Mexican Agricultural Development; Irrigation Development and the Puebla Project, by Huntley H. Biggs, June 1972.

7. The Puebla Project: Progress and Problems, by Huntley H. Biggs, July 1972.

8. Maximum Water Delivery in Irrigation, by James Henry Duke, Jr., August 1971. (partial support of 211(d) Grant funds)

Dissertations and/or M.S. Theses:

1. Effect of Settlement on Flume Ratings, by Tsu-Yang Wu, August 1971.

2. Width Constriction in Open Channels, by J. W. Hugh Barrett, November 1971.

3. Culverts as Flow Measuring Devices, by Va-son Boonkird, February 1972.

4. Cutthroat Flume Discharge Relations, by Ray S. Bennett, March 1972.

5. A Systematic Approach to the Water Supply of a Large Area, by Alain Deredec, 1972.

1972-73

CUSUSWASH Publications:

1. The Puebla Project: Progress and Problems, by Huntley H. Biggs, July 1972.

2. Index for the Eight Near East-South Asia Irrigation Practices Seminars, by William L. Neal and Clifford Stockmyer, August 1972.

Technical Papers:

1. Culverts for Flow Measurement in Irrigation Systems, by Gaylord V. Skogerboe, Wynn R. Walker and Va-son Boonkird. Published in Soil and Water Division of ASAE Journal, October 1972.

2. Generalized Discharge Relations for Cutthroat Flumes, by Gaylord V. Skogerboe, Ray S. Bennett and Wynn R. Walker. Published in Journal of the Irrigation and Drainage Division, December 1972.

3. The Green Revolution and Economic Development, by Huntley H. Biggs. Published in The Rocky Mountain Social Science Journal, June 1973.

4. Comparison of Bridge Backwater Relations, by Gaylord V. Skogerboe, J. W. Hugh Barrett, Wynn R. Walker, Lloyd H. Austin. Published in Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers.

5. Slope-Discharge Ratings for Cutthroat Flumes, by Gaylord V. Skogerboe, Wynn R. Walker, Tsu-Yang Wu, and Ray S. Bennett. Published in Soil and Water Division of ASAE.

Dissertations and/or M.S. Theses:

1. The Organization of Thai Irrigators, by Michael C. Schiefer, May 1973.

2. A Laboratory Study of Bed Material Withdrawal in Farm Turnouts, by Ata Mohammad Nazar, May 1973.

3. Optimal Parameter Identification of Nonlinear, Time-Variant Hydrologic System Models, Samuel Tuffuor, June 1973.

4. The Problem of Rural-Urban Water Competition, by Everett Myers, June 1973.

Appendix F

Faculty Improvement

During the past four (4) years Colorado State University has received many benefits from the Grant program. Many of these have already been mentioned in the foregoing pages. However, the major benefit has been the acquisition of new faculty, the improvement of existing faculty and the achievement of Grant objectives through interdisciplinary action. Though appreciation for the help received from the Grant program has been repeated many times by faculty members and credit given to this source of funding, the full impact of the 211(d) Grant program has only recently been recognized and accepted. The main approach used by CSU to improve its competence was through a coordinated plan involving multidisciplinary activities. At the beginning of this report it was stated that engineers and agriculturists working in the area of water delivery and removal systems have little or no understanding of, or concern for, the related institutional structure which is required today for the successful operation of water systems. Also, that a primary purpose of the 211(d) Grant program is to overcome these shortcomings by recognizing the concomitant need to analyze prevailing social systems as they affect water delivery and removal systems including the kinds of institutional changes necessary, the sources of resistance to change, and effective ways of dealing with social resistance.

How has CSU tackled these shortcomings? Examples of faculty participation in and reaction from the Grant program are given below. Three faculty members were selected. Dr. Evan Vlachos, a sociologist; Professor Gaylord V. Skogerboe; and Dr. David B. McWhorter. Though Dr. McWhorter is associated with the water management project in Pakistan, his statement regarding the 211(d) Grant program is included here as an example of the Grant effect on faculty outside of its purview.

Dr. Evan Vlachos

It is a privilege indeed to trace the benefits derived from the association with the 211(d) Grant program. To start with, one may indicate that I simply did not have any interests on water resources at the time nor did I understand exactly the role of water or irrigated agriculture on developmental efforts. It is true, as many people realize, that natural resources is a vital component for the planning and welfare of the country. However, both the literature and current research efforts on the part of social scientists have given little attention, both as to the physical limitations as a major constraint in development and to potentialities involved, as a means in bettering water resources as a basic thrust for developmental efforts.

My first exposure to the Grant program started in the context of explicating the concept and mechanisms of development in some logical fashion. However, very soon the exposure to other professionals, especially those in departments related to water resources planning, brought very forcefully forward the role of irrigated agriculture and on-farm management as a vital tool for my efforts to understand the development process underway in various countries. All this has led me to recapitulate in some chronological fashion the types of activities that cumulatively led to my present very deep involvement, interest, and professional commitment to the field of water resources planning and on-farm water management.

One of the first tasks was to determine how a sociologist should view the role of the water system in the context of human community. I started by reviewing available literature. I was particularly amazed to see that there were very few comprehensive books that discuss the social dimensions of water resources planning. This certainly was true around 1969 when my involvement with the Grant started, although recently an increasing number of books are the culmination of this particular occupation. One of the first exposures that I had as a result of the Grant involvement was the participation in an institute of urban water systems where my first work on social, economic,

and political processes in water management systems appeared. At the same time exposure to colleagues brought me together with such people as Professor Gaylord Skogerboe from Agricultural Economics, and Professor George Radosevich from Economics, in preparing a project concerning the consolidation of irrigation systems in the Western United States. Thus, two parallel activities, 211(d) Grant and the above project, reinforced my interest in this particular area. As a result, a number of papers were written overlapping both the Grant and the consolidation of irrigation project concerning the organizational characteristics and alternatives of irrigation companies as well as the general sociological considerations in irrigation water management. But before long, I was increasingly invited to participate in a number of meetings that emphasized water management. This involved meetings and participation with the American Society of Civil Engineers, Rural Sociological Society, the Irrigation and Drainage Section of ASCE, the American Water Resources Association, and similar societies where either through papers, lectures or panel discussions, I increasingly had the opportunity to exchange information with colleagues in the area.

However, the effects of the Grant were much more far reaching than the typical academic performance and write-ups that follow funded research. One effect was the opportunity to probe the extensive knowledge of the people in the field and to participate beyond a formal academic meeting. Thus I had opportunities to work with the World Bank, the Army Corps of Engineers, as well as consulting with a number of private companies concerning larger problems of water resources and an assessment of the role of water planning both in the United States and abroad. I would like to particularly emphasize that thanks to my exposure to questions of water resources planning as a result of the Grant program, I was involved as a lecturer and resident social scientist with the Institute for Water Resources for the Army Corps of Engineers, and gave a series

of lectures on Environmental Impact Assessment at the University of Massachusetts, University of Michigan, and University of Washington. More recently, the Institute for Water Resources asked me to participate as a consultant in defining the role of social scientists in water resources development. This is an example of the larger consequences of involvement with the 211(d) Grant program and the acquired sensitivity to the questions of the role of water in developmental efforts. Although these questions are not as centrally involved with the key theme of on-farm water management of the project, they are natural consequences of the general preoccupation, knowledge, and expertise gained by being involved and committed to the area of water resources research.

In addition, I would like to emphasize a number of research trips both within the United States and abroad that widened my horizons regarding water resources planning. Such trips involved the visit and a delivery of a paper in Nigeria regarding irrigated agriculture in Africa, and making valuable contacts with scientists of other nations. As a result of one contact, an invitation was extended to visit Israel and review with Professor Goldberg, the tremendous potentiality for innovative irrigated techniques in this arid area, especially as demonstrated in trickle irrigation. Within the United States, I participated in professional meetings, and visited water resources centers and projects in such places as Utah, Arizona, and Nevada. Another consequence of my involvement with the Grant, was my intense exposure to the Society for International Development which was also concerned with questions of development, part of which was also water resources planning.

Within the Department of Sociology at CSU there is an increasing awareness now of the role of water and water resources planning as a vital element of our intellectual and professional thrust and as a result, a new course has been proposed entitled, "Sociology of Natural Resources", which hopefully will make an overview with a specific emphasis on water resources for people who want to see the social aspects of natural resources

planning. Also, within our department a number of students are interested and involved in water resources activities and currently one of my Ph. D. candidates is completing his thesis in the area and hopefully other students have been exposed to the potential of "water" as a vital area of concern in sociological studies.

Exposure to the 211(d) Grant program made it possible for me to participate as an advisor to a number of theses in other departments. This also provided exposure to other colleagues and therefore, joint efforts which culminated in a number of projects such as Water Law and its Relation to Environmental Quality, Pakistan Water Law and Local Farmer Users Association, Projects in demography and modernization. Eventually, through exposure to the College of Engineering, a joint appointment as both professor of Sociology and Civil Engineering (Environmental Engineering) will make it possible to work in a truly interdisciplinary fashion in bridging the gap between the Social and Physical Sciences.

Professor Gaylord V. Skogerboe

As the world-wide demands on agricultural food production increase, more effective water management practices must be incorporated in existing and planned irrigation systems. The water delivery and measurement inputs to irrigation systems are among the first requirements for improving water use practices. These two areas have been actively investigated by myself and various students in the Agricultural Engineering Department at Colorado State University since the project's conception.

The 211(d) support has allowed me to expand the number of contacts with foreign students and foreign professional engineers, soil scientists, and economists, from less developed countries, while at the same time gaining an appreciation for the irrigation practices in these countries. Research has been accomplished which will serve to alleviate the needs these countries have concerning water measurement, conveyance, and control. The course, AE 555, Irrigation Structures, which came as a direct result of the project is to be offered for the third time this winter and has been strengthened by the completed research.

Probably one of the more important results accrued from the project thus far is the experience being obtained by working in this area. The experience has better prepared me to act in an advisory and consulting capacity both to students and individuals or agencies who may be interested in

service abroad. This was well demonstrated by the participation during the last four summers in the "Irrigation Practices Training Course" conducted by the Agricultural Engineering Department for AID and FAO.

The world-wide implications of this work are many fold. First, water delivery and measurement problems are areas of specific interest to irrigation planners in the developing countries, and thus, this material has wide general applicability. Second, a large amount of general information and design procedures have been collected into a few presentable sources. During the 1972-1973 fiscal year, this work entered its final phase; the dissemination and implementation of the results and conclusions generated by the previous years of research.

A potential exists for developing additional useful design manuals, as well as preparing short courses for presentation abroad which would facilitate rapid dissemination of project results in other countries. Finally, I feel that my technical competance has reached a level where the expertise I have gained should now be channeled towards problem evaluation and solution in developing countries (i.e., I would now like to get my feet "wet").

Dr. David B. McWhorter

My association with the 211(d) program has been indirect for the most part. However, I have been heavily involved in certain aspects of on-farm-water management in developing countries; a subject closely related to the objectives of the 211(d) program. Benefits that I have derived stem mostly from association with people from disciplines other than my own. While I have gained no in-depth knowledge in most of the other disciplines which the 211(d) program has brought together, I have learned to appreciate the different viewpoints of these people, and I now have a greater appreciation for the importance of an interdisciplinary approach to water resources planning and development.

As a result of my work in on-farm-water management, I have made three trips abroad. These trips have greatly enhanced my appreciation of the need for better water management, as well as providing some insight into the importance of water resources development in national development. It has also introduced me to many of the problems faced by other cultures, made me increasingly aware that the United States is really a part of a larger community, and that the task of feeding the world's people is a responsibility that we in the United States must accept as one of high priority. The above experiences have contributed a great deal to my professional development.

Following are listings of 19 new faculty who have been added since July 1969 and 43 faculty who have improved their ability in the subject areas of the Grant.

New Faculty since July 1969:

1. Henry Caulfield, Political Science, is formerly Executive Director of the Water Resources Council and has many years experience in water resource development both in the United States and abroad where he has served as a consultant.

2. Garth Jones, Political Science, has had many years experience in developing countries and has recently resigned CSU to work with the United Nations.

3. Ronald Tinnermeier, Economics, specializes in agrarian reform, water management, farm management, and production economics.

4. Arnold Klute, Agronomy, specializes in soil-water relations and the chemical composition of drainage water.

5. Wayne Clyma, Agricultural Engineering, has specialized in on-farm water management and is presently serving with the CSU research team in Pakistan.

6. William Hart, Agricultural Engineering, specializes in design of irrigation systems, hydrology, and irrigation engineering. He has served as a consultant in several developing countries in Africa.

7. David McWhorter, Agricultural Engineering, specializes in flow through porous media, and design and operation of wells. He has served as a consultant in developing countries on tubewell layout, design, and operation.

8. Alan Early, Agricultural Engineering, has had experience in the Philippines and specializes in soil and water management, and the use of remote sensing for water resource investigations.

9. Doral Kemper, Agronomy and Agricultural Engineering, specializes in soil chemistry, soil physics, multiphase flow through porous media, and on-farm water management. He is the Director of the CSU Water Management Research projects in Pakistan and Vietnam.

10. Michael White, Agricultural Engineering, specializes in water law, both surface water and ground water.

11. Judson Harper, Agricultural Engineering, is head of the department, and because of his strong interest in water resources, irrigation, drainage, and salinity control, is providing the leadership necessary to develop a strong department in this area.

12. Willis Shaner, Mechanical Engineering, specializes in the economics of water resources development. He has had many years experience in economic analysis in developing countries.

13. Neil Grigg, Civil Engineering, specializes in water systems, water management, optimization hydraulics, and hydrology. His experience abroad is in South America.

14. Khalid Mahmood, Civil Engineering, specializes in water conveyance and erosion and sedimentation problems. He was formerly with the Irrigation Department in Pakistan.

15. Talib Chaudhry, Civil Engineering, specializes in water resources systems, optimization, conjunctive use of surface water and ground water, salinity, and seepage. He was formerly with WAPDA in Pakistan.

16. John Labadie, Civil Engineering, is a specialist in water systems analysis, operations research, optimization, environmental dynamics, and conjunctive uses of surface and ground water.

17. Warren Hall, Civil Engineering, is the father of modern water resources systems engineering -- having produced many of the world leaders in the field today and having co-authored the first textbook on the subject. He is presently on leave to serve as director of the Office of Water Resources Research.

18. Cornelis deMooy, Agronomy, specializes in soil-water relations and is presently posted with the CSU Water Management Research team in Pakistan.

19. Jerry Eckert, Economics, specializes in agricultural economics and the economics of water resources development and management. He is presently located with the CSU Water Management Research team in Pakistan.

Improvement of Existing Faculty:

The following individuals have been involved in various types of Grant activities and have consequently improved their ability in the subject areas of the Grant to do research, teaching, consulting and other service activities.

1. Willard Schmehl, Agronomy
2. John Reuss, Agronomy
3. Everett Richardson, Civil Engineering
4. Daryl Simons, Civil Engineering
5. Maurice Albertson, Civil Engineering
6. Albert Mercer, Civil Engineering
7. Hubert Morel-Seytoux, Civil Engineering
8. Morris Skinner, Civil Engineering
9. Robert Danielson, Agronomy
10. William Thomas, Agriculture
11. Gene Wilken, Geography
12. Leo Teller, Watershed Science
13. Gaylord Skogerboe, Agricultural Engineering
14. Wynn Walker, Agricultural Engineering
15. Robert Longenbaugh, Civil Engineering
16. Robert Whitney, Agronomy
17. William Franklin, Agronomy
18. Arthur Corey, Agricultural Engineering
19. Albert Barnes, Civil Engineering
20. David Hendricks, Civil Engineering
21. George Olson, Civil Engineering
22. Edmund Schulz, Civil Engineering
23. Hsieh Shen, Civil Engineering
24. George Smith, Civil Engineering
25. Charles Thomas, Civil Engineering
26. Vujica Yevjevich, Civil Engineering
27. Kenneth Nobe, Economics
28. Huntley Biggs, Economics
29. Lee Gray, Economics
30. Loyal Hartman, Economics
31. Terultoma Ozawa, Economics
32. George Radosevich, Economics
33. Rex Rehnberg, Economics
34. David Seckler, Economics
35. Robert Young, Economics
36. William Marlatt, Watershed Science
37. Linwood Hodgdon, Sociology
38. David Freeman, Sociology
39. Evan Vlachos
40. John Straayer, Political Science
41. Norman Wengert, Political Science
42. Phillip Foss, Political Science
43. Duane Hill, Political Science

Research Assistants:

Counting the reporting year, about 40 research assistants -- who desire to work in the field of water delivery and removal area, want to understand more about it, and have taken a deep interest in developing countries -- have been helped in part or wholly by Grant funds during the past 4 years.

Appendix G

Curriculum Improvement

One of the Primary objectives of the 211(d) Grant has been to improve our existing course offerings and to develop new ones which are related to water delivery and removal systems. To this end, 18 courses have been upgraded and improved and ten new ones have been added by new faculty and by existing faculty whose competence has been improved as a result of the 211(d) Grant.

The new courses include:

1. Irrigation Structures -- with special emphasis on water delivery and removal structures.

2. Farm Irrigation Systems -- including international considerations.

3. Water Resource Systems -- which looks at the total water delivery and removal system and its relationship to specific uses such as irrigation.

4. Institutions and Economic Development -- which includes water resources institutions.

5. Economic Analysis and Water Resource Development -- which studies the economic interrelationship of the various aspects water resource develoment, including delivery and removal systems.

6. Geography of Native Farming Systems -- which include various irrigation systems and the problems of water delivery and removal.

7. Irrigation Practices in Developing Countries -- which includes the way that water is delivered, applied and removed at present, and how this could be improved.

8. Interdisciplinary Seminar in Water Resources Management -- which is a credit course and involves students and faculty from 5 different colleges studying new concepts, research existing projects, and projects which are now being planned or built.

9. Planning Engineering Projects in Developing Countries -- which applies benefit - cost techniques to water resource project analysis in the setting of the developing countries.

10. Politics and Policy in Water Resources Planning and Management -- which discusses the politics of legislative and administrative policy development in water and related land resources planning and management - federal, state and local.

Because of the increased activity across the campus in water delivery and removal systems caused by the 211(d) Grant, there has been much entrainment resulting in other courses being improved or added in fields directly or indirectly related to the Grant, but without Grant financial support.

Appendix H

Services Performed

Developing linkages by faculty, staff, and research assistants at CSU with faculty and staff of other universities, government officials, officials of private companies, institutions, and individuals in developing countries. The responses for technical assistance abroad that have been made by members of the faculty the past four years supported in part or fully under the Grant are as follows:

1. David Freeman, Sociology Department
   West Pakistan
   22 August to 21 September 1969

The purpose of Dr. Freeman's trip was to determine research capabilities and interests in selected universities in Pakistan pertaining to social factors relevant for maximizing the effectiveness of water and agricultural projects designed to increase agricultural production. Discussions were held with university social science personnel in the following universities: a) West Pakistan Agricultural College, Lyallpur, West Pakistan; b) University of the Punjab, Lahore, West Pakistan; c) University of Peshawar, Peshawar, West Pakistan; and d) University of East Pakistan, Dacca, East Pakistan.

2. W. R. Schmehl, Agronomy Department
   West Pakistan and Iran
   9 September to 4 October 1969

Iran: Dr. Schmehl reviewed sugar beet production in a developing area comparable to West Pakistan. Sugar beets are being considered as an alternative winter crop in West Pakistan since higher wheat yields will release land for additional crops. Dr. Iraj Poostchi, Agronomist, Pahlavi University, was his guide to show the sugar beet production in Iran. Dr. Poostchi was on sabbatical leave at Colorado State University in 1968-69 to study sugar beet production in the United States. Preliminary arrangements were made with the Ministry of Agriculture for a cooperative Ph. D. training program.

Pakistan: Dr. Schmehl made initial contacts for the establishment of adaptive water management research projects with cooperative Pakistani Institutions. Among the people in West Pakistan visited were:

Dr. Leon Hesser, Agricultural Officer, USAID, Rawalpindi

Dr. Stefan Krashevski, Soil Salinity Advisor, USAID, Lahore

Mr. Curry Brookshier, Food and Agricultural Officer, USAID, Lahore

Dr. Albert Shaw, Washington State University Advisor, WPAU

Dr. Inam-Ul-Haque, Head, Soils Department, WPAU

Mr. Allah Bakhsh, Chief Engineer, Reclamation, WAPDA

Mr. S. M. Suid, Chief Engineer, Administration, WAPDA

Mr. Nur-Ud-Din, Soils Research, Land Reclamation Directorate

Dr. Nanwar Hussain, Director Ayub Research (now Minister of Agriculture for Punjab Province)

3. V. Yevjevich, Civil Engineering
   Philippines, Thailand, India, Pakistan
   8 August to 9 September 1969

Dr. Yevjevich of the Civil Engineering Department made a world trip in August and September 1969. The portion of the trip supported by Grant funds covered the period 11 September to 24 September for visits to Manila, Bangkok, New Delhi, Lahore, Rawalpindi, and Peshawar. The purpose of Dr. Yevjevich's visit to the above locations was to establish contacts in the Philippines, Thailand, India, and Pakistan regarding problems related to scarce hydrologic data and large continental droughts. The contacts will establish a base for studies and teachings oriented to develop competence in selecting methodologies for solving the above important problems.

4. D. B. Simons
West Pakistan
29 August to 23 September 1969

The portion of Dr. Simons trip to Tokyo and return was paid for by CSU. The portion of his trip from Tokyo to Pakistan was supported by Grant funds. The purpose of Dr. Simons visit to Pakistan was to gather information for ideas and promotion of Grant objectives.

5. E. V. Richardson
West Pakistan
1 September to 29 September 1969

The main purpose of Dr. Richardson's trip to Pakistan was in connection with other projects. While there he assisted in gathering information for ideas and promotion of the Grant program. While in Pakistan he made field trips concerning water management projects for irrigated land, with special emphasis on delivery and removal structures and systems, and erosion and sedimentation problems associated with water supply and irrigation and removal of drainage water of irrigated land. The information obtained, in addition to being of benefit to other projects Dr. Richardson is involved with, was used to improve education and research programs on water management in the developing countries.

6. M. L. Albertson
Japan, Thailand, Pakistan, and Iran
30 August to 7 October 1969

Japan: Dr. Albertson visited Tokyo, Japan to attend a conference for the International Association for Hydraulic Research where discussions and research reports were given on water management problems, water delivery, and water removal problems.

Pakistan: In Pakistan he made contacts and developed agreements with various institutions in Pakistan for joint and cooperative research programs on problems of water management. These arrangements were for research in Agronomy, Agricultural Soils, Irrigation Engineering, Hydraulic Engineering, Rural Sociology, Agricultural Economics, and Political Science.

Tunisia: In Tunis, Tunisia, he met with Mr. Samuel Litzenberger, Head, Food and Agriculture Division, USAID, and Mr. William McNeil, General Engineering Officer, Public Works Division, among others, to discuss and review USAID projects on watershed planning and management, water resources development for drilling fifty wells, and the Medjerda Valley development.

Iran: In Teheran, Dr. Albertson visited with US Embassy personnel and AID training personnel regarding Mr. M. Monadjemi, a Ph.D. graduate student in Agronomy, and CSU's plans for him to do his dissertation in Iran. The preliminary plans were developed at that time, and leter firmed up by Dr. Schmehl, Professor of Agronomy at CSU, in June 1970.

7. M. L. Albertson
   West Pakistan and Manila
   22 November to 10 December 1970

West Pakistan: As Project Director for the Water Management Contract, he reviewed the research project with AID Mission officials as well as the sociology project initiated with the West Pakistan Agricultural University.

Manila: In addition, he visited the International Rice Institute in Manila where discussions were held regarding agricultural irrigation, water research engineering, soil and plant studies.

8. Bert L. Ellenbogen, Chairman, Department of Sociology and Anthropology and David M. Freeman, Assistant Professor, Department of Sociology and Anthropology
   Greece and West Pakistan
   18 October to 22 November 1970

Greece: Visited Greek government officials and scholars in Athens for the purpose of discussing water management studies having a significant sociology component as well as establishing a center for research in water management and socio-economic development. They

West Pakistan: They also visited West Pakistan where they helped to establish some sociological courses and research projects at West Pakistan Agricultural University as well as participated in water management research program discussions with government officials.

9. Manuel Alers-Montalvo
   Peru, Venezuela and Costa Rica
   17 July - 26 August 1970

Dr. Manuel Alers-Montalvo, Director of the Center for Latin American Studies, visited with officials from universities and other institutions of Peru, Venezuela and Costa Rica in regard to specific ways in which CSU could be of help to their institutions in solving problems in water resources management. Specifically, to explore the possibilities

of exchanges between faculty and students between these universities and CSU, as well as opportunities for collaborative research projects in the social sciences, natural sciences and agriculture. In addition, Dr. Alers-Montalvo presented a paper at the Congress of Americanists in Lima, Peru.

10. Dr. Hubert J. Morel-Seytoux, Associate Professor, Civil Engineering Department
North Africa
10 June to 9 July 1970

Dr. Morel-Seytoux visited several North African countries in June and July 1970, namely, Morocco, Algeria, Tunisia and Lybia. As a result of this trip, a system of communications was established with competent persons in positions of responsibility. Hopefully, it will be possible to proceed with special studies of water resources development in North Africa in the near future.

11. Dr. Edmund F. Schulz, Associate Professor, Department of Civil Engineering
India, Hawaii, Japan, Thailand, Hong Kong
12 April to 28 May 1971

The purpose of Dr. Schulz making this round-the-world trip was to establish linkages with more than 100 outstanding scientists and high government officials in India, Pakistan, Thailand, Taiwan, Japan, and Hawaii. Some of his activities included presenting a paper at the Symposium of Water Resources, Indian Institute of Science, Bangalore, India; consultation with hydrologists in the above listed countries regarding modernization of methods of acquisition and retrieval of hydrological data including ground water recharge experiments; discussions with agricultural engineers regarding consumptive use of water under the impact of multiple cropping practices; and acquiring data on optimum timing of irrigation on multiple cropping sequences through observing farming practices after harvesting crops--such data are essential to set up comput er based simulation models.

12. Dr. John O. Reuss, Associate Professor, Department of Agronomy
Dr. Huntley H. Biggs, Assistant Professor, Department of Economics
Mexico
7 to 16 June 1970

During June 1970, a group from CSU took a field trip to Mexico to investigate the water projects in the Balsas Basin. The above named faculty members accompanied the group to determine whether such a trip might be beneficial to faculty and graduate students associated with the Water Management Project to repeat in following years. The final report recommended a future trip be scheduled. This was endorsed by the International Interdisciplinary Committee.

13. Huntley Biggs, Team Leader of Field Trip
Balsas River Basin, Michoacan, Mexico
16 to 24 March 1971

Background: Being a semi-arid country, one of the key aspects of the Mexican development strategy has been the stimulation of regional progress through the construction of multi-purpose water projects. Perhaps no other LDC has had such a long history of water resource development experience as Mexico, even going back to pre-Columbian times. A number of River Basin Commissions have been established with the responsibility for promoting development in all of its aspects including health, education, agricultural production, irrigation works, electrification, and transportation. While most of the persons managing the River Basin Commissions are engineers, they are constantly faced with problems requiring interdisciplinary solutions.

One such commission is the Balsas River Commission established as the Commission of Tepalcatepec in 1947. Fortunately, CSU has connections with an individual, Walter Illsley, who has been intimately associated with the development of this River Basin since its inception under President Lazaro Cardenas. Mr. Illsley received an M.A. degree in International Economics from Johns Hopkins University. He was in China from 1946-1953, part of his time being spent with the Agricultural Rehabilitation Program of the United Nations Relief and Rehabilitation Agency. For the past 16 years he has been living in Mexico practicing a weaving skill, which he acquired in China, and promoting community development projects on a voluntary basis. In addition, he has conducted several tours of U.S. university students and faculty in the Michoacan area of Mexico. These include Montana State University, Friends World Institute in Long Island, and Putney School in Vermont. Mr. Illsley is a person thoroughly familiar with Mexico's culture and her development problems as they exist both at the community and at the national levels. He is also one of those rare individuals who is capable of exchanging ideas with persons from all disciplines and from all social levels.

14. Philip A. Hostermann
Afghanistan
8 October to 23 December 1971

The purpose of this trip to Afghanistan was to study the Helmand River Valley and other water resources in Afghanistan in relation to the Grant.

15. M. L. Albertson
Bulgaria and Nigeria
10 May to 6 June 1972

Nigeria: Dr. Albertson was the official representative at CUSUSWASH (Council of United States Universities for Soil and Water Development in Arid and Sub-Humid Areas) at the meeting of the International Institute of Tropical Agriculture in Ibadan, Nigeria. This meeting was held in conjunction with a research conference on tropical soils where a number of African soil scientists were in attendance, making it possible to provide an important linkage between the soils research in our water management contract and the IITA in Nigeria.

Bulgaria: Dr. Albertson attended the meeting of the International Commission on Irrigation and Drainage (ICID) Executive Council in Varna, Bulgaria. The agenda for this meeting included a World-Wide Survey on the Effects of Salinity in Irrigation Waters and their Effects on Soils and Crops and the Utilization of Saline Water for Irrigation. The total program dealt with on-farm water management in less developed countries and was an excellent opportunity to become informed on salinity research in other areas of the world, and to establish new linkages for further development of the Grant.

16. Huntley H. Biggs
Mexico City
5 to 14 June 1972

Dr. Biggs trip enhanced the competence of the faculty member in the water resources problem of a developing country in an arid and sub-humid environment. The knowledge gained from this experience is being shared with the other participants in the Grant via the International Interdisciplinary Seminar. It also supported the research of a faculty member which hopefully will result in a publication that will be beneficial to other LDC's on a world wide basis. It also established contacts with other institutions concerned with water resource management problems in the developing countries.

17. Christopher Dowswell
Guatemala
5 June 1972 to 1 January 1973

Mr. Dowswell went to Guatemala to collect data for his thesis as well as establishing contacts with institutions and individuals working in Water Resources and avail his services to assist in solving water problems confronting their society. He also collected literature on issues relating to Water Resources in Latin America which adds to our knowledge of water management problems abroad and provides resource information to the International Interdisciplinary Seminar.

18. George Radosevich
Nigeria
7 to 24 August 1972

Dr. Radosevich went to Nigeria in reply to a request from USAID/Nigeria through the Director of the Agricultural Bureau of Technical Assistance. The purpose of this trip and request was to assist in a comprehensive feasibility study in the area of irrigation development.

19. Huntley H. Biggs
Guatemala
14 to 23 March 1973

Dr. Biggs travelled to Guatamela City in order to review the research program of Mr. Chris Dowswell who needed faculty direction in designing his thesis research, and to offer advice as to how to proceed in this research. Dr. Biggs also made contacts with persons in the Ministry of Agriculture, AID/Guatemala and the Inter-American Development Bank to discuss the possibilities of CSU's becoming involved in Guatemala.

20. M. L. Albertson
William B. Hart
W. Doral Kemper
Evan Vlachos
Nigeria
23 to 27 October 1972

The four faculty members of CSU named above went to Nigeria at the invitation of the American Embassy at Lagos to participate in the IITA Seminar on "Prospects for Irrigation in West Africa". All four of them presented papers at this seminar. Their participation in the seminar will hopefully be instrumental in the establishment of a feasible, well-planned system of irrigation which will benefit the farming and urban communities of West Africa, and other nations as well.

21. M. L. Albertson
Afghanistan
10 and 11 February 1973

Dr. Albertson stopped in Kabul, Afghanistan in order to follow-up with a CSU graduate student regarding his research on the Helmand Valley Project as it relates to water delivery and removal systems. He further strengthened the linkage between CSU and USAID Mission personnel through the Agricultural Officer and the Educational Officer in meeting with them to discuss planning, development, management and utilization of water resources with special emphasis on water delivery and removal systems and relevant institutional development related to the needs of the less developed countries.

22. M. L. Albertson
Costa Rica
21 February to 3 March 1973

Dr. Albertson, as Chairman of the Professional Sections Committee of the Society for International Development, travelled to Costa Rica to attend the 13th World Conference of the SID. Conferences of this type not only assist in building the capability of CSU, but are also related to the water delivery and removal systems, and relevant and related institutional development. Furthermore, his attendance served as an important linkage to various organizations and individuals over the world working with developing countries in the above areas.

Appendix I

New Water Resources Funding Since July 1969

Department	Project Title & Leader	Sponsor	Date	Amount
Ag Eng	Water Quality Management Decisions in Colo. Skogerboe			8,700
Ag Eng	Data Acquisition Systems in Water Quality Management. Russell Freeman	Fed. Water Poll. Contr.	7/1/70 12/31/71	48,909
Ag Eng	Grand Valley Salinity Control Demonstration Project. G. V. Skogerboe	Fed. Water Poll. Contr.	7/1/70 1/31/72	76,053
Ag Eng	Irrigation Return Flow Quality Literature Abstracting. G. V. Skogerboe	Environ. Protection Agency	2/1/71 1/31/72	29,269
Ag Eng	Optimal Water Quality Management. G. V. Skogerboe	O.W.R.R.	7/1/71 6/30/73	30,000
Ag Eng	Irrigation Return Flow Quality Literature Abstracting. G. V. Skogerboe	E.P.A.	2/1/72 1/31/73	31,327
Ag Eng	Grand Valley Salinity Control Demonstration Project. G. V. Skogerboe	E.P.A.	2/1/72 1/31/74	99,890
Ag Eng	System of Management for Optimum Water Utilization. W. E. Hart	Bur. Rec.	7/1/72 6/30/73	9,187
Ag Eng	Irrigation Practices, Return Flow Salinity and Crop Yields. G. V. Skogerboe	E.P.A.	10/11/72 10/11/73	146,476
Ag Eng	Grand Valley Salinity Project. G. V. Skogerboe	E.P.A.	thru 1/31/74	8,493
Ag Eng	Irrigation Return Flow Quality Literature Abstracting. G. V. Skogerboe	E.P.A.	2/1/73 1/31/74	29,216
Ag Eng	Systems of Management of Optimum Water Utilization. W. E. Hart	Bur. of Rec.	7/1/71 6/30/73	9,188
Ag Eng	Artificial Recharge in W-Y Groundwater Management District. David McWhorter	W-Y Groundwater Mgmt. Dist.	7/6/71 12/31/71	3,325

NEW WATER RESOURCES FUNDING - continued

Department	Project Title & Leader	Sponsor	Date	Amount
Civil Eng	Selection of Test Variable for Minimal Detection of Basin Response to Natural or Induced Changes. Morel-Seytoux			9,750
Civil Eng	Development of Computer Program for Application of Stochastic Hydrology. V. Yevjevich	Bur. of Rec.	6/1/70 6/30/71	10,300
Civil Eng	Theory and Experiments in Prediction of Small Watershed Response. V. Yevjevich and E. Schulz	O.W.R.R.	7/1/70 6/30/71	41,000
Civil Eng	Metropolitan Water Intelligence Systems. M. L. Albertson	O.W.R.R.	11/1/70 10/31/71	100,000
Civil Eng	Research Facilities - Water Resources Research Program of USGS. Carl Nordin	U.S.G.S.	thru 6/30/71	14,120
Civil Eng	Hydrologic Stochastic Processes. V. Yevjevich	N.S.F.	thru 6/30/71	20,000
Civil Eng	Theory and Experiments in Prediction of Small Watershed Response, Phase II E. Schulz	O.W.R.R.	7/1/71 6/30/72	20,000
Civil Eng	Systematic Treatment of Infiltration with Applications. H. J. Morel-Seytoux	O.W.R.R.	7/1/71 6/30/73	25,000
Civil Eng	Stochastic Processes in Water Resources. V. Yevjevich	N.S.F.	11/15/71 11/14/72	85,400
Civil Eng	Investigation of Water Resources in Karst Region. V. Yevjevich	N.S.F.	10/1/71 9/30/72	33,800
Civil Eng	International Symposium on Floods, Droughts, and Decision Making with Scarce Data. R. Longenbaugh	N.S.F.	4/1/72 3/31/73	33,300
Civil Eng	Feasibility of Remote Evaporation and Precipitation Estimates. J. Ruff, W. Sadeh and D. B. Simons	N.A.S.A.	5/18/72 5/17/73	99,000

NEW WATER RESOURCES FUNDING - continued

Department	Project Title & Leader	Sponsor	Date	Amount
Civil Eng	Use of Remote Sensing to Obtain Data for Describing the Large River Environment. D. B. Simons	Army Eng.	thru 12/31/72	29,329
Civil Eng	Stochastic Analysis of Sediment Bed Transport. H. Shen and P. Todorovic	N.S.F.	9/15/72 9/14/73	36,700
Civil Eng	Water Rights Tabulation Update. R. Longenbaugh	State of Colo. Nat. Res.	8/11/72 6/30/73	21,300
Civil Eng	Determination of Urban Watershed Response Time. E. Schulz	Dept. Army Corps Eng.	10/1/72 9/30/73	9,940
Civil Eng	Stochastic Processes in Water Resources. V. Yevjevich	N.S.F.	11/15/72 11/14/74	90,300
Civil Eng	Investigation of Water Resources in Karst Region. V. Yevjevich	N.S.F.	thru 12/31/73	39,600
Civil Eng	Systematic Design and Legal Regulations for Optimal Surface - Groundwater Useage. H. M. Morel-Seytoux	O.W.R.R.	7/1/72 6/30/73	16,550
Civil Eng	THEMIS Project. J. Cermak	O.N.R.	7/15/72 7/14/73	96,528
Civil Eng	Environmental Impact of Mississippi River Channel Development. D. B. Simons	Dept. Army	10/17/72 12/16/72	8,000
Civil Eng	Water Data Bank Establishment. R. Longenbaugh	State of Colorado	8/1/72 6/30/73	85,050
Civil Eng	Transport and Dispersion of Bed Materials in Open Channels. Shen and Todorovic	N.S.F.	9/15/69 9/14/71	87,200
Civil Eng	Multivariate Analysis of Small Watershed Rainfall-Runoff Relations. Holland			6,500
Elec Eng	Rapid Measurements of Soil Moisture and Water Table Depth by a Short Pulse Radar. R. Vickers	Bur. of Rec.	5/1/72 1/31/73	10,000

NEW WATER RESOURCES FUNDING - continued

Department	Project Title & Leader	Sponsor	Date	Amount
Agriculture	Experimental Study of Soil Water Flow Systems Involving Hysteresis. A. Klute			6,500
Agriculture	Soil and Water Research. R. Whitney	Fed Water Pol. Control	7/1/69 6/30/70	37,500
Agriculture	Systems of Management of Optimum Water Utilization. K. Brengle & H. Moore	Bur of Rec	7/1/71 6/30/72	17,812
Agronomy	Soil and Water Research. R. Whitney	A.R.S.	7/1/72 6/30/73	100,000
Agronomy	Systems of Management for Optimal Water Utilization. K. Brengle	Bur. Rec.	7/1/72 6/30/73	17,812
Economics	Systematic Design of Legal Regulations for Optimal Surface - Groundwater Usage. R. Young	O.W.R.R.	7/1/72 6/30/73	10,450
Ext. Service	Soil and Water Research. F. Willhite	Fed Water Pol. Control	7/1/69	37,500
Forestry	Identification of Urban Watershed Units Using Remote Multispectral Sensing. L. Miller			6,000
Forestry	Classification and Designation of Water for Specific Uses. A. Wilcox	Nat. Water Commission	6/30/70 6/30/71	14,400
Forestry	Management of Colorado Mountain Lands for Increasing Water Yields. R. Dils	Bur. Rec.	thru 6/30/72	30,000
Forestry	Snow-Air Interactions and Management of Mountain Watershed Snowpack. J. Rasmussen and J. Meiman	O.W.R.R.	7/1/71 6/30/74	26,000 9,000
Human. & Soc Sci	Systems of Management of Optimum Water Utilization. R. L. Tinnemeier	Bur of Rec	7/1/71 6/30/72	3,000

NEW WATER RESOURCES FUNDING continued

Department	Project Title & Leader	Sponsor	Date	Amount
Human. & Soc Sci	Economic Analysis of Water Quality Standards. K. Nobe	O.W.R.R.	7/1/69 6/30/73	40,000
Human. & Soc Sci	Development Techniques for Estimating Potential of Water Resources Develop. Henry Caulfield	Utah State University	7/1/70 6/30/71	5,400
Human. & Soc Sci	Economic, Political and Legal Aspects of Colorado Water Law. K. Nobe			8,115
Human. & Soc Sci	Economic, Political and Legal Aspects of Colorado Water Law. P. Foss			6,104
Human. & Soc Sci	Technique for Estimating Potential of Water Resources Development. H. Caulfield	Utah State University	10/1/71 9/30/72	15,017
Microbio.	Training Grant in Water Supply and Pollution Control. S. Morrison	Fed. Water Poll. Control Admin.	7/1/70 6/30/71	52,754
Nat Res Center	Economic, Political and Legal Aspects of Colorado Water Law. J. Flack			7,337
Natural Sciences	Drainage Basin Evaluation and Influence of Landforms on Hydrologic Variables. S. Schumm	U. S. Army Research	1/1/71 12/31/71	33,885
Political Science	Development of Techniques for Estimating Potential Water Resources Development. H. P. Caulfield	Utah State University	10/1/72 12/31/73	20,880
Vet Med	Training Grant in Water Supply and Pollution Control. S. Morrison	Fed Water Poll. Control	7/1/69 6/30/70	55,492
Vet Med	Water Quality Study. S. Morrison	Eastman Kodak	3/1/70 2/28/71	10,800
Vet Med	Water Quality Study. S. Morrison	Eastman Kodak	3/1/71 3/31/72	14,400
Watershed Sciences	Management of Colorado Mountain Lands for Increasing Water Yields. J. Meiman	Bur of Rec	7/1/72 6/30/73	30,000
Watershed Sciences	Application of Remote Sensing in Hydrologic Modeling of River Basins. D. Striffler	N.A.S.A.	9/1/72 5/31/73	18,000

Appendix J

CUSUSWASH Cooperative Programs

CSU has considered cooperation in CUSUSWASH activities a major responsibility. For this reason, many CSU staff have attended the twice yearly meetings of CUSUSWASH; a great amount of time has been spent serving on the Trustees; and we have spent many man-days in meetings and developing material for such activities as the Integrated Approaches Committee, the Irrigation Management Program, and the Saltillo, Mexico project.

Irrigation Management Program

The Irrigation Management Program (IMP) Committee, appointed as an Ad Hoc committee of the IAC, has essentially completed its assignment of developing a comprehensive report on irrigation management practice for lands in arid zones. The report identifies in considerable detail all components of a long range program in the efficient and effective use of irrigation water including delivery and retrieval. The perspective presented by the report includes the social, economic, political, agricultural and water resources engineering aspects of efficient use of water - delivery and retrieval - by lesser developed countries lying within the arid and semi-arid zones. The action and interaction of these components is described in sufficient detail so that studies such as water harvesting, water delivery, water retrieval can be identified not only in the agronomic context but also in the context of the total development of a water resource program for lesser developed countries (regions in U. S. such as Indian Reservations would also qualify) in arid zones. The four phase program outlined in the report covers a period of time of 5 to 7 years with an estimated budget of nine million dollars. The report in final form is now in preparation.

Appendix K

Brief Four Year Summary of 211(d) Grant Activities

Improvement of Faculty and Staff

We have taken the position that improvement can result from either adding new personnel, who already have most or all of the qualifications desired, or improving the knowledge, experience, and ability of existing staff. To this end 19 new staff have been added and more than 43 existing staff members have improved their capability as a result of the 211(d) activities. Appendix F contains a tabulation of these faculty and staff members.

Curriculum Improvement

To improve the capability of CSU in water resources management, ten (10) new courses have been added, and significant improvements have been made in eighteen (18) existing courses. The new courses are as follows:

1. Irrigation Structures -- with special emphasis on water delivery and removal structures.

2. Farm Irrigation Systems -- including international considerations.

3. Water Resource Systems -- which looks at the total water delivery and removal system and its relationship to specific uses such as irrigation.

4. Institutions and Economic Development -- which includes water resources institutions.

5. Economic Analysis and Water Resource Development -- which studies the economic interrelationship of the various aspects water resource develoment, including delivery and removal systems.

6. Geography of Native Farming Systems -- which include various irrigation systems and the problems of water delivery and removal.

7. Irrigation Practices in Developing Countries -- which includes the way that water is delivered, applied and removed at present, and how this could be improved.

8. Interdisciplinary Seminar in Water Resources Management -- which is a credit course and involves students and faculty from 5 different colleges studying new concepts, research existing projects, and projects which are now being planned or built.

9. Planning Engineering Projects in Developing Countries -- which applies benefit - cost techniques to water resource project analysis in the setting of the developing countries.

10. Politics and Policy in Water Resources Planning and Management -- which discusses the politics of legislative and administrative policy development in water and related land resources planning and management - federal, state and local.

Because of the increased activity across the campus in water delivery and removal systems caused by the 211(d) Grant, there has been much entrainment resulting in other courses being improved or added in fields directly or indirectly related to the Grant, but without Grant financial support.

Publications

Reporting on activities related to the 211(d) activities has been in the form of special reports, theses, dissertations and papers published in professional journals. These are tabulated in Appendix E, which shows there have been 10 Masters theses and Ph. D. dissertations, 12 reports and 8 papers.

Library Improvement

Although the CSU Library has historically been strong in its collection related to water resources in general, and water management in particular, several thousand additional volumes have been added during the period of the Grant through Grant funds and from various other sources. The collection has now been set apart so that students and faculty have easy access to all materials.

Seminars

The International Interdisciplinary Seminar was initiated early in the Grant period to serve as a focal point for interdisciplinary consideration of various water resources projects throughout the world and various other topics which have a bearing on the subject of the Grant. This has now been formalized as a regular course for credit. The total attendance for a year is between 800 and 1000, and the average attendance for a single seminar is approximately 30. Appendix C lists the purposes of the seminar and the program topics.

Graduate Students

A large number of graduate students have been supported in the participating departments during the period of the Grant. The following is a tabulation of numbers for the various departments:

Agricultural Engineering	6
Agronomy	3
Civil Engineering	31 1/2
Economics	9
Political Science	13
Sociology	7

By having these students working on Grant-related research, the major professor and other committee members move more completely into the area of on-farm water management. Several of the students either have gone, or will go, to a developing country to collect data for his research and his thesis or dissertation.

Meetings and Travel

A very important part of the 211(d) activities is attendance of staff and students at meetings. This helps to generate contacts, communications and linkages among CSU personnel and others interested in the same or similar subjects. Such meetings are also stimulating to those in attendance and new ideas, approaches and analysis result from them. Frequently, the staff member delivers a paper at a meeting so that the new knowledge which has been developed at CSU is transmitted to the profession at large.

Travel may also be for consulting or advising in which funding is borne by some outside source. If such funding is not available, however, then 211(d) funds are used if the activity is considered to be sufficiently important for meeting Grant objectives. A specific example is the help CSU gave the IITA with its irrigation seminar in October 1972.

Several graduate students have traveled abroad to collect data for their research.

Service

We have taken the position that a primary purpose of the 211(d) Grant is to prepare the CSU faculty to be of service when called upon to do so. In this connection, most of the new faculty have been either assigned overseas or have served as consultants since joining CSU, and most of the existing staff have served on one or more assignments overseas since the beginning of the Grant. Appendix H is a list of 21 services which have been performed.

Linkages

Throughout the period of the Grant, the faculty members have been diligent about establishing linkages with various individuals, with private organizations, with government agencies, and with other groups in order to maintain connections, to carry on correspondence, to exchange publications and to discuss research activities and field problems. Many of the service opportunities reported were initiated through these linkages.

Entrainment

Because of the increased activity across the campus in water delivery and removal systems caused by the 211(d) Grant, there has been much entrainment resulting in other courses being added or improved in fields directly or indirectly related to the Grant, but without financial support from the Grant.

In part, because of the stimulation provided by the Grant, additional projects have been funded by other sources throughout the CSU campus. Appendix I is a list of 64 projects totalling $2,200,000 which are related to the Grant topic that have been funded from other sources since July 1969.

Interdisciplinary Activity

At the beginning of the 211(d) Grant period, CSU had a few instances of limited interdisciplinary research activity. Since the Grant, however, the interdisciplinary team approach has developed in at least a half dozen major research contracts that involve as many as 4 or 5 different colleges and many more departments. Without the 211(d) Grant, it would not have been possible to develop these new programs.

CUSUSWASH Activities

CSU has considered cooperation in CUSUSWASH activities a major responsibility. For this reason, many CSU staff have attended the twice yearly meetings of CUSUSWASH; a great amount of time has been spent serving on the Trustees; and we have spent many man-days in meetings and developing material for such activities as the Integrated Approaches Committee, the Irrigation Management Program, and the Saltillo, Mexico project.

Monitoring and Evaluation

Throughout all previous discussion a key underlying component has been the recognition of monitoring and evaluation as vital parts of the overall 211(d) program. Essentially, evaluation is viewed as a means for increasing the rationality of decision making, as a mechanism for better program planning, and as a device for assessing project accomplishments. Thus, in the context of the systems approach adopted for the overall program, it becomes possible to evaluate component parts and/or subsystems in a fashion summarized in Fig. 4 (page 136).

This diagram exemplifies four key distinctions we make in the 211(d) Grant evaluation:

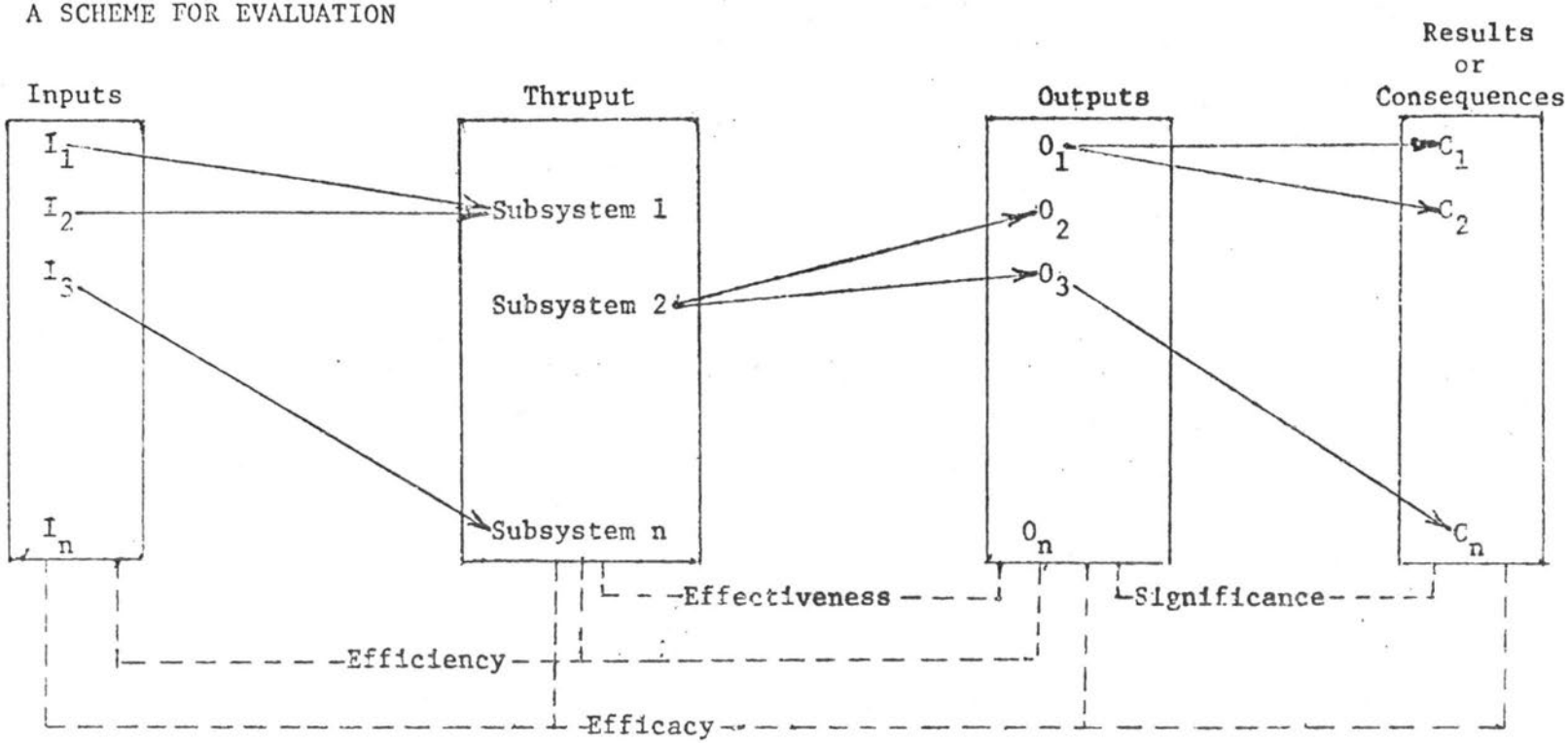
1. Accomplishments, i.e. the achievement of certain outputs as specified in the contract agreement.

2. Performance, or the meeting of organizational goals, or the effectiveness of various subsystems in meeting project goals.

3. Efficiency, or primarily an economic benefit-cost analysis relating given resources (inputs) to proposed goals or attempted targets (output).

4. Efficacy, or the attempt to incorporate "social benefit-cost" considerations, aspects of social policy and all those intangible benefits that cannot be easily quantified in traditional input-output analysis. Indeed, efficacy considerations become more pertinent when examined in the context of AID's program dimension, significance or the extent to which the achievement of targets contribute to general development or other broader goals.

Fig. 4 A SCHEME FOR EVALUATION



We need indicators in order to measure and/or assess:

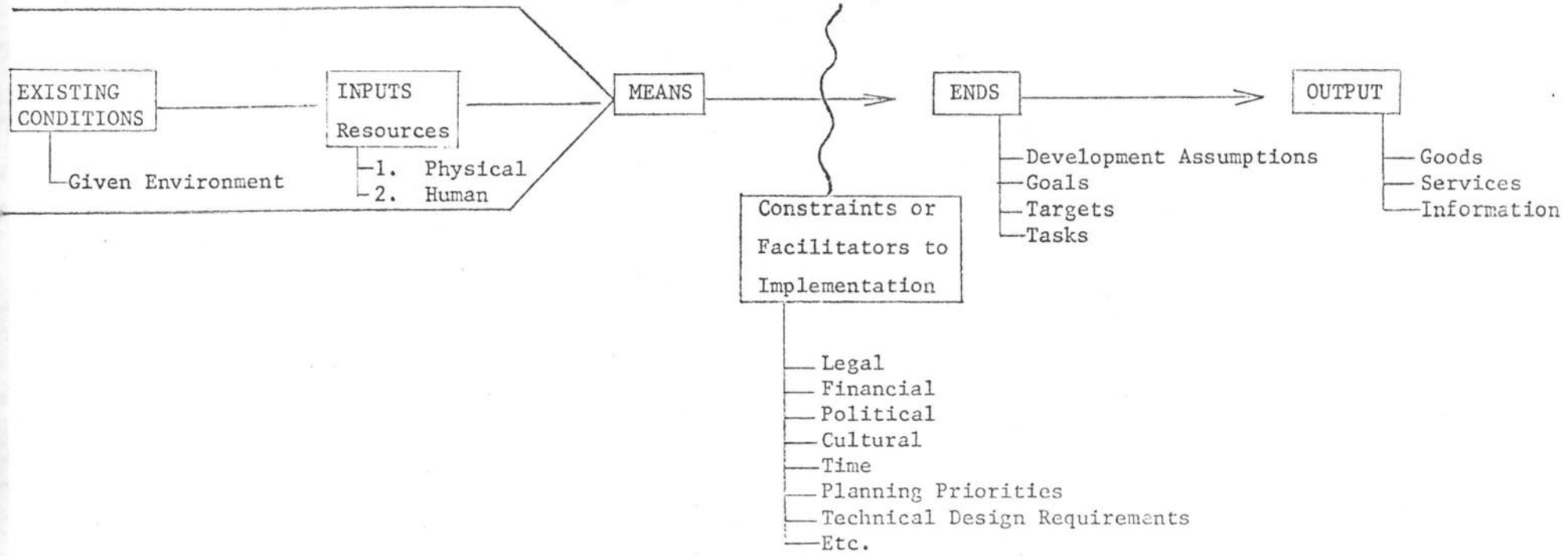
1) Accomplsihments (Output)

2) Effectiveness (Performance)

3) Efficiency (I/o ratio)

4) Efficacy (Questions of social cost, ultimate significance)

Fig. 3. A Simplified Version of Systems Dimensions *



INPUTS (Constraints/Facilitators)	THRUPUT (Means)	OUTPUT (Ends, Goals, Objectives)	SIGNIFICANCE (Consequences)
Physical Resources Natural Resources Financial Resources Infrastructure Environment (Physical & Bio.) Human Resources Manpower resources Institutional Information Cultural Political resources Legal resources Social environment	Personnel Campus — Field Infrastructure Physical — Organizational Rules of Operation	Increased productivity Collective betterment Quality product Increased income Etc. resulting in more Goods Services Information (knowledge)	Indicators or Criteria of Development 1. Growth in economic resources and production. Industrial res. & production Agricultural res. & prod. Infrastructure Etc. 2. Growth in Social Resources Cultural Political res. system -- Values and attitudes Institutions Administration of justice -- Etc. 3. Growth in Manpower Resources Literacy — Education Health — Training

* Adapted from "The Development Process" by Maurice J. Allen

Appendix L

The Development Process as Applied to Water Delivery and Removal Systems and Related Institutions

CSU accomplishments in the area of Grant objectives are due essentially to a systematic approach to an area study of water delivery and removal which may be described as a developmental process. Underlying the entire scope and thrust of the 211(d) Grant program are key assumptions concerning the role of water management as a vital element in the total developmental process -- which is a sequential system. Whenever development takes place -- whether it is planned and deliberate or unplanned -- there are certain steps which tend to follow. Such steps, and their sequential nature, are illustrated compactly by the Development Wheel in Fig. 2.* From this diagram it can be seen that development involves various types of resources, broadly classified as physical resources and human resources.

Fig. 2 shows that the manpower resource is motivated by his values and attitudes to take the action and provide the thrust which drives the development wheel. Development is accomplished by his effort and for his benefit. Briefly, the manpower resource acquires and uses information, processes and systems by working through the institutional resources as vehicles to conserve and utilize the natural resources in order to expand the supporting infrastructure, within certain constraints, to produce additional goods and services for his own use and benefit, and to provide greater impetus for driving the development wheel still faster.

Note that there is a variety of linkage mechanisms between various stages or phases of the developmental process, and that this process is a dynamic one with feedback loops among the various subsystems.* Just as in a microscope (mechanism) there are a series of lenses which enables us to see what could not be seen distinctly without it, so there must

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* For a more complete presentation of the development process, and the role of research and education for development, see "Research and Education for Development" by Maurice L. Albertson and M. T. Chaudhry, from "Transfer of Water Resources Knowledge" edited by Evan Vlachos, Water Resources Publications, Ft. Collins, Colorado, 1973.

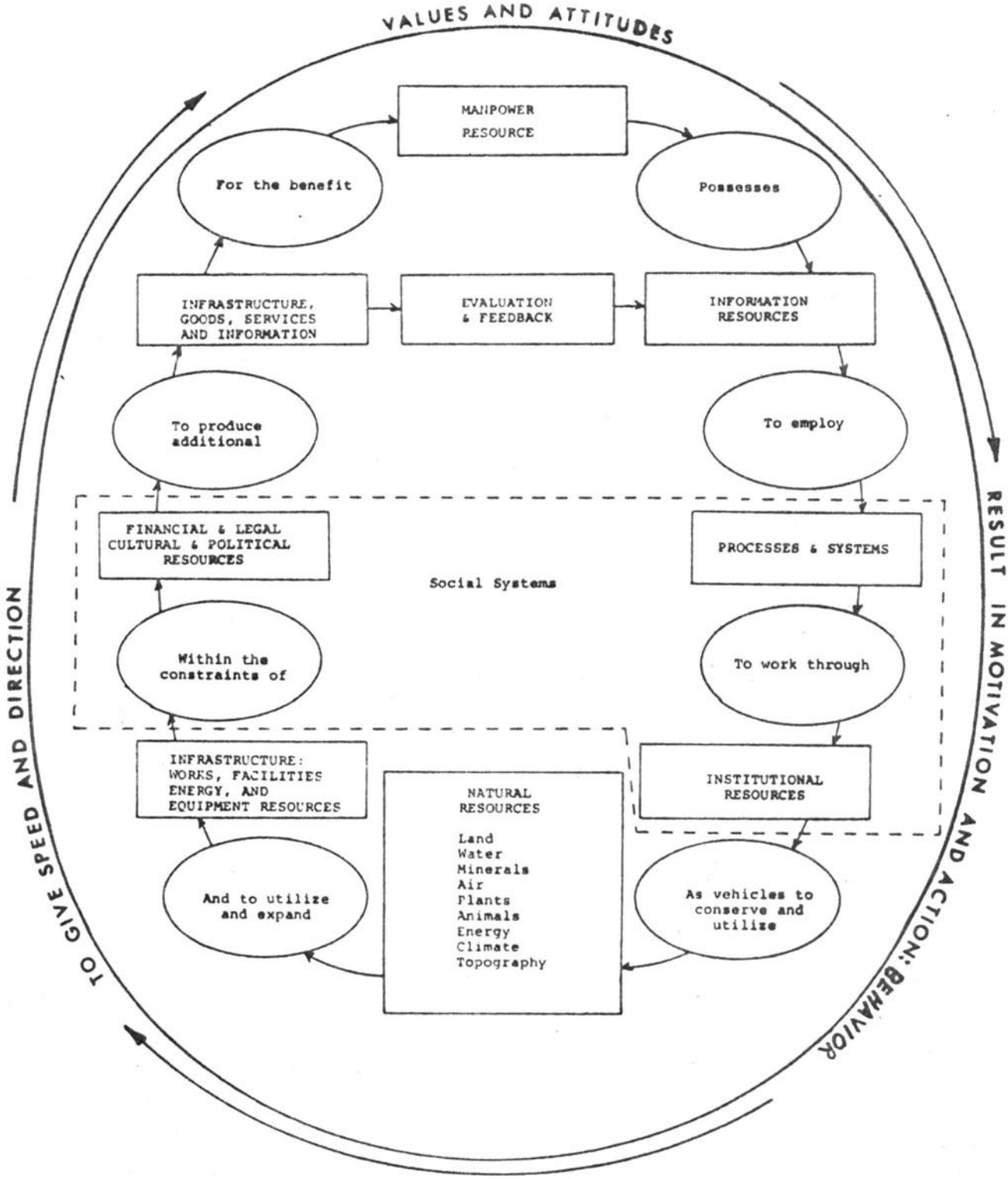
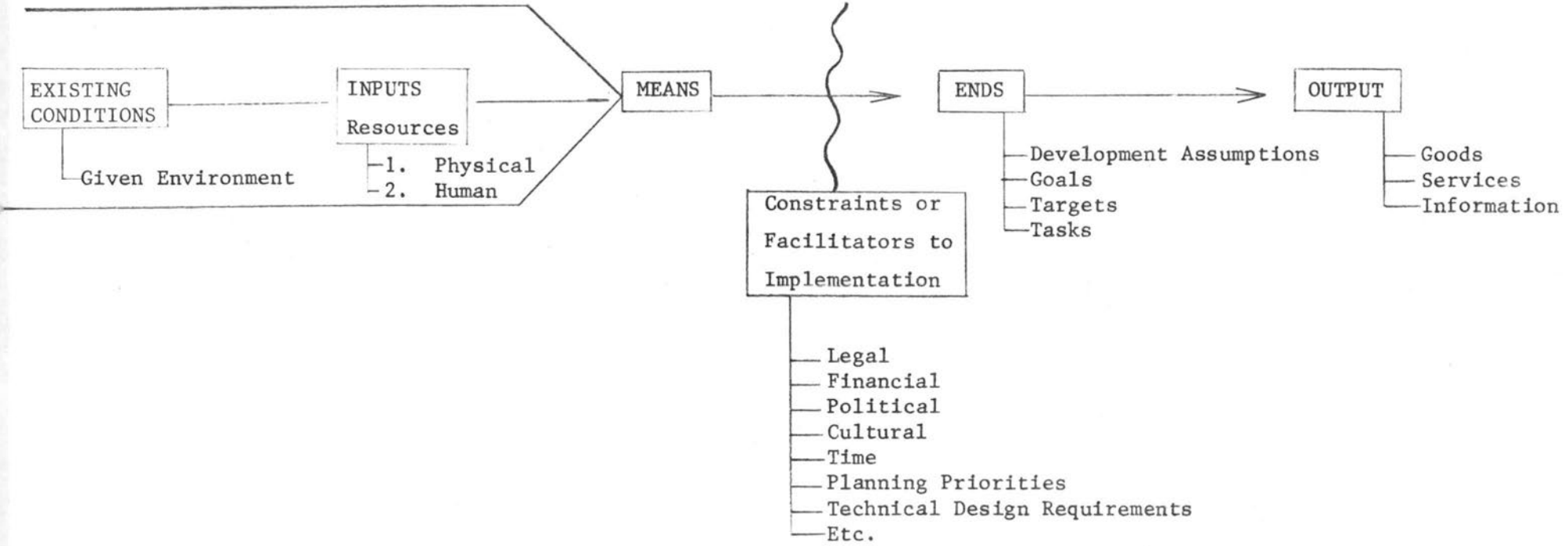


Fig. 2: The development wheel, illustrating the development process. (Adapted from Albertson, 1973 - see footnote page 12)

be a means (mechanism) for focusing on causes of problems. Not knowing the true nature of these causes adversely affects early solutions, rate of progress, and accomplishment--all of which are encompassed in the developmental process and systems approach. In order to present and assess project performance and objectives in a more cogent fashion, it is important to dwell briefly on their overall structuring and operation. CSU has adopted a systems approach to the study and analysis of development. The general orientation with the systems approach is part of the effort to integrate physical and nonphysical dimensions of irrigation systems, provide common vocabulary, and delineate appropriate parameters for interdisciplinary studies. In adopting a systems analysis, CSU views water management as a system operating in a given environment where inputs (physical and nonphysical) processed through the "organization" (the thruput) result in outputs or goals achieved (as infrastructure, goods, information, and services). Fig. 3 summarizes these ideas and provides an abbreviated format of the connecting concepts and dimensions guiding project assessment. Thus, CSU's aim is to generate the kinds of activities that may fulfill the objectives of the Grant, but in such a way as to be able, through appropriate indicators, to evaluate how efficiently and effectively such goals have been reached. Or, in the following succinct summary:

- CSU is providing a systems model
- In order to construct a framework for evaluation
- Which, through the use of appropriate indicators
- Will make possible the measurement and assessment of
    1. Program performance
    2. Specific achievements
- As they relate to general project and development goals.

Fig. 3. A Simplified Version of Systems Dimensions *



INPUTS (Constraints/Facilitators)	THRUPUT (Means)	OUTPUT (Ends, Goals, Objectives)	SIGNIFICANCE (Consequences)
Physical Resources Natural Resources Financial Resources Infrastructure Environment (Physical & Bio.) Human Resources Manpower resources Institutional Information Cultural Political resources Legal resources Social environment	Personnel Campus Field Infrastructure Physical Organizational Rules of Operation	Increased productivity Collective betterment Quality product Increased income Etc. resulting in more Goods Services Information (knowledge)	Indicators or Criteria of Development 1. Growth in economic resources and production. Industrial res. & production Agricultural res. & prod. Infrastructure Etc. 2. Growth in Social Resources Cultural Political res. system -- Values and attitudes Institutions Administration of justice -- Etc. 3. Growth in Manpower Resources Literacy Education Health Training Food Consumption Etc.

* Adapted from "The Development Process" by Maurice L. Albertson.

In completing this brief introduction, CSU would like to emphasize that three key concepts (systems analysis, indicators, evaluation) are not only parts of a concerted approach of all disciplines in the project, but also methodological milestones for identifying causes and corresponding effects and alternative options for more effective water delivery and removal systems.