

ANNUAL TECHNICAL REPORT  
1969-70

IMPROVING CAPACITY OF CUSUSWASH UNIVERSITIES  
FOR WATER MANAGEMENT  
FOR AGRICULTURE

REPORT NUMBER I  
VOLUME I

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COUNCIL OF U. S. UNIVERSITIES FOR SOIL AND WATER  
DEVELOPMENT IN ARID AND SUB-HUMID AREAS

August 31, 1970

## FOREWORD

This is the first consolidated annual report on the section 211(d) Grants made to three of the member universities of the Council of U. S. Universities for Soil and Water Development in Arid and Sub-Humid Areas (CUSUSWASH): the University of Arizona (Contract AID/csd 2457), Colorado State University (Contract AID/csd 2460) and Utah State University (Contract AID/csd 2459), for the purpose of enhancing the competence of these universities in the field of water management for agriculture. These programs were initiated July 1, 1969. CUSUSWASH provides a mechanism for joint planning and review of accomplishments for the three programs and coordinated leadership for the inter-university aspects of the program. Besides the three recipient universities, CUSUSWASH also includes the University of California.

The report consists of two volumes. Volume I contains four parts. Part I deals with the overall CUSUSWASH program and the following three parts report the activities of the universities. Volume II includes appendix materials.

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## SUMMARY

This constitutes the first annual report of the CUSUSWASH Universities participating in a 211(d) Grant for increasing competence in "water management for agriculture." The University of Arizona, Colorado State University and Utah State University along with the University of California share nearly a century of leadership in this field and have been involved in technical assistance programs for many years. The impact of the Grant has already significantly increased the capability of these universities for overseas service in their technical area under a coordinated program of federal and university coordination. The multiple effect in committing other resources and capturing the interest of faculty and students has been at least equal to the effects directly financed by Grant funds. Although not presently a Grant recipient, University of California at Davis has shared in the efforts of CUSUSWASH.

Increased teaching competence is shared by thirteen departments in the three universities. Teaching programs have been reviewed and international implications have been strengthened. Six new courses and an interdisciplinary seminar have been added. Eleven new staff members of high distinction and competence have been added partly using 211(d) funding. New library collections in the specialty field have been implemented; watershed management teaching models have been developed at Arizona and new laboratories are underway at Utah,



with partial support of Grant funds. Preparation of circulars, manuals and monographs is underway or being planned. Nineteen graduate students were supported partly using Grant funds.

New staff acquisitions are engaged heavily in research. Two Utah graduate students will conduct their thesis research in Latin America during FY 1971. Research programs in which 211(d) staff and students are participating include water use optimization, drainage, irrigation structures, hydrological systems analysis, sociology, political science and public administration.

Consulting capability has been increased largely through modest partial support of eight trips undertaken for other purposes. At Utah State and University of Arizona a total of twenty-three faculty members made thirty-nine consulting trips.

Inter-university programs on publications, seminars, and student faculty interchange are being actively developed by the Council.

## PART I

### THE COORDINATED CUSUSWASH PROGRAM

Water management has been established as a critical and limiting factor in increasing agricultural productivity throughout the world. This is particularly the case in the lesser developed countries. The importance of this element in the mix of agricultural inputs necessary to increase agricultural production has been well stated 1/2/3/ and provided the incentive which led to the establishment of the Council of U. S. Universities for Soil and Water Development in Arid and Sub-Humid Areas (CUSUSWASH or Council), by four land-grant universities and subsequent grants to the University of Arizona, Colorado State University and Utah State University in June, 1969, under Title II, Section 211(d) of the Foreign Assistance Act. The University of California is also a member of the CUSUSWASH and has participated in the activities of the Council as a regular member. Within the past eighteen months it has placed in operation a water management program in India under a Ford Foundation Grant.

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- 1/ World Food Problem, Report of the Panel on World Food Supply. A Report of the President's Science Advisory Committee. The White House, Washington, D. C. May, 1967. Vol. II. Ch. 7.
  - 2/ Provisional Indicative World Plan for Agricultural Development. Food and Agricultural Organization of the United Nations. Rome, 1970. Vol. I. Ch. 2.
  - 3/ Proposals for Institutional Grants to Improve Competence in Water Management for Agriculture. Part I. Overview and Common Assumptions of Programs of Member Universities. Submitted to Agency for International Development by Council of U. S. Universities for Soil and Water Development in Arid and Sub-Humid Areas. Logan, Utah. April 20, 1968. 16 pages multilithed.

Establishment of CUSUSWASH and initiation of programs under Section 211(d) is a logical extension of the efforts of the U. S. Land-Grant University system to the problems of international assistance. The American land-grant universities are widely recognized as a major factor in meeting man's ever-growing needs for food and other agricultural products throughout the World. These universities have participated in international technical assistance programs since these began following World War II. Their efforts have provided the U. S. personnel necessary for that effort and a large share of the agricultural leadership in the developing countries have been trained by them. They have provided the model for university development in many of the developing countries.

The CUSUSWASH universities' activities in water management for agricultural production began a century ago and much that is known and that has been placed into practice in this field has been developed at their research stations. These institutions also have shared in the increasing task of international development, but, like other U. S. universities, have not been able to develop their full capacities for international service because of limited state support for international activities and irregular and uncertain support from other sources. This deficiency has been well recognized by the universities, the Congress and the Agency for International Development, who have been concerned about improving the effectiveness of technical assistance.

Section 211(d) of the Foreign Assistance Act, as revised in 1966, was passed as a result of these concerns. This Section provides that the Agency for International Development (AID) can



support "research and educational institutions for the purpose of strengthening their capacity to carry out programs concerned with economic and social development of the less developed countries."

In accordance with the spirit of the legislative history of the Act, the CUSUSWASH universities and AID have adopted a joint university-federal government approach to strengthening capacity of the nation for research and education in the area of water management for agriculture. Considering technical assistance efforts determined to be of national interest, the program has enjoyed broad scope in its planning and initiation by the universities in consultation with AID within the agreed-upon goals.

#### Delineation of Responsibility

Water management for agriculture is a complex art which involves protecting or reclaiming land from excess precipitation or flooding; husbanding and managing soil moisture; optimizing cropping practices to the moisture regime; impoundment; 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. The art of transferring technology and of assisting in the related institutional development in the developing countries is also a difficult and complex one which must be merged with the technical arts of water management.

Discussions of how the CUSUSWASH universities might increase their joint capacities to provide resources for agricultural water management began January 31, 1967, at

Davis, California. In the interim, prior to initiation of the 211(d) Grants on July 1, 1969, three formal meetings of the Council and one informal meeting of representatives in Washington, D. C. formalized the Council's Charter and Agreement and its organization. Other accomplishments during this period included:

- 1) development of the objectives and philosophy of the consortium,
- 2) developing an operational procedure for the consortium,
- 3) conceptualizing the program and assignment of responsibility,
- 4) assistance in preparing specific university proposals,
- 5) interchange of ideas at the University operating level, and
- 6) development of plans to implement some specific inter-university activities.

The universities recognized from the beginning that joint cooperation and planning with the federal government was essential in order that programs would be meaningful to technical assistance. Planning and implementation has proceeded with representatives of AID in a spirit of mutual cooperation.

All of the CUSUSWASH universities have some existing capability and teach some courses in most of the water management topics listed above, their students desire and need broad backgrounds that include some exposure to most of them. Extending capacity for international service in all of them at each university however would be inefficient and wasteful. Rather, leadership

responsibility should be identified in each case; the results may be shared by all. Research is a necessary and important element of all graduate education. In the context of technical assistance, like teaching, it has two dimensions also: the technical one and the one of extending it overseas. While separately administered and reported, complementary research programs based in developing countries are essential adjuncts to the 211(d) program.

Implementation of programs for all of the topics which are included in the art of water management for agricultural production is not immediately possible. Priorities have been considered and choices have been made. Attention needs to be given to perfecting the sciences and the arts at the most advanced levels having potential for technological and social transfer. There is not time to go through the decades of evolution that led to the present level of agricultural technology in developed countries. Based on these concepts and considering existing capability and interest of the universities, assignments of responsibility were made as follows:

#### University of Arizona

Watershed management with special emphasis on the science and methodology of applying systems analysis techniques to problems of less developed countries.

#### Colorado State University

Optimum Utilization of Water Resources: with special emphasis on water delivery and removal systems and relevant institutional development.



### Utah State University

On-farm water management for increased agricultural production.

Figure 1 shows systematically how these assignments relate to management of the physical water cycle for use in agriculture. The University of Arizona has responsibility in the first box shown in the first column, Colorado State University has responsibility for the second and the fourth and Utah State University for the third. The second column identifies specific technical topics and the third column considers institutions, the essential link of social implementation; Colorado State University has primary responsibility for this element of the system.

Clearly, interactions between the various elements of the water management system are essential. Knowledge of on-farm water needs is essential in order to properly design water delivery and removal systems; likewise, a knowledge of watershed characteristics and a mechanism for predicting water production from them is necessary both to the design of delivery and removal systems and to optimizing the use of available water supplies on the farm. Adequate institutional structure impinges at all three levels; without this structure neither optimal watershed management, operation of delivery and removal systems nor management of water once it reaches the farm can be very efficient. Operational coordination by CUSUSWASH has been designed to make sure that products of increased capability flow freely among the several institutions, and to provide mechanisms whereby personnel and

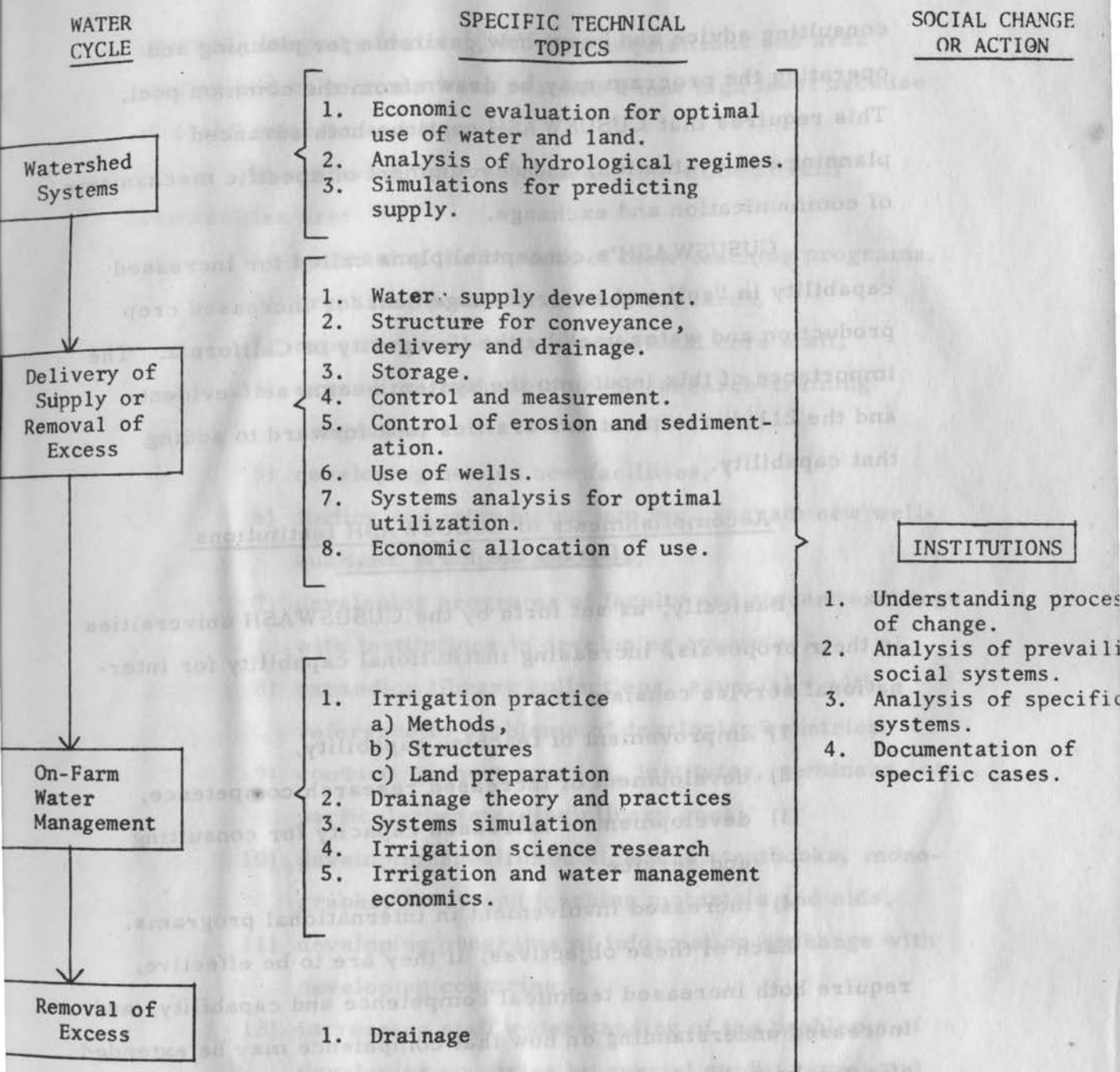


Fig. 1 - System Diagram of CUSUSWASH 211(d) Program as Implemented 1969/70.

consulting advice and know-how desirable for planning and operating the program may be drawn from the common pool. This requires that CUSUSWASH continue both advanced planning and evaluation, and development of specific mechanisms of communication and exchange.

CUSUSWASH's conceptual plans called for increased capability in "soil and water management for increased crop production and water use" by the University of California. The importance of this input into the system seems self-evident and the 211(d) recipient universities look forward to adding that capability.

#### Accomplishments of CUSUSWASH Institutions During the First Year

Basically, as set forth by the CUSUSWASH universities in their proposals, increasing institutional capability for international service consists of:

- 1) improvement of teaching capability,
- 2) development of increased research competence,
- 3) development of increased capacity for consulting and service,
- 4) increased involvement in international programs.

Each of these objectives, if they are to be effective, require both increased technical competence and capability, and increased understanding on how that competence may be extended effectively to developing countries. But increased capacity of the institutions is more than what is specifically financed by 211(d) funds. These funds have opened up new opportunities for initiatives across the board. Related research programs, new



courses, language training, library acquisitions and area studies and collections have reached a new high level because of 211(d) interest and support.

In achieving their objectives, the CUSUSWASH universities are:

- 1) increasing the breadth of their teaching programs,
- 2) preparing plans for needed research,
- 3) expanding full-time professional core staff,
- 4) expanding graduate student research-training programs,
- 5) developing needed new facilities,
- 6) finding and introducing into the program new well-qualified graduate students,
- 7) developing programs of faculty and student exchange with institutions in developing countries,
- 8) expanding library collections, especially with reference to problems of developing countries,
- 9) conducting short courses, institutes, seminars, etc., particularly interdisciplinary ones,
- 10) developing specific publications, textbooks, monographs, etc., and teaching materials and aids,
- 11) developing programs of information exchange with developing countries,
- 12) increasing staff understanding of the problems of developing countries by special study, travel and consulting,
- 13) increasing appropriate language capability of staff and students,

- 14) collecting and analyzing existing information, especially that relating to problems of the developing countries.

Application of these techniques was discussed in detail by university representatives and AID personnel at meetings held October 24 and 25, 1969 in Logan and January 13 and 14, 1970 in Denver. These meetings were attended by personnel actively engaged in implementing the program as well as by administrative personnel. Resulting face-to-face discussions led to a significant interchange of ideas and suggestions drawing on the total experience of those participating.

#### Increasing the capability for teaching

Use of 211(d) funding has already led to significant increases in scope and depth of teaching and to an increased and sharpened consciousness of international considerations by the CUSUSWASH universities. In each university this benefit is shared by several departments directly and by many departments indirectly.

At Utah State University, an interdisciplinary committee has been formulated with the objective of rounding out the teaching program to include greater understanding of social and economic factors including international ones and of area considerations. Arizona has reviewed all water-related courses in concerned departments in order to determine how more international problems can be introduced into them and has mobilized the efforts of three departments in developing its program in watershed systems analysis. Six departments at Colorado State are involved in the Grant program and their efforts have resulted in

a multidisciplinary international educational and research program in water resources management known as WATREMAN. These efforts have significantly increased the interest of related departments in all of the universities.

New courses have been added or are being developed by all of the universities. Arizona has added courses in World Soils and Hydrologic Modeling and re-structured an advanced Watershed Management course. Colorado has added courses in Irrigation Structures and Farm Irrigation Systems and developed a new course on Water Resource Systems Engineering. In sociology at Colorado, Comparative Family Institutions and Social and Cultural Factors in Technological Change and a seminar, Industrialization and Urbanization in the Third World have been added using Grant and university funds.

All of the universities have added distinguished specialists to their permanent teaching staffs. Henry J. Caulfield at Colorado, a political scientist, has served as director of the program staff of the Department of the Interior and as Executive Director of the Water Resources Council; William I. Palmer at Utah has been an Assistant Commissioner of Reclamation; Development Finance Officer for Agriculture for AID and an international consultant for Ralph M. Parsons Company. Dr. Martin Fogel at Arizona is a specialist in watershed modeling. In summary, Arizona has added two new staff members, Colorado seven, and Utah three; utilizing, in part, 211(d) funding.

New opportunities for graduate research having international significance have been identified and made realizable



through the 211(d) program. Two Utah State University graduate students are conducting their thesis research in Latin America. Nine graduate students at Arizona, ten at Colorado and five at Utah were supported wholly or in part by 211(d) funds. All three institutions are developing graduate student recruiting programs and CUSUSWASH has plans for a joint brochure. Colorado State University distributed more than 90,000 copies of its brochure announcing its "WATREMAN" program. By June 30, 1970, sixty-five applications had been received from 400 responses.

New teaching facilities are being developed at all three universities utilizing 211(d) Grant support. Arizona has developed a passive electronics watershed model which has proven to be an effective teaching tool. At University expense, Utah has provided a special laboratory and workroom for graduate students in agricultural economics and has begun development of a new irrigation laboratory at an estimated cost of \$40,000.

All of the universities have programs involving exchange of graduate students. Arizona has had a long-standing exchange program with the University of Ceara in Brazil. Utah has been working with the University of the Andes in Venezuela for six years and Colorado, informally, with West Pakistan Agricultural University. Many students are also drawn by these universities from the junior ranks of the government services principally from the Latin American countries, the Middle East, India and Pakistan and Southeast Asia.

Grant support has led to significant enhancement of library collections. Colorado State has added about 750 new

publications in water management using, in part, Grant funds. Grant expenditures of \$4,000 for new library acquisitions under an entirely new program of collecting "on-farm water management" literature at Utah have been matched by expenditure of \$10,267 by the University. Arizona has prepared a collection of abstracts concerned with hydrologic and range research using, in part, 211(d) support.

All of the universities are increasing their collections of existing hydrological and water resource use information in developing countries. Most of this effort is conducted in connection with research programs, but the results are available for teaching and student research efforts as well. Utah has concentrated on Latin America and Colorado State on Pakistan in this activity.

Colorado State University has initiated a scheduled (weekly) international interdisciplinary Seminar on water resources under the leadership of Professor Caulfield, utilizing, in part, Grant funds. A two-week summer workshop on Water Resources Planning for Developing Countries with emphasis on agriculture was planned for June, 1970, by Utah with cooperation from Colorado, but because of scheduling difficulties, this has been postponed for one year. All of the universities have held one or more international seminars in the water resource field, using other sources of funding, during the year.

Plans have been developed for new textbooks, monographs, manuals and circulars utilizing partial 211(d) support. These plans are coordinated through the Council. A color slide

series for sprinkler irrigation has been prepared and one circular on irrigation completed by Utah State. Arizona is developing a complete interfaced hydrologic data system for use in teaching and research. Colorado has initiated a technical report series which will include reports prepared with support of Grant funds.

New international experiences and the institutional commitments implied by the 211(d) grants have led to a significantly increased international interest and awareness in teaching programs at all universities. For the past four or five years Utah State has purposefully tried to introduce new international awareness and examples in all of its agricultural and irrigation courses, and in many soils and agricultural economics courses. Colorado traditionally has had a commitment to international programs evidenced by the cooperative program with the University of Peshawar in the 1950's, a Congressional study on the Peace Corps in 1961 and the establishment of an Office of International Programs in 1963. Similar efforts have been made in many agricultural courses at Arizona. Use of 211(d) support has provided the staff time and resources to continue these ambitions in a significant way.

Travel has been an important part of the program which impacts on increased teaching capability as well as on research and consulting. Usually, 211(d) funds have been used only to extend travel basically paid for from other sources. More directly, modest support by 211(d) funds pooled with other resources made possible a field trip to the Lower Balsas River Basin in Mexico by eight Colorado State graduate students

and two staff members. More information on travel is contained in the section on "Increasing the Capacity for Consulting and Service Work."

#### Increasing Research Competence

Use of 211(d) Grant funds has increased research competence of the CUSUSWASH universities particularly in its application to problems of developing countries. These funds have permitted acquisition of new staff members, and have supported graduate students and their research projects. They have provided resources by which staff members have become aware of needs of developing countries and provided the time to plan research programs that take these needs into account. Both Colorado State and Utah State have research projects underway through other AID contracts. Utah State has initiated field research in Chile, Venezuela and Colombia on irrigation water management, agricultural input interactions and drainage which provides a base for its graduate research program under 211(d). Colorado State is initiating field experiments in West Pakistan and is expected to expand its cooperative field efforts in that Province during the coming year. Colorado State research includes water management structures and political science and sociology. Arizona's experience in Brazil has provided a basis for planning its research enhancement program under 211(d) funds, emphasizing watershed relationships.

Acquisition of new staff members by the CUSUSWASH universities has been mentioned under the section on increasing teaching capability. Besides those mentioned in that section,



Utah State has employed, partly using Grant funds, a new associate professor specializing in soil and water chemistry and a new professor specializing in water quality. Colorado State has added two new staff members, partly with Grant support, specializing in irrigation water control structures; besides Mr. Caulfield, two new staff members have been added in political science. At Arizona, besides Dr. Fogel, a specialist on hydrological watershed modeling has been added.

Plans were developed and arrangements completed by Utah State for two graduate students to conduct their experimental research at Latin American field stations during FY 1971. An agronomist from the West Pakistan Atomic Energy Agricultural Research Center was brought to Colorado State as a visiting professor. A joint project proposed by Colorado and Utah is designed to study irrigation distribution and measurement structures for Latin and Central America and Colorado State has initiated a program to develop measuring flumes and distribution structures.

Utah State held a two-week training workshop on field research in Brazil and Arizona has plans underway for a joint seminar on systems approaches to problem solving.

At all universities, the capability to add an active new element of international concern to on-going extensive research programs has already had exciting consequences. Across the concerned departments, there is an awareness of a new opportunity to extend a realistic international dimension to research because graduate research support opportunities are now available. Thus, members of all of the concerned departments

in the three universities are thinking about new possibilities in their own specialties. At Colorado State this applies to the extensive programs in hydraulic engineering, agricultural engineering, agronomy and soils as well as in the social sciences. At Utah State this enthusiasm extends to the Water Research Laboratory as well as to the departmental disciplines of soils, economics and agricultural and irrigation engineering. At Arizona, Departments of Watershed Management and Hydrology and Water Resources and Systems Engineering are closely cooperating in the new venture.

#### Increasing Consulting Competence

Use of 211(d) Grants provided some extension of travel and study of faculty members adding to their consulting capability. Generally, this support was relatively modest; at Colorado State 211(d) funds supported all or part of six international trips. Partial support for two trips was provided at Utah. Nine University of Arizona faculty members made a total of eleven consulting trips; at Utah State 14 faculty members made 27 such trips. Arizona has an impressive list of staff members available for overseas consultation service in the general area of Optimum Use of Water Resources for Agriculture, and Colorado lists 13 people from six departments to illustrate their consulting competence.

### Inter-University Activities Implemented by the Council

Through the efforts of the CUSUSWASH Council, a number of inter-university efforts and sharing of program responsibility have been initiated. One of the most effective mechanisms has been the face-to-face discussion by a fairly large representation -- inter-university and inter-disciplinary -- at the two meetings held during the year. Included also in this discussion were representatives from AID as well as university staff members having extensive international experience. These discussions led to many new ideas, screening of ideas, elimination of duplicate efforts and considerable enhancement of interdisciplinary communication plus a pervading orientation of thinking toward developing-country problems.

Through these discussions a number of inter-university activities arose. Colorado State is supporting Utah State's efforts to bring to fruition a workshop on water resources planning for developing countries with emphasis on agriculture. Based on Utah State experiments with a low-head measuring flume, Colorado State is developing this device for use in developing-country situations. Two Utah State faculty members participated in summer courses at Colorado State and one Colorado staff member is scheduled to participate in the Second International Seminar for Professors of Hydrology sponsored by the International Hydrological Decade and to be held at Logan. Plans were made for the Chairman of CUSUSWASH to visit Pakistan to assist in developing Colorado State's plans there, but this has been deferred. These two universities have conferred frequently in procuring staff members. In the

agricultural water management area one staff member and two Utah State University graduate students transferred to Colorado State; one Colorado State graduate was added to Utah State's staff.

The Council has taken some definite steps in order to stimulate inter-university activities which will lead to more capability jointly than can be achieved individually. These include appointment of a publications committee to suggest an operational procedure (possibly a manual) on format, acknowledgments, reprints and distribution of project and project-related publications and abstracts, including their numbering and bibliographical entry; priorities for monographs, textbooks and manuals and possible authors will be examined and recommendations for writing made. Recommendations will be made on needed translations. A common brochure designed to stimulate interest of competent graduate students and to provide general information about the program will be prepared. Use of videotaped special lectures will be considered, and, if desirable, some specific programs will be recommended and implemented. Using video tapes, seminars and lectures held at one university could be made available to the others. Demonstrations of some teaching devices such as use of microfiche, television, etc., will be arranged through the university having the most experience.

Plans for an international seminar are being explored by a Seminar Committee and recommendations will be made to the Council and to AID. A Committee consisting of the 211(d) directors will study inter-curricular, inter-student, or inter-



faculty activities.

In order to carry on the work of more effectively utilizing opportunities for cooperation and improved coordination, the executive members of the Council will meet bi-annually. This, with the two large meetings of the expanded Council now being held each year will result in quarterly meetings. The University of California representatives are participating fully in these activities.

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August 31, 1970

# SUMMARY OF CONTRIBUTIONS TO THE UNIVERSITY CAPABILITY

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## SUMMARY OF CONTRIBUTIONS TO THE UNIVERSITY CAPABILITY

### General

In the first year of the 211(d) Grant the University, under the leadership of the Watershed Management Department, has made significant progress toward attaining the goals of strengthening its capabilities in teaching, research and service in the area of systems analysis of watershed management with special emphasis on the problems of less developed countries.

The improvements in teaching facilities, new and revised courses, abstract compilations, analyses of research programs and new faculty, as well as the expanded University support have all increased the awareness and interest of professionals and students in the goals and objectives of the Grant. The net effect has greatly increased potential of the University to render services to individuals, government agencies, private companies and students from foreign countries.

### Teaching

Teaching competence has been expanded by curricula reviews, seminars, developing new courses and facilities and adding qualified, motivated professional staff in watershed management.

The Grant has motivated the review and restructuring of all water-related courses in several departments and the development of new courses e.g. World Soils and Hydrologic Modeling. The Agricultural Engineering Department organized and presented seminars for professors and students from the Universities of Arizona and Ceara, Brazil. Collections of abstracts and summaries have been made of available knowledge in wildland hydrology that will be of value in systems analysis. These will provide reference to efficient expansion of the knowledge base for ourselves and others in less developed countries.

An active program is underway in the development of teaching aids. A Passive Electronic Watershed Model has been developed which may be particularly useful for instruction in underdeveloped countries because of its portability and low cost. There is an active interplay between model user and the model and foreign visitors have been enthusiastic about its teaching applications. With the support of the Grant, State funds and other programs in the University, the Department of Watershed Management has developed a unique teaching-research facility consisting of a completely interfaced hydrologic data acquisition system. It consists of a small computer, software and hardware for working with live-telemetered data and provides for rapid

recall of past data. A magnetic tape library of modeling programs and subroutines for systems analysis is being assembled for use with the facility.

Dr. Martin M. Fogel, a specialist in hydrologic modeling and systems analysis, and Dr. Edwin Lamar Smith, a specialist in soil-plant-water relations joined the faculty of the Department of Watershed Management as a result of the Grant and have greatly increased the teaching competence of the University in this field. Seven graduate students were partially supported from the grant. One has completed his M.S. degree and accepted a job working for an American firm in Brazil.

#### Research

Increased research competence is inter-related with increased teaching competence. The new faculty members will teach, conduct research, and direct the work of graduate students. Many of the new graduate students mentioned above are under the direction of the new faculty members, Drs. Fogel and Smith who have had overseas research experience. Interdisciplinary research has been emphasized. For instance, faculty and their graduate students from the Hydrology and Water Resources, Systems Engineering and Watershed Departments are increasing their cooperative efforts in stochastic and parametric modeling of

hydrologic events for prediction of surface runoff and sedimentation and for development of decision-making models for resource planning. The Agricultural Engineering and Agronomy Departments are cooperating in a project of collecting rainfall from larger areas to augment direct rainfall available to crops. These cooperative efforts have greatly increased the University's awareness of and interest in the Grant objectives and goals, as well as the teaching and consultative capabilities.

#### Consulting and Services

The addition of new faculty teaching facilities, abstract and summary compilations, cooperative research and training, and the increased awareness and interest of personnel in the Grant are resulting in greater capability of the University to offer consulting, advice and services. New faculty added to the University with the assistance of the Grant, have considerable overseas consulting experience and will directly increase the consulting capability of the University.



## OBJECTIVES AND SCOPE

The major objective of the Section 211(d) Grant is to strengthen the existing capabilities of the University of Arizona's watershed management program centered in the Department of Watershed Management with special emphasis on the science and methodology of applying systems analysis techniques to problems of less developed countries.

Specifically, the objectives and scope of the University of Arizona program are:

1. Expand its professional staff in Watershed Management who are now and would be specifically involved in systems analysis of watershed management activities related to the needs of the less developed countries.
2. Expand the number of graduate students in Watershed Management from, or interested in, the less developed countries.
3. Expand graduate student research-training programs and activities related to the needs of less developed countries.
4. Expand course offerings in systems analysis of Watershed Management and watershed modeling especially

as related to assistance in solving problems of 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 natural resources and nature of societies of less developed countries with

the hope of finding ways and means of better assisting them to resolve crucial problems relating to development and management of their watersheds.

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 the University of Arizona and the less developed countries.

The expansion of its full-time professional core staff, course of study, research base, and information sources will enable the University to respond more adequately to requests on watershed management problems from: AID/Washington, USAID country missions, other U.S. federal agencies, other U.S. universities, foreign governmental agencies, institutions and private individuals. Specifically, the University of Arizona, working under other contractual arrangements, will be in a more favorable position to: render greater technical assistance in foreign countries; provide a higher quality of training for both U.S. and foreign nationals; do more problem-solving research; provide more consultation; and provide generalized prediction models which can be used by less developed countries.

The interrelated teaching, research and informational service competencies will include, but not be limited to, the following subjects:

1. Development and economic evaluation of land management practices for optimizing productivity of watersheds including alternative goals of maximum on-site use of moisture, or maximum water yield for downstream use consistent with stabilization of the site and maintenance of water quality.

2. Developing systems of quantitative analyses for the hydrologic regimes in areas with extended or cyclic dry periods and/or areas with potential flooding.

This will include characterization, surface slope and roughness, watershed slope, and cover amount and distribution on the hydrologic regimes.

3. Formulation of simulation models for predicting the time and space distribution of water within watersheds typical of U.S. and other countries. These will provide the basis for the completion of the first objective. Subsequent investigation will be necessary to determine the ability of the models to predict hydrologic behavior under the varying produc-



tivity levels. Special attention would be given to generalized prediction models which, when adapted to specific physical parameters of less developed countries, can be used by land planners, administrators and specialists of foreign countries.

## MAJOR ACCOMPLISHMENTS

In the first year of the 211(d) program, the University of Arizona under leadership of the Watershed Management Department has deviated little from its operational plan for building competency in the area of systems analysis of watershed management as related to less developed countries. Accomplishments are presented as a progress report since specific objectives were not expected to be completed within the first year of the grant.

The initial phases of the project have included coordinating on-going programs that have objectives related to those of the 211(d) program. Interdisciplinary aspects have been strengthened through associations with the Departments of Agricultural Engineering, Agronomy, Hydrology and Water Resources and Systems Engineering. Their relationship to the program will be discussed in other sections of the report.

### Development of Teaching Competence

Expanding the teaching competence of the University of Arizona has been in the development of new courses and training facilities, restructuring of existing courses and the addition of motivated and qualified professional staff to work in the area

of systems analysis of watershed management.

A review of all water-related courses in the Department of Watershed Management, Agricultural Chemistry and Soils, Agronomy and Agricultural Engineering was made during the year 1969-70. These reviews were made to determine how more international problems could be introduced into these courses to make them more relevant for foreign students and U.S. students interested in foreign service as well as to make all students more aware of the international problems. No new courses were developed in the Agronomy and Agricultural Engineering Departments as a result of the review however individual faculty members have added an international dimension to their courses.

The Agricultural Chemistry and Soils Department added a new course entitled World Soils. In the Watershed Management Department a new course in hydrologic modeling of natural watersheds was developed and will be taught in 1971.

Close cooperation between the Departments of Watershed Management and Hydrology and Water Resources and Systems Engineering on research projects has given the latter two groups a greater understanding of the project needs. In effect, this has added to the total (teaching and research) capability of the Watershed Management Department. Interaction with the above

departments make it possible to draw on the best talents in integrating the techniques of systems analysis and hydrologic modeling in teaching resource management. An advanced Watershed Management course (WSM 345) was restructured to incorporate some of these principles.

In an effort to draw knowledge from the several disciplines that wildland hydrologists must employ, a portion of the text materials for WSM 262 (Watershed Management II) have been prepared. The sections on evapotranspiration and timber production have been completed while others on precipitation interception, snow hydrology, water yield improvement, erosion and watershed modeling will be worked on at a later date.

A collection of abstracts concerned with hydrologic and range research in arid lands has been prepared under the grant with partial support of the Office of Arid Lands (See Appendix A Section I). The abstracts do not all necessarily deal with modeling but may serve to help an investigator to become acquainted with the variables needed for models particular to his needs.

In executing the grant, one of the needs is summaries of the available knowledge in wildland hydrology that could be of value in systems analysis of watershed management. The first in a series of such summaries of hydrologic processes which in-



fluence the routing of water through a watershed is given in Appendix A, Section II. The purpose of these summaries is to provide a reference of literature for our own use, but if it proves useful to others working on hydrologic problems of under-developed countries, it is all to the good. Only studies published in English have been reviewed. A collection of the European work in wildland hydrology is planned for the future. Copies of all papers reviewed except a few that are virtually unobtainable have been catalogued and incorporated into a library for students and faculty.

A Passive Electronic Watershed Model, developed by the Watershed Management Department under the Grant, has proven an extremely useful teaching aid (see Appendix A, Section IV). The approach is to use electrical components in a nearly direct physical correspondence to their field elements. These elements are passive in the sense that they function only in response to an external electrical stimulus. The model is most useful in instructing students from underdeveloped countries because: (1) there is an active interplay between the model user and the model; (2) the model is portable and compact, so that it can be moved anywhere, and the system can be operated completely from battery power and in most any environment; (3) its low cost re-

quires a minimum of funding; and (4) digital computers are generally not available in the underdeveloped countries. The model has been demonstrated to a number of visiting professors from foreign countries and was met with considerable enthusiasm.

With support from this grant and through cooperation with the International Biological Program, Analysis of Ecosystems, the Department is installing a unique teaching-research facility as part of the program for improving curricula and upgrading teaching methods. The facility is a completely interfaced hydrologic data acquisition-analysis system. In addition to a small computer, it also includes software and hardware for working with live-telemetered data. Provisions are also made for the rapid recall of data and programs from a magnetic tape library.

The facility is extremely flexible and unifies the entire process of data collection, compilation and analysis into a single unit. By means of high speed computation it offers the possibility of having data collected, reduced and analyzed in any desired fashion almost immediately and in some cases while the hydrologic event is occurring. The student is able to observe and work with hydrologic processes in the laboratory, at any time and under more inclement conditions.

With this versatility it offers an opportunity to lessen the gap between the publication of research results and their eventual incorporation into classroom instruction. Because of the convenience of having a variety of data immediately at hand and ready for the computer, new developments in hydrologic techniques and research can be tested and demonstrated with the facility as they become pertinent. Teaching efficiency and educational effectiveness are increased by dealing with complex problems in a very practical but dramatic way.

The Department of Agricultural Engineering organized and presented a series of seminars for all University of Arizona personnel who are or have been involved with the Brazil Program, AID Project 1a-145, and professors from the University of Ceara, Fortaleza, Ceara, Brazil who are pursuing advanced degrees at The University of Arizona. The objectives of the seminars were to examine the agricultural problems of the State of Ceara in Northeast Brazil, to encourage the Brazilians to seek solutions to these problems, and to increase the interest and knowledge of the University of Arizona faculty members in international agriculture.

The addition of new faculty, staff and graduate students have enhanced the University's teaching competence in systems

analysis of Watershed Management. Dr. Martin M. Fogel, a specialist in Hydrologic Modeling and Systems Analysis, joined the Department of Watershed Management as Professor of Watershed Hydrology. He is revising the WM 260 course, Watershed Hydrology, and has assisted in the development of a new course in Hydrologic Modeling. Dr. Edwin L. Smith, a specialist in soil-plant-water relations, joined the Department of Watershed Management as Assistant Professor. He has assisted in the revision of two courses in conservation of natural ecosystems which should be of interest to many foreign students.

A new systems analyst and programmer staff position was also added. Seven graduate students, interested in foreign work as careers, received partial support from the grant. One has completed his M.S. degree and accepted a job working for an American firm in Brazil.

#### Development of Research Competence

Expanding the research competence of the University of Arizona in the area of systems analysis in watershed management has necessarily been interrelated with increased teaching competence. As with teaching, the interdisciplinary approach to research has been emphasized. Personnel from the Departments of Hydrology and Water Resources, Systems Engineering and



Watershed Management have and are continuing to collaborate on such problems as the development of a stochastic precipitation model for use in water management applications, space-time validation of such a model, prediction of surface runoff from rainfall and watershed parameters, and the stochastic analysis of ephemeral flow in arid land channels.

Pertinent research projects primarily within the Watershed Management Department have included the following:

1. A decision-making model for planning optimal resource development.
2. Computer simulation of the hydrologic response of watersheds to precipitation inputs.
3. Prediction of effects of land treatment on sedimentation in small catchment basins.
4. Spatial distribution of watershed infiltration parameters.
5. Prediction of the effect of soil shrinkage and swelling on movement of water into and through soils.
6. Development and testing of transpiration retardants.
7. Prediction of snowpack water balance by means of a seasonal energy balance.

8. Development of electrical analog models of watersheds.

9. Climatological patterns and their effects on agriculture and forestry.

In an effort to update the Watershed Management Department's knowledge of current research in watershed systems and modeling, a tour of major research offices and field installations in four southeastern states was made by John L. Thames and David B. Thorud. Research and management programs of the U.S. Forest Service Tennessee Valley Authority, Oak Ridge National Laboratory and Duke University were reviewed. A detailed report of the trip which was supported by Section 211(d) is contained in Appendix A, Section III.

A compilation of current research in the United States applicable to systems analysis of watershed management has been prepared under the grant (see Appendix A, Section V). Its purpose is to summarize current research projects being carried out by federal and state agencies and universities in the United States that may be pertinent to the "Optimum Utilization of Water Resources for Agriculture with Special Emphasis on Systems Analysis of Watershed Management."

Systems Analysis of watershed management implies integrating hydrologic, ecologic, and economic principles into operational models that will provide quantitative guides for the management of land for the optimum yields of water for: (1) on-site use in the production of timber, forage or crops; (2) use further downstream for irrigation, municipal needs or power production; (3) control of erosion, sedimentation and floods; and (4) all or any combination of these uses.

From more than 1000 research projects in progress, 152 were selected as particularly applicable to these objectives. The science information exchange was the primary source of information supplemented by correspondence, telephone communication and personal visits with the organizations involved.

Partially funded by the Grant, The Agricultural Engineering Department, in cooperation with the Agronomy Department, has inaugurated a project which is attempting to make more beneficial use of the limited rainfall that occurs in semi-arid regions. The possibility of farming relatively small areas of the desert by collecting runoff water from a much larger area to augment the crop's available water supply from direct rainfall is the objective of this project. A more detailed account of this project is found in a paper presented at the 1970 annual meeting of the American

Society of Agricultural Engineers (See Appendix A, Section VI).

The Department of Agronomy has several programs underway in the general area of water use by crop plants. Although these programs are not funded by the Grant, they do provide expertise, equipment and facilities for two graduate students training under the Grant.

New faculty members, Dr. Martin Fogel and Dr. Edwin L. Smith added as a result of the grant, have substantially increased the research capabilities of the University in system analysis in Watershed Management. These professors will also advise some of the new graduate students assisted by the grant with their research programs. A new systems analyst and programmer staff position was added to assist faculty and graduate students in the development of better research and teaching.

#### Development of Competence for Consultations and Service

The addition of new faculty, facilities, library holdings, abstract and bibliographical compilations, and the increased awareness and interest of personnel in the Objectives of the Grant have resulted in greater capability of the University to offer consulting advice and services. The new faculty added to the staff with the assistance of the Grant, Drs. Fogel and Smith have more than 5 years total overseas consulting experience. Gradu-



ate students particularly those from less developed countries, working with these faculty will increase the talent available for research and teaching in less developed countries.

A brief listing of the staff and their consulting assignments follows:

Dr. John H. Ehrenreich, June 26 to July 12, 1969 - to Northeast Brazil in connection with the USAID/Brazil Contract with the University of Ceara.

Dr. Martin Massengale, November 22 to December 9, 1969 - to Northeast Brazil in connection with the USAID/Brazil Contract.

Dr. R. E. Dennis, September 20 to September 30, 1969 - To West Pakistan.

Dr. M. H. Schonhorst, September 23 to September 30, 1969 - To Venezuela Private Consulting.

Dr. Martin M. Fogel, November 25 to November 30, 1969 - To Mexico. Private Consulting.

Dr. W. Matlock, July, 1979 - To Brazil in connection with the USAID/Brazil Contract.

#### Involvement of Other University Resources

An up-to-date and complete library is essential to any teaching or research program. The University has responded to

this and other projects by embarking on an expansion program for the Science Library. State and Federal funds in excess of two million dollars are being used to construct additional space and for acquiring additional reference materials.

The usefulness of the recently completed Computer Center to systems analysis has been greatly enhanced by the University's purchase of a multiplex unit for the CDC 6400. This will make it possible to install terminals which will facilitate the teaching and research concerned with highly complex watershed management problems. The terminal will allow the eventual interfacing between the CDC computer and the hydrologic data acquisition and analysis system referred to on page B-14 of this report.

All personnel added to the project have been funded, at least in part, by other University sources. The time of the Project Director and other closely associated personnel has been paid from University funds.

Associated departments, such as the Department of Agricultural Engineering, Agronomy, Agricultural Chemistry and Soils, Hydrology and Water Resources and Systems Engineering have all made significant contributions to the project. The assistance of the Office of Arid Land Studies has been invaluable in obtaining pertinent abstracts, bibliographies and research summaries.

## EXPENDITURES

The approximate expenditures during the year are indicated for the various categories in Table 1. Expenses for professional services were slightly greater than anticipated because of employment of persons to assist in the software package development for the instructional modeling and hydrologic simulation facility and for assistance in installation of electronic instruments for the telemetry phases of the facility.

Travel costs were less than anticipated partly because all foreign travel was financed from other funds. The most significant domestic travel expense was the trip to the East and the Southeast by Drs. John L. Thames (\$552) and David B. Thorud (\$863) to observe experimental and instructional watersheds in more humid vegetation types, to build a backlog of data available for modeling and to aid in course development. A detailed description of their trip and accomplishment appears in Appendix A, Section III.

Equipment costs were less than anticipated because most of the hardware including the modeling and hydrologic instructional facility were obtained from state and other federal sources. The only item costing more than \$100 was a sickle mower

attachment for a garden tractor (\$181.10) to be used in obtaining production data for water use effectiveness modeling problems. Computer costs were also lower than anticipated because the instructional facility has not yet reached a fully operational stage and because additional computer use in courses was financed for the most part with state funds. The general operational expense was very close to anticipated amount.



Table I. Expenditures and Anticipated Expenditures For Fiscal Years 1969-70 through 1973-74

	<u>69-70</u>	<u>70-71</u>	<u>71-72</u>	<u>72-73</u>	<u>73-74</u>	<u>Total</u>
Salaries	38,113	40,000	38,000	37,000	36,000	189,113
Wages	9,430	5,000	5,000	4,000	3,500	26,930
Fringe Benefits	<u>3,771</u>	<u>4,000</u>	<u>4,000</u>	<u>4,000</u>	<u>4,200</u>	<u>19,971</u>
Sub Total	51,314	49,000	47,000	45,000	43,700	236,014
Stipends	6,213	8,500	14,000	10,000	8,500	47,213
Travel						
Foreign	--	4,000	4,000	4,500	3,500	16,000
Domestic	3,368	2,000	2,000	2,000	1,500	10,868
Equipment	2,694	4,000	2,000	2,000	2,000	12,694
Computer	1,348	3,000	3,000	3,000	2,000	12,348
Operations	<u>2,993</u>	<u>3,000</u>	<u>3,000</u>	<u>3,000</u>	<u>2,870</u>	<u>14,863</u>
TOTALS	67,930	73,500	75,000	69,599	64,070	350,000

## WORK PLAN AND BUDGET FORECAST

Many of the activities initiated during the first year will be continued in the forthcoming period. These include:

1. Assemble and analyze existing information devoted to the use of the techniques of systems analysis in the development and management of watersheds in less developed countries.
  - a. Available bibliographies and abstract compilations with reference to the major processes in the hydrologic cycle will be collected and amended if necessary to bring up to date. Additional compilations will be made to include those processes not previously reviewed and published.
  - b. Assemble and catalog a library of research pertinent to the general field of watershed management. A library of computer programs of existing watershed models will be assembled.
2. Develop and analyze computer simulation models that quantitatively characterize the natural hydrologic processes. These models route the precipitation

input through the vegetation-soil complex of the watershed to predict streamflow. Data from actual watersheds will be used to validate the models.

3. Prepare plans for research programs that are concerned with the development and economic evaluation of land management practices for optimizing productivity of watersheds. An example of where such work appears to be needed is in the country of Indonesia. Reports have indicated that serious erosion problems have developed in the up-land areas which have affected downstream water storage facilities. This problem has occurred as a result of people migrating to these upland, water-source areas from the population centers in the valleys. The settling of the people in the predominantly forested regions have altered the vegetation complex in these areas resulting in the erosion problem. Support for these complementary research programs will be sought through CUSUSWASH and other sources.

In addition to the above, broad operational plans have been prepared to meet project objectives. For example, in an effort to

strengthen its competency for consultations, the Watershed Management Department will emphasize this aspect through a systematic investigation of those less developed countries that have serious watershed management problems. Efforts will be made to obtain first-hand familiarity with such areas in an endeavor to assist in finding a solution to these problems.

The Watershed Management Department in conjunction with the Hydrology and Water Resources Department will explore the possibility of holding the Fourth International Seminar for Hydrology Professors, a United States Contribution to the International Hydrological Decade at the University of Arizona during 1972. Based on the subjects that were or will be presented, the theme that suggests the use of systems analyses in watershed management appears to be a logical choice.

Insofar as the budget forecast for the 1970-71 year is concerned, no major changes from the proposal document is contemplated.



### PART III

#### SUMMARY

C-IV

#### INTRODUCTION

C-1

#### DEPARTMENTAL ACTIVITIES, ACCOMPLISHMENTS, AND PLANS

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##### Agricultural Engineering

C-7

##### **OPTIMUM UTILIZATION OF WATER RESOURCES:**

C-7

##### **WITH SPECIAL EMPHASIS ON WATER DELIVERY AND REMOVAL SYSTEMS AND RELEVANT INSTITUTIONAL**

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##### Agronomy

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##### **DEVELOPMENT**

##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to

Project Objectives

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##### Planned Work for FY 1970-71

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23 May 1969 - 23 May 1970

##### Civil Engineering

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##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to

Project Objectives

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##### Planned Work for FY 1970-71

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by

Colorado State University

##### Economics

##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to

Project Objectives

C-14

##### Plans for FY 1970-71

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##### Political Science

C-15

##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to

Project Objectives

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##### Planned Work for Fiscal Year 1970-71

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##### Sociology

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##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to

Project Objectives

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##### Planned Work for FY 1970-71

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Colorado State University

#### INTERNATIONAL INTERDISCIPLINARY SEMINAR

#### IN WATER RESOURCES

Fort Collins, Colorado

C-25

##### Accomplishments to Date, FY 1969-70

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##### Relationship of Accomplishments to Project Objectives

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During 1969-70, ten graduate students were supported to various extents by grant funds. This number will be expanded to thirteen graduate students fully supported by grant funds in 1970-71.

Grant funds directly supported research on "Combination Check-Drop-Energy Dissipators." In the Agricultural Engineering Department during 1969-70. This research will be continued in 1970-71. A proposal was submitted to AID by Texas Tech University (TTU) for "Irrigation Distribution and Water Control Structures for South and Central American Countries," jointly written by L. H. Austin of TTU and D. V. Skogerboe of the Civil Engineering Department. The research will be conducted in a cooperative basis. The Agricultural Engineering Department will begin research on cut-throat flow measuring flumes and on small water management structures for irrigation distribution systems.

Research will begin in the Fall of 1970 in the Agronomy Department on soil moisture. Research was started in the Civil Engineering

## SUMMARY

A grant was awarded Colorado State University (CSU) on May 23, 1969 by the Agency for International Development (AID) pursuant to the authority contained in Section 211 (d) of the Foreign Assistance Act of 1961, as amended. The purpose of the grant is to implement the project "Optimum Utilization of Water Resources, With Special Emphasis on Water Delivery and Removal Systems and Relevant Institutional Development." The grant funds are \$750,000 and are to be utilized over a five year period. This report covers the first year of the grant.

There have been several additions of individuals having experience in water resources to the CSU professional staff since the grant began in May 1969. Mr. Wynn R. Walker joined the Agricultural Engineering Department staff in July 1969. Dr. A. Klute and Dr. Bashir Malik from the Atomic Energy Agricultural Research Center in West Pakistan joined the staff of the Agronomy Department. Dr. Malik will be a visiting professor for one year. Mr. H. P. Caulfield joined the staff of the Political Science Department in September 1969, and Dr. Garth N. Jones and Dr. Norman Wengert joined the Political Science Department staff during the Summer of 1970. Mr. L. Scott Tucker joined the Civil Engineering Department and will assist Dr. Maurice L. Albertson in administering the grant funds.

During 1969-70, ten graduate students were supported to various extents by grant funds. This number will be expanded to thirteen graduate students fully supported by grant funds in 1970-71.

Grant funds directly supported research on "Combination Check-Drop-Energy Dissipators," in the Agricultural Engineering Department during 1969-70. This research will be continued in 1970-71. A proposal was submitted to AID by Utah State University (USU) for "Irrigation Distribution and Measurement Structures for South and Central American Countries," jointly written by L. H. Austin of USU and G. V. Skogerboe of the CSU Agricultural Engineering Department. The research will be conducted on a cooperative basis. The Agricultural Engineering Department will begin research on cut-throat flow measuring flumes and on small water management structures for irrigation distribution systems.

Research will begin in the Fall of 1970 in the Agronomy Department on soil moisture. Research was started in the Civil Engineering



Department on "Optimal Timing of Irrigation Water," by Professor G. L. Smith, Professor M. L. Albertson, and graduate students. Research funded by the grant was conducted by the Political Science Department on comparative successes of American Indians and Caucasian farmers as related to irrigation agriculture. A graduate student in the Political Science Department will examine political aspects of watershed management in Uruguay in 1970-71.

The grant was responsible, either directly or indirectly, for the expansion of course offerings related to the less-developed countries in several departments. Agricultural Engineering added AE455, Irrigation Structures, as a direct result of grant support. The course will be offered for the first time Winter Quarter 1971. Another new course, AE752, Farm Irrigation Systems, has also been added. Professor G. L. Smith of the Civil Engineering Department taught CE795, a special studies graduate course on water resource systems, during the Winter Quarter 1970. The course was initially developed by grant funds. A new course, EC464, Institutions and Economic Development, will be developed with grant funds by the Economics Department in 1970-71. A concentration of courses will be developed during 1970-71 in Public Administration by Professor G. N. Jones of the Political Science Department. Funds allocated from the grant enabled the Sociology Department to expand its curriculum offerings in the area of developmental change in two courses, S740, Comparative Family Institutions, and S460, Social and Cultural Factors in Technological Change. A new Seminar, S747, Industrialization and Urbanization in the Third World, supported by grant funds, will be offered during Fall Quarter 1970 by the Sociology Department.

An International Interdisciplinary Seminar in water resources management was held weekly for two hours during the 1969-70 academic year under the chairmanship of Professor Henry P. Caulfield of the Political Science Department. Faculty members from the following departments assisted in developing the seminar: 1) Agricultural Engineering, 2) Civil Engineering, 3) Agronomy, 4) Economics, 5) Fishery and Wildlife Biology, 6) History, 7) Political Science, 8) Range Science, 9) Recreation and Watershed Resources, and 10) Sociology. During the 1969 Fall Quarter the seminar was limited to faculty members in these departments, but the seminar was later opened to all interested graduate students in addition to the faculty.

A brochure was developed and distributed to approximately 90,000 persons to recruit highly qualified students interested in pursuing graduate study in disciplines associated with water resource management in developing countries. The brochure described the multidisciplinary international education and research program in water management resources at CSU. The brochure not only assisted in locating students for grant supported activities, but also located other students interested in water and the developing countries.

Approximately 750 publications were added to the water management program library during 1969-70. Most of these publications were purchased with grant funds, but many were donated by faculty returning from projects overseas. Approximately two people per week (faculty and students) check out material, and approximately 20 per cent of the publications are in use at one time.

Six international trips were partially or completely funded by the grant. These include a trip to Pakistan by Professor D. M. Freeman; Iran and Pakistan by Professor W. R. Schmehl; Philippines, Thailand, India, and Pakistan by Professor V. Yevjevich; Pakistan by Professor D. B. Simons; Pakistan by Professor E. V. Richardson; and Japan, Pakistan, Thailand, and Iran by Professor M. L. Albertson. A trip to the Lower Balsas River Basin in Mexico by Professors H. H. Biggs and J. O. Reuss and eight graduate students was partially supported by grant funds. The grant also supported travel costs for several faculty members to attend conferences and meetings in the U. S. Much of the travel, both abroad and in the U. S., was directed at establishing lines of communication and interaction with other persons interested in water resources in developing countries.

## INTRODUCTION

### Program Objectives

The objective of this program, supported by a grant from the U. S. Agency for International Development (AID), is to strengthen the already existing competence of Colorado State University (CSU) 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 project is coordinated with similar projects at the University of Arizona and Utah State University through the Council of U. S. Universities for Soil and Water Development in Arid and Sub-Humid areas (CUSUSWASH or Council).

The competence of CSU in water removal and delivery systems and in development of institutions relevant to various aspects of optimum utilization of water resources exists in several departments whose staff members constitute the basic capability and interest. The grant has been used and will continue to be used to expand both the depth and breadth of this capability in its application to the less developed countries (LDC's). Specifically, the grant has been used and will continue to be used to support the salary of staff members and graduate students, and their travel and other expenses related to these activities.

### Land Grant Background

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. There is now well over 100 faculty and more than 300 graduate students from both the United States and abroad that are involved in various water resource programs of research and education in the various departments of Colorado State University.

With the funds from the grant, CSU has been improving its level of excellence with respect to planning, development, management, and utilization of water resources. This has been accomplished through the following steps:

1. Expansion of number and competence of professional staff in the various departments of the University which are involved in water resources activities related to the needs of the LDC's.
2. Expansion of the number of graduate students in these departments from, or interested in, the LDC's.
3. Expansion of departmental research programs and activities related to the needs of the LDC's.
4. Expansion of course offerings in these departments -- including interdisciplinary courses -- which are related to the LDC's.
5. Expansion of special activities 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 LDC's.
6. Help to alleviate the critical shortage of qualified professional personnel with international interests,



experience, and expertise, and with cross-cultural insights.

7. Expansion of the 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.
8. Improvement of the understanding of the nature of the less developed societies, and determination of ways and means of assisting them to resolve crucial problems relating to water resources development and management.
9. Development of 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 LDC's.

Subject areas of specialization that have been enhanced as related to the needs of the developing countries include the following:

1. Development of water supplies from various sources.
2. Conveyance, delivery, and drainage of water in open 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 LDC's 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 LDC's 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 LDC's.
12. By use of systems analysis, develop case studies analyzing and documenting the above relationships in selected areas of the LDC's for instructional research, and training purposes in a multidisciplinary setting.

An operational plan was developed to use as a guide in managing the grant funds. The broad aspects of the plan are as follows:

1. Assemble and analyze existing information on water delivery and removal systems related to the LDC's.
2. Assemble and analyze existing information on development of institutions relevant to optimum utilization of water resources in the LDC's.
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 LDC's.

4. Increase the breadth and depth of teaching and educational materials for the subjects of this program and for the situations in various LDC's.
5. Solicit especially well qualified graduate research assistants, from both the United States and the LDC's, 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 LDC's.
7. Develop a program of student and faculty exchange with certain LDC's.
8. Plan, initiate, and expand an interdisciplinary seminar on development and the interrelationship of the many factors involved in development -- especially in the LDC's.
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 development.

The first year of the program was devoted to "tooling up" and getting the program underway. Some of the activities included the following: an interdisciplinary seminar on water resources was organized and conducted on a weekly basis; a brochure was prepared and distributed to locate qualified graduate students; students were supported through graduate research assistantships; faculty members were supported to direct students, develop research proposals and projects, and develop new course work; faculty members visited LDC's to increase their awareness and understanding; faculty members attended professional meetings and conferences in the U. S. ; and significant additions were made to the library. The direction of these activities was guided by the general objective of the grant, namely to increase the competence of CSU in water delivery and removal systems and in the

various aspects of optimum utilization of water resources.

The above activities are discussed in detail in the remainder of this report. Sections are included on the following:

Departmental Activities, Accomplishments, and Plans; International Interdisciplinary Seminar in Water Resources Management; Publications and the WATREMAN Brochure and Response; Complementary Activities Supported by Other Funds; Travel Report; Expenditures; and People Available for Consulting.

Appendix B, Volume 2 includes the following sections:

Section I, Final Proposal; Section II, Some Biodata Indicating CSU Consulting Competence; and Section III, Publications Added to Library During 1969-1970 Fiscal Year.



## DEPARTMENTAL ACTIVITIES, ACCOMPLISHMENTS, AND PLANS

The objectives of the grant (to increase the competence of CSU with regard to teaching, research, and consulting in the area of water resources related to LDC's) are accomplished through the following six departments:

1. Agricultural Engineering
2. Agronomy
3. Civil Engineering
4. Economics
5. Political Science
6. Sociology

Each department developed a program and requested funds to pursue their program. The accomplishments of each department during 1969 and 1970, the relationship of accomplishments to grant objectives, and planned work for 1970 and 1971 are discussed in this section. Funds are administered and allocated through the Program Director, Professor M. L. Albertson, to insure coordination and compliance with grant objectives.

### Agricultural Engineering

Accomplishments to Date, FY 1969-70: To date, the primary research emphasis as a part of delivery of water at Colorado State University in the Agricultural Engineering Department has been with respect to "Combination Check-Drop-Energy Dissipators." The work on these types of structures is being pursued by Miss Venus T. Somoray, a M. S. student in Agricultural Engineering under the supervision of Professor G. V. Skogerboe. Miss Somoray has completed two interim reports regarding problems involved in the design of check-drop-energy dissipators. Miss Somoray, who is from the Philippines, has a Graduate Research Assistantship (GRA) funded by the grant which will continue until October 1970. A paper will be presented at the annual winter meeting of the American Society of Agricultural Engineers in

Chicago in December 1970.

A proposal, "Irrigation Distribution and Measurement Structures for South and Central American Countries," was submitted to AID by Utah State University (USU). The proposal was written by Messrs. Lloyd H. Austin of USU and G. V. Skogerboe of CSU. The proposal would have Mr. Austin located in South America during fiscal years 1971 and 1972. Part of his assignment would be the field evaluation of various irrigation structures. A cooperative effort between CSU and USU would be developed which would consist of laboratory research at CSU with field performance evaluations being conducted by USU in South America. The field evaluations could be easily extended to other LDC's such as Pakistan.

Two other graduate students, Mr. Tsu-Yang Wu and Mr. Va-Son Boonkird will undertake M. S. theses on topics in irrigation structures for water delivery and removal. Both students are AID participants programmed through the U. S. Department of Agriculture, and are not supported by grant funds. In each case, the student will be generating data which are needed to fill present gaps in design information with specific application to the LDC's. The results of the laboratory data will provide the necessary background information for conducting field evaluations.

Relationship of Accomplishments to Project Objectives: The research project, "Irrigation Distribution System Structures," initiated by the Department with support of grant funds, has allowed the Principal Investigator, Professor G. V. Skogerboe, who had little previous experience with irrigation in the LDC's, to develop a knowledge of irrigation practices in Pakistan, Southeast Asia, South America, and Central America.

As a direct result of grant support, a new course, AE455, Irrigation Structures, has been approved and will be offered for the first time during Winter Quarter, 1971. The course will be taught by Professor Skogerboe and will have both a foreign and U. S. emphasis. Another new course, AE752, Farm Irrigation,

Systems, will also be initiated due to the increase in staff with expertise in irrigation and drainage. Professor D. L. Miles will teach AE752.

A number of personnel in the Agricultural Engineering Department attended the weekly International Interdisciplinary Seminar. The department will initiate a Graduate Seminar next school year which will allow graduate students participating in the grant and other AID programs to present and disseminate the results of their research efforts. The interest of faculty in the water problems of the LDC's has noticeably increased due to seminars and projects funded by the grant.

The Agricultural Engineering Department conducted an "Irrigation Practices Training Course" for the first time during the period 8 June through August 1970. This course was funded by other AID funds and was attended by 14 foreign engineers from Turkey, India, and Thailand. The course will probably be continued next summer.

Planned Work for FY 1970-71: Miss Somoray's GRA will be continued under AID 211 (d) support until October 1970. A GRA has been offered to a student, Mr. Ray S. Bennett, presently at Utah State University. This student began his graduate work July 1, 1970. His thesis is concerned with cutthroat flow measuring flumes which have special application to the LDC's where convenient, simple, and low cost water management devices are urgently needed to develop better water management. The results will be published in both British and metric units and will be printed in both the English and Spanish languages. He will be supported by grant funds.

Another M. S. student, Mr. James H. Barrett from Australia, will begin graduate work in September 1970. He will be supported by grant funds and will undertake one of the research topics listed in the report, "Analysis of Small Water Management Structures in Irrigation Distribution Systems," by G. V. Skogerboe and W. R. Walker.

Professor Skogerboe contemplates two trips during fiscal year 1971. One trip would be made to South and Central America, at which time some of the field evaluation work cited in the Utah State University proposal would be initiated. The other trip would cover Pakistan and possibly portions of Southeast Asia to determine the types of irrigation structures, along with available design information, used in this portion of the world. The trip to South and Central America would also entail the development of this same type of information.

Mr. Wynn R. Walker joined the staff of the Agricultural Engineering Department in July 1970. Mr. Walker is one of the co-authors, along with Professor Skogerboe, of the report, "Analysis of Small Water Management Structures and Irrigation Distribution Systems." Thus, Mr. Walker will be able to effectively participate in the project, "Irrigation Distribution System Structures."

### Agronomy

Accomplishments to Date, FY 1969-70: Dr. John Reuss represented the Department of Agronomy on the committee that developed and planned the International Interdisciplinary Seminar directed by Professor Henry P. Caulfield. He participated in program planning and in the seminar from September 1969 through May 1970.

Dr. Bashir Malik visited the CSU campus in March 1970 and participated in seminars of international scope. He was also available for individual consultation on water management and related problems in West Pakistan. Dr. Malik is on leave as a soil scientist at the Atomic Energy Agricultural Research Center in Tandojam, West Pakistan. Dr. Malik's visit was supported by funds other than the grant funds.

Dr. W. R. Schmehl traveled to Iran and Pakistan in September 1969. His trip was supported by grant funds and the purpose of the travel is discussed in more detail in the "Travel Report."



Relationship of Accomplishments to Project Objectives: The seminar and the visit by Dr. Malik have provided a better understanding of the technical as well as social and political problems of developing countries. This has increased the interest and capability of the staff to serve in advisory or consulting capacities on foreign programs. These activities have also increased the capability of the teaching staff to present and discuss problems of food production in LDC's with both undergraduate and graduate students.

Planned Work for FY 1970-71: Dr. John Reuss will continue to serve on the International Interdisciplinary Seminar Committee.

Increased emphasis will be made to provide new training and education experiences for the Agronomy Staff in International Development. Dr. Malik, from West Pakistan, will be at CSU for post doctoral study and will be assigned to participate in the International Interdisciplinary Seminar. He will also assist in developing seminars of international scope for both undergraduate and graduate students in the Agronomy Department, and will be available for committee work on CSU International Program planning, for individual consultation, and for lectures on selected topics. Dr. Malik will not be supported by grant funds.

A Ph.D. cooperative training program with the Ministry of Agriculture of Iran is being planned. A student from Iran, Mr. M. Monadjemi, will complete his training in academic courses and in research techniques at CSU during April 1971. After completing his preliminary examination he will return to his position in the Ministry of Agriculture to conduct research of mutual interest to Iran and CSU (research will probably be related to sugar beet production in southern Iran). Progress during the research will be reviewed from time to time by CSU Staff in route to the AID-CSU Water Management Research Project in West Pakistan. A dissertation will be written from the research and following a successful exam in Iran, the Ph.D. degree will be granted by CSU. Mr. Monadjemi is not supported by grant funds.

A GRA will also be awarded to a student yet to be selected. He will study under Professor A. Klute and will be involved in soil moisture research.

### Civil Engineering

Accomplishments to Date, FY 1969-70: During the 1969-70 fiscal year, the Department of Civil Engineering made accomplishments in the following areas:

1. Active participation in the interdisciplinary seminar
2. Development of additional courses and a new program in the Civil Engineering Department
3. Planning for future special institutes
4. Preparation, planning, and undertaking of international travel
5. Active participation in preparing WATREMAN brochure
6. Support of graduate students

Professor G. L. Smith developed, with Professor M. L. Albertson, an outline for an improved Water Resource Systems Engineering Program in the Department of Civil Engineering. This program involves, to a very large extent, the problem of water development in arid and sub-humid regions and stresses the international dimension. Professor Smith attended a two-week intensive course on water resource systems at UCLA from August 18 through September 1, 1969 to provide him additional background for developing the program.

In addition, Professor Smith developed and taught CE795, a special studies graduate course on water resource systems, during the 1970 Winter Quarter. Twelve students were officially registered for the course, and up to 18 were usually in attendance. The CE795 course was refined by Professor Smith and submitted to the Civil Engineering Department for acceptance as a scheduled course. The course was accepted and will be taught as CE545. This course was not supported by grant funds, but was a direct outgrowth of previous efforts by Professor Smith, which were

supported by grant funds.

As an additional outgrowth of grant seed money, Professor Smith is developing a special studies course in Water Resources Engineering for Colorado SURGE, a CSU program providing graduate-level education through video tape. This course is very similar to CE545, and is designed to acquaint students with the fundamental concepts and definitions involved in water resource systems engineering.

Professor Smith was also partially supported by grant funds to develop research dealing with optimal application and timing of irrigation water. He wrote an unpublished report on "Optimal Timing of Irrigation Water," using work by Warren Hall of the University of California, Riverside. He used corn as a crop example, but it is intended that this concept will eventually be applied to research in Pakistan. Mr. Yasumi Yamaguchi's M. S. thesis was on this topic, and Professor Smith contributed to the development of the thesis.

Professor Smith was also involved with Professors Albertson and Caulfield on development of a brochure on a Multidisciplinary International Educational and Research Program in Water Resources Management (WATREMAN). His efforts with the WATREMAN brochure were supported by grant funds.

Another Civil Engineering course, CE745, Water Resource Systems Engineering, taught by Professor Albertson, was also improved and refined due to grant support. Assistance was provided through grant funds for help from G. L. Smith, Warren Hall, Richard Males, and others.

Professor Hubert J. Morel-Seytoux devoted some time making preparations, contacts, and arrangements for an information tour of North Africa and the Middle East. The trip was taken in July 1970 and was supported in part by 1970-71 grant funds.

Professor Morel-Seytoux devoted additional time supported by grant funds to planning a five to six week Mobile Institute on Water Resources Management. The institute is being designed

to provide American and foreign students already in the U. S. an opportunity to visit water resource projects in the arid sectors of the U. S. It is planned that the field trips would alternate with course instruction which could be given at university or college campuses at various points on the circuit. The institute will be taught for the first time in the summer of 1971. A letter of interest was mailed to prospective interested groups asking them to indicate their interest in attending such an institute. A very favorable response to the letter was received.

Professor E. F. Schulz was involved in the planning stages of the International Interdisciplinary Seminar directed by Professor Caulfield. He was also responsible for the planning of two sessions of the seminar. The seminar is discussed in detail in the section, "International Interdisciplinary Seminar in Water Resources Management."

Professor V. Yevjevich made a world tour in August and September 1969; Professor E. V. Richardson visited West Pakistan in September 1969; Professor D. B. Simons visited Japan and West Pakistan in September 1969; and Professor Albertson visited Japan, Thailand, Pakistan, and Iran during September and October 1969. All these trips were in some degree supported by grant funds and are summarized in greater detail in the section on "Travel Report."

During Fiscal Year 1969-70, eight graduate students were funded in various degrees by grant funds. The students were: Luciano Cepeda, Mohammad Talib Chaudrhy, Emilio Rios, Donald Taylor, Fang Hong Wu, Jaime Millan, Philip Hosterman, and Suresh Doddiah.

Luciano Cepeda, who was supported for only one month by grant funds, searched and reviewed literature for Professors Albertson's and Smith's classes. Mr. Chaudrhy is involved in a systems analysis of irrigation for conjunctive use of surface water and groundwater resources for West Pakistan. Emilio Rios is studying optimal timing of irrigation water, considering other



factors such as fertilizer application and stochastic inputs. Mr. Taylor studied rural-urban aspects of water resources development. Mr. Wu has been conducting research on minimizing the cost of a canal network water distribution system while also considering the sediment transport effect. Jaime Millan, who was supported for only one month by grant funds, collected data for a research proposal on "Application of Systems Analysis to Water Resources Development in Developing Nations," for Professor Smith. Philip Hosterman is involved in developing a new interdisciplinary perspective on LDC's. His thesis will be on determining some of the social effects caused by technical change in West Pakistan. Mr. Doddiah worked on a report on Reclamation of Water-Logged Lands Under Irrigation for M. L. Albertson.

Relationship of Accomplishments to Project Objectives: The support provided Professor Smith allowed him to develop a competence in water resource systems engineering. His teaching competence related to water development was improved as evidenced by his teaching CE795 on water resource systems engineering which has now been approved as a regular course. He now has the capability to conduct research and provide consulting services on water resource systems engineering problems related to arid or sub-humid regions.

The traveling (mobile) institute being planned by Professor Morel-Seytoux will be a positive teaching instrument for instructing U. S. and foreign students studying water resources. His trip to North Africa and the Middle East will give him an opportunity to gather information for the development of a course on water resources in the developing world and will serve to stimulate and develop his existing interest in research concerning water resources and the developing world.

Professor Albertson was able to improve and refine CE745, Water Resources Systems Engineering, and to lay plans for new courses on water management.

Research was initiated on optimal application and timing of

irrigation water by Professors Albertson and Smith. Hopefully, this research will eventually be extended to field studies in Pakistan.

Professor Schulz's effort with regard to the International Interdisciplinary Seminar resulted in learning experiences being acquired by those in attendance. Professor Schulz, however, has had much experience with resource problems in developing nations and his involvement in the seminar did keep him active in this area. This involvement will carry over to his classroom teaching and research.

Professor D. B. Simons and others in the Civil Engineering Department are currently involved in consulting activities for the World Bank, Acres International, and the Government of Pakistan. They are studying river mechanics, flood control, erosion and sedimentation problems in the delta of the Ganges and Brahmaputra Rivers near their confluence.

Planned Work for FY 1970-71: The support of graduate students will continue in 1970-71 at about its present level.

Professors Albertson and Smith will continue to develop the Water Resource Systems Engineering Program in the Civil Engineering Department, with an international dimension, and to developing new programs. Professor Smith will continue to improve his new course, CE545, and Professor Albertson will continue to refine CE745 and plan and develop new courses concerned with optimum utilization of water resources.

Professor Morel-Seytoux toured North Africa and the Middle East in July 1970. The results of his trip will be discussed in the 1970-71 annual report. He will also continue to develop the Mobile Institute on Water Resources Management, and direct a GRA in assembling information and doing research appropriate to grant objectives.

#### Economics

Accomplishments to Date, FY 1969-70: During the 1969-70

academic year, the Department of Economics has made accomplishments under the grant primarily in three areas:

1. Active participation in the International Interdisciplinary Seminar.
2. Offering of additional courses.
3. Planning for future institutional development and departmental participation.

During the past year the following faculty members actively participated in the Interdisciplinary Seminar: H. H. Biggs and L. M. Hartman. Other members of the department who attended many of the sessions but were not funded under the grant included Professors R. G. Walsh and G. D. Wilken (Geography). In cooperation with Ivan Wymore, graduate student in Watershed Management, Professor Hartman delivered a seminar on 18 February 1970 on "Economic Evaluations and Projections as a Part of Comprehensive River Basin Planning." Professor Biggs also served on the seminar planning committee.

Due to increasing interest among students in the economic problems of the LDC's, a second section of EC460, Economic Development, was taught by Professor Biggs during the Spring Quarter. Non-economic majors were encouraged to attend, particularly graduate students, both U. S. nationals and foreign students, who were involved in field research in the LDC's. Specific economic problems were approached with special attention to interdisciplinary implications (e. g., the technical, social, and political implications of agrarian reform). There is still the need for a course which examines the relationship between institutions and economic development. Such a course will be developed under the grant for the coming year entitled, EC464, Institutions and Economic Development.

A number of discussions were held among persons within this department and with members of other departments concerning prospects for further development of expertise at CSU in dealing with the problems faced by the LDC's. In particular,

emphasis has been placed on the potential benefits of an on-going interdisciplinary social sciences seminar, the need for funding graduate students with an interest in LDC's, and the expansion of course offerings of particular interest to both economic and non-economic majors.

Relationship of Accomplishments to Project Objectives:

Professor L. M. Hartman was the only person from the Economics Department who was supported directly by grant funds. Professor Hartman's active participation in the seminar increased his interest in water problems related to developing nations and upgraded his competence to teach, perform research, and engage in consulting activities regarding this subject area.

The participation of other Economics Department staff in the International Interdisciplinary Seminar substantially increased the staff interest in water development problems related to developing countries.

Plans for FY 1970-71: The Economics Department has been budgeted funds to support six man-months of faculty salary. Two man-months are for continued participation in the International Interdisciplinary Seminar.

Two man-months are to develop two courses in geography. One course, GR340, Economic Geography of Underdeveloped Areas, will examine geographic aspects of underdeveloped areas; their natural resources, population characteristics, patterns of indigenous and introduced agricultural systems, trade, and industry. The other course, GR422, Geography of Indigenous Agricultural Systems, will examine various agricultural systems found in undeveloped regions. The course, GR340, will be offered during the 1970 Fall Quarter, and GR422 will be introduced during the 1971 Winter Quarter.

The remaining two man-months will be devoted to expansion of course offerings related to LDC's, particularly those with an interdisciplinary orientation. The course to be developed will



focus on the evolution of institutions and the role which they have played and are currently playing in economic development of Latin America. The course has been designated EC464, Institutions and Economic Development: Latin America. The course will be taught during the 1970 Fall Quarter in order to precede EC466, Economic Development of Latin America, which is available during the 1970 Winter Quarter.

The support of graduate students will be increased from none in 1969-70 to two in 1970-71. One of the students is Mr. Larry Caswell, M. A. candidate in economics, for a 12 month period beginning Summer 1970. Funds from the grant will support this master's thesis on the impact of irrigated agriculture on export earnings in Mexico and provide him teaching experience. Professor Biggs will direct Mr. Caswell's research efforts. The second graduate student, Mr. Phouangphang Sananikone from Laos, will start in September 1970 and will study natural resource economics and agricultural economics in resources. Mr. Phouangphang will also study under Professor Biggs.

#### Political Science

Accomplishments to Date, FY 1969-70: During the academic year 1969-70, Professor Henry P. Caulfield, Jr., served as Chairman of the International Interdisciplinary Seminar in Water Resources Management. The activities of the seminar during the first year are summarized in the following section, "International Interdisciplinary Seminar in Water Resources Management." Professor Caulfield also assisted Professor Albertson, Director, in the administration of the grant.

One graduate student, Mr. T. J. Manninen, was funded by grant funds to conduct research on comparative successes of American Indians and Caucasian farmers as related to irrigated agriculture. Professor Caulfield was Mr. Manninen's faculty advisor. One NSF trainee, Robert Dildine, conducted research on the personnel problems of water management agencies in West

Pakistan with Professor Phillip Foss as faculty advisor. Mr. Dildine began work on a master's thesis and expects to complete it during the academic year 1970-71. Under the supervision of Assistant Professor Straayer, two graduate students, Robert F. Schmidt and Arlene Dwyer, participated in the Pakistan Water Management Resources Research Project. The work of Mr. Schmidt resulted in a master's thesis, "Water Management in West Pakistan," which was completed in June 1970. Possibilities for publishing the thesis are being investigated with the Rural Development Academy at Peshawar, and one part of the thesis is being abstracted and reworked for submission to Pakistan Development Review, Karachi.

Relationship of Accomplishments to Project Objectives: The grant enabled, in part, the bringing to CSU of Professor Caulfield, who was formerly Executive Director of the Federal Water Resources Council, Washington, D. C., and oriented his activities to a very significant extent, to the water needs of the LDC's. The grant, during the first year, extended existing interest in the Department in domestic water development research problems (as indicated by the work of Professors Foss, Hill, Meek, and Straayer) to the developing countries. While Professors Foss, Hill, Meek and Straayer were not funded at all by the grant (Professor Hill was on leave of absence on a water research project at the Georgia Institute of Technology for much of the year), they actively participated in consideration of problems related to water and developing countries.

Planned Work for Fiscal Year 1970-71: Professor Caulfield will continue to provide the leadership in the International Interdisciplinary Seminar during the 1970-71 academic year. Part of the cost of his effort regarding the seminar will be provided by grant funds. In addition to his teaching responsibilities and research on domestic problems relating to water and environment generally, Professor Caulfield will continue his participation on the United Nations Expert Panel on Water Resources Development

Policies. The Panel met in Buenos Aires in June 1970, and will meet again in Delft in December 1970. The United Nations has contracted with Professor Caulfield to draft a paper reflecting the Panel's thoughts on this subject.

Dr. Garth Jones, an internationally known authority on development administration, joined the staff of Political Science Department in late July 1970. Professor Jones will develop a concentration of courses in public administration including:

(a) courses in public personnel administration, public finance administration and organizational (administrative) theory and behavior; and (b) courses on political modernization or nation building, development administration and change, and development planning administration (organization of central planning agencies, program budgeting, modern accounting and revenue systems, etc.). He will teach a current course, PS449, Politics of Development and Nation Building, which could not otherwise be given in the Fall or Winter of 1970-71, and work on completing publications initiated during his period at the East-West Center at the University of Hawaii: (a) "Planning, Development, and Change, A Bibliography on Development Administration," co-authored with Dr. Shankat Ali and ten graduate assistants; (b) "Monastery Model of Development: Towards a Strategy of Large Scale Planned Change," (c) supplement to bibliography by Garth N. Jones and Shankat Ali, Pakistan Government and Administration: A Comprehensive Bibliography, (Rawalpindi: Research Centre on Public Administration: 1970); (d) Bibliography on Indonesian Government and Administration, and (e) a book on "Pakistan Government and Development Administration," edited with the assistance of Dr. B. A. Abbas and Dr. M. Rashiduzman. In addition, Dr. Jones will be principal investigator with respect to the political science element of CSU's Pakistan Water Management Project that is separately funded by AID.

Professor Norman Wengert, an internationally known expert on natural resources policy and administration, who will also

join the staff in the Political Science Department in September, is not funded by the AID grant. Nevertheless, he will substantially strengthen the Department's competence in the natural and environmental resources field, including water and related land resources, both with regard to the United States and the LDC's. Dr. Wengert in 1959 was consultant to the Government of India, provided by the Ford Foundation, to advise on problems of food and agriculture. This experience resulted in a book on "India's Food Crisis and the Steps to Meet It," (Ministries of Food, Agriculture and Commodity Development, Government of India: 1959).

Equivalent funds to support 1-1/2 graduate research assistants will be provided the Political Science Department under grant funds. One GRA will be with Dr. Jones and will assist in preparing the following:

1. Information Sources for Water Management in West Pakistan for Food Production: Institutional and Human Factors,
2. Water Management for Food Production in West Pakistan: International and Human Factors (an edited work),
3. Comparative Institutions for Water Development.

The other graduate student will be with Professor Caulfield and he will examine political aspects of watershed management in Uruguay.

### Sociology

Accomplishments to Date, FY 1969-70: Funds allocated from the grant have enabled the Department of Sociology and Anthropology to expand its curriculum offerings in the area of developmental change. In the case of two courses, (S740, Comparative Family Institutions, and S460, Social and Cultural Factors in Technological Change) the offerings were broadened from once an academic year to twice, in the case of S740, and three times in the case of S460. As a result of grant seed money, the department was also able to develop and offer new courses and seminars related to



LDC's, largely at the graduate level. These new course offerings included the following:

S560 - Literature of Development, 5 credits

S571 - Education and the Development of Nations, 4 credits

S692 - Methods of Evaluation Research, 4 credits

S770 - Institutional Order and Developmental Change, 3 credits

Professor Freeman traveled to West Pakistan in August and September 1969. The trip was supported by grant funds and is summarized in the section on "Travel Report. "

Relationships of Accomplishments to Project Objectives: The accomplishments enumerated above indicate that the Sociology Department has been able to expand its course offerings related to the LDC's. In addition, the department has increased the professional involvement of the faculty in dealing with the substantial questions of the LDC's. The expansion of courses on developmental change also increased the opportunities for students (e. g., student enrollment in S460 was 35 in the Fall Quarter of 1969; 22 for the Winter Quarter, and an enrollment of 25 for the Spring Quarter) to acquire sociological perspectives and knowledge related to LDC's. More specifically, grant funds have permitted the department to provide students with a greater understanding of the social and cultural factors of technological change and the social progress (e. g., urbanization, industrialization, differentiation, etc.) related to developmental change and some of the technical skills necessary for evaluating such changes (e. g., S692, Methods of Evaluational Research).

Planned Work for FY 1970-71: The Department of Sociology has proposed to develop a "center" within the department. The center is viewed as an initial step towards a systematic undertaking of the following activities:

1. Designing and establishing a set of data banks related to demography and modernization.
2. Broadening the knowledge and skills for the retrieval of international and national data from a multitude of public

and private resources.

3. Obtaining more appropriate sample designs of ecological units, such as natural river systems, irrigation systems, strip cities, etc., for undertaking research on problems of developmental change.
4. Increasing the training opportunities of graduate students in conceptualizing problems relating to developmental change, data retrieval, computer and analytical skills, etc.

The "center" will contribute towards increasing CSU's understanding of the social and cultural factors related to the developmental change. Specifically, it will expand the opportunity for a broad spectrum of research on aspects of development, including that related to the second order of consequences from the introduction of technological innovations, e.g., water management, agricultural, etc., in ecological units at home and abroad. The primary responsibility for the development of the "center" initially will be shared by Professors Kenneth Berry and Evan Vlachos. Funds are allocated to partially support Professor Vlachos and Professor Berry for this purpose. Also, one GRA will be funded from grant funds to assist in the development of the center.

In addition to the initiation of the center, Professor Thomas Harblin will offer a new seminar, S727, "Industrialization and Urbanization in the Third World," for four credits during the Fall Quarter. An allocation of grant funds will be used to develop the seminar as well as offer it. Some of Professor Harblin's time for this purpose will be supported by grant funds.

The department will also continue to contribute a faculty member to the International Interdisciplinary Seminars throughout the academic year 1970-71. The departmental representative at the seminar will be Professor Hodgdon.

## INTERNATIONAL INTERDISCIPLINARY SEMINAR IN WATER RESOURCES MANAGEMENT

### Accomplishments to Date, FY 1969-70

In implementation of item eight of the operational plan for use of the AID grant, which called for the planning, initiation, and expansion of an "interdisciplinary seminar on development and the interrelationship of the many factors involved in development -- especially in LDC's," an international interdisciplinary seminar in water resources management was planned in the late summer of 1969, initiated with the beginning of the academic year 1969-1970, and met for two hours each week throughout the academic year.

During the Fall Term 1969, faculty members from ten academic departments -- Agricultural Engineering, Agronomy, Civil Engineering, Economics, Fishery and Wildlife Biology, History, Political Science, Range Science, Recreation and Watershed Resources, and Sociology -- constituted the seminar under the chairmanship of Professor Henry P. Caulfield, Jr. of the Department of Political Science and, up to August 1969, Executive Director of the Federal Water Resources Council, Washington, D. C. Initial guidelines for the conduct of the seminar were adopted. They provided that the purposes of the interdisciplinary seminar (with respect to water resources management generally, but especially in LDC's) are to:

1. Identify the factors involved in such management and their interrelationships;
2. Relate these factors and their interrelationships to optimum water resource utilization;
3. Develop models reflecting alternate strategies for achieving of one or more conceptions of optimum utilization of water resources;
4. Test these models in relation to the experience of practitioners and observers of water resources management;

5. Recommend research to test these models explicitly and in greater depth;
6. Enable through the seminar, in successive terms and years, the cumulative development of multidisciplinary and interdisciplinary knowledge of water resource management and the diffusion of such knowledge among members from all participating academic departments; and thus
7. Contribute to the achievement of increased levels of competence in water resources management among faculty at Colorado State University (CSU) in accord with the objectives of the Congress providing for institutional development programs through enactment of Section 211 (d) in the Foreign Assistance Act of 1966 (P. L. 89-583) and of AID in making its grant to CSU of May 23, 1969.

For the Fall Term 1969, the seminar program included:

1. Identification of those disciplines that now have a role in water resources management, how they are institutionalized in management, how they interrelate, and of existing and planned seminars and courses relating to water resources management with Colorado State University.
2. Presentation by experts from inside or outside Colorado State University on:
  - a. General cultural development of one or more countries in the Near East, South or East Asia; and
  - b. Development of water resources management in one or more of the same countries.
3. Further consideration of tentative statement of the mission and program of the seminar within a five year frame of reference, and agreement upon a seminar program for the balance of the year.



A total of eleven two-hour sessions were held. Four sessions focused primarily upon 1 above. Mutual understanding was developed as to: the nature of academic "disciplines" as analytical systems; "professions" as relating to the application of disciplines in society; the distinction between interdisciplinary and multidisciplinary activities; the role performed by interdisciplinary and multidisciplinary activities; the role performed by interdisciplinary models in bringing together the relevant parameters and variables of each discipline and certain of the problems in trying to develop such models; the analytical content of the several disciplines involved in water resources management; and some of the interdisciplinary relationships that are involved. Four presentations carrying out 2 above, followed by discussion were as follows:

1. "Water Management Problems in the Near East and Southeast Regions," Rolland F. Kaser, Vice President, Harza Engineering Company, Chicago, Illinois.
2. "American Indians and the Development of Their Natural Resources," Dr. Roderick H. Riley, Economic Advisor to the Commissioner, Bureau of Indian Affairs, Department of the Interior, Washington, D. C.
3. "Development of Water Resources Management in Pakistan," Khalid Mahmood, Graduate Student in Civil Engineering from Pakistan.
4. "India as a Cultural Region," Professor Linwood Hodgdon, Department of Sociology, Colorado State University.

And three sessions were devoted to 3 above.

Beginning with the Winter Term 1970, the seminar was opened to all interested graduate students in addition to faculty in the several concerned academic departments. The program for the Winter and Spring terms aimed at development of broad understanding of water resources management, both in the United States and the LDC's, at the several levels of focus and activity:

national, regional, provincial or state, and local. As carried out in weekly two-hour sessions, the program was as follows:

National Water and Related Land Resource Management Systems

- (1) "The Federalist System of the United States,"  
Reuben Johnson, Acting Executive Director, Federal  
Water Resources Council, Washington, D. C.
- (2) "Tanzania," Harold Nelson, Regional Director,  
U. S. Bureau of Reclamation, Boise, Idaho\*
- (3) "Pakistan," Rev. Robert Schmidt, Graduate Stu-  
dent in Political Science, Colorado State University.

Comprehensive River Basin Planning

- (4) "Missouri River Basin, with Special Reference to  
the South Platte River," Charles Cox and Gus  
Karabotsus, Planning Division, Corps of Engineers,  
Omaha, Nebraska.
- (5) "Rio La Plata Basin, an International Basin in  
South America," Charles Alvarez, Senior Econo-  
mist, Inter American Development Bank,  
Washington, D. C.
- (6) "Mekong River Basin," J. Carl Lee, Water Resources  
Advisor, Office of Regional Affairs, Embassy of the  
United States, Bangkok, Thailand.

Special Problems in Comprehensive River Basin Planning

- (7) "Economic Evaluation, Economic Projections and  
Their Use," Professor L. M. Hartman, Depart-  
ment of Economics, and Ivan Wymore, Graduate  
Student in Water Management, CSU.
- (8) "Land Classification for Agricultural Use," John  
T. Maletic, Chief, Land Resources Branch, Office  
of the Chief Engineer, Bureau of Reclamation,  
Denver, Colorado.

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\*Author of "Rufigi River Basin - Reconnaissance Appraisal of  
Land and Water Resources Development Plans and Potentials," an  
AID report of March 1969.

State Organizational Patterns and Activities in Comprehensive Planning of Water Resources Development

- (9) "State Organizational Patterns in General, " Dr. Daniel H. Hoggan, Associate Professor of Civil Engineering, Utah State University
- (10) "Comprehensive Planning Activities in Nebraska, " Warren Fairchild, Executive Secretary, Soil and Water Conservation Commission of Nebraska, Lincoln, Nebraska.

The Poudre River System of Northeastern Colorado

- (11-a) "Organizational Study of Irrigation Water Companies, " Dr. Roy Meek, Department of Political Science, Colorado State University.
- (11-b) "Water Management: Resources, Legal Controls and Development Potentials, " James H. Duke, Graduate Student in Civil Engineering, Colorado State University.
- (12-a) "Gaining Water User Acceptance of Changes, " Dr. Donald L. Miles, Extension Irrigation Engineer and Assistant Professor of Agricultural Engineering, Colorado State University.
- (12-b) "The Economics of the Water Rights System of Northeastern Colorado," Dr. Raymond Anderson, Research Economist, Economic Research Service, U. S. Department of Agriculture, Fort Collins, Colorado.
- (13-a) "Municipal Water Supply in Northeastern Colorado, " Dr. Norman Evans, Director, Environmental Resources Center, Colorado State University, and Chairman of the Water Board, City of Fort Collins; Dr. Morton Bittinger, Water Resources Engineer, Fort Collins, Colorado.
- (13-b) "Reclamation's View on Further Federal Development in Northeastern Colorado, " Larry Nelson, Field

Investigation Engineer, Regional Division of  
Project Development, Region 7, Bureau of Reclama-  
tion, Denver, Colorado.

A Local Focus Abroad

- (14) "Water Resources Management in Scarp No. 1, Pakistan," Don Smith, Tipton and Kalmbach, Denver; Dr. Kenneth C. Nobe, Department of Economics, Colorado State University; and Mohammad Chaudhry, Graduate Research Assistant, Department of Civil Engineering, Colorado State University.

Additional Seminar Sessions by Special Arrangement

- (15) "Radio-Active Material in Water Resources Management," Dr. Muhammad Malik, Senior Scientific Officer, Pakistan Atomic Energy Commission, Tandojam, West Pakistan.
- (16) "Social and Political Aspect of Water Development in India," Dr. Richard Gable, Professor of Political Science, University of California, Davis, California.
- (17) "Kenya's National Program for Development of Rural Domestic Water Supplies," S. K. Ichungwa, Superintendent of Rural Water Supplies, Department of Agriculture, Government of Kenya.
- (18) "Domestic Water Use and Decisions -- Reflections on Field Work in East Africa," Dr. Gilbert White, Professor of Geography and Director, Behavioral Sciences Institute, University of Colorado, Boulder, Colorado.
- (19) "Canadian-American Water Relations -- The Work of the International Joint Commission," Eugene Weber, Member, U. S. Section, International Joint Commission.
- (20) "Future Water Resource Development in Pakistan," Sarfraz Khan Malik, Chief, Water Resources Section,



National Planning Commission, Government of  
Pakistan, Rawalpindi, West Pakistan.

In addition to the foregoing seminar program during the Winter and Spring Terms, a Seminar Program Committee, a multidisciplinary faculty group, was established and planned the program for the International Interdisciplinary Seminar in Water Resources Management for 1970-1971.

The Seminar Program Committee also reviewed a proposal for a Faculty-Student Field Trip to the Lower Balsas River Basin Project, Mexico, and concluded that the proposed trip from June 7-15, 1970 would be a useful educational experiment. The Program Director, upon recommendation of the Seminar Program Committee, agreed to finance the travel costs of participation of two faculty members.

Ten professional participants took part in the trip. Dr. Huntley Biggs, Assistant Professor of Economics, and Dr. John O. Reuss, Associate Professor of Agronomy, took the trip. Eight graduate students -- four in Agricultural Engineering, and one each from Civil Engineering, Industrial Construction Management, Ecology, and Political Science -- were able to participate through use of student-body and personal funds.

The field trip proved to be an excellent opportunity, at no great distance from Fort Collins and at moderate expense, for faculty and graduate students to observe first hand water resource projects and their effects on social and economic development within the context of an LDC.

It has been recommended that the field trip be repeated in the future and that CSU explore the possibilities of developing a special cooperative and student-faculty exchange relationship with the University of San Nicolas, one of the oldest universities in this hemisphere and located near the Balsas Basin. The Seminar Program Committee will consider these recommendations early in the new academic year and advise the Program Director of its views.

### Relationship of Accomplishments to Project Objectives

In implementing item eight of the Operational Plan for carrying out the AID Grant Agreement, the International Interdisciplinary Seminar in Water Resources Management (an entirely new approach to education in water resources management at Colorado State University) is clearly contributing to the grant's overall objectives of increasing the competence and expertise of CSU among U. S. research and educational institutions and "to improve its level of excellence with respect to planning, development, management, and utilization of water resources." More specifically, in terms of specific grant objectives, the Seminar has expanded the interest of professional staff and graduate students in several departments in water resource management generally, and in less developed countries. Its wide multidisciplinary composition has furthered the interdisciplinary approach to understanding and solution of management problems. It has improved understanding of the nature of developing societies and of effectiveness in assisting them through comparative treatment of national experiences in developed and LDC's in water resources management. Plans for conducting the Seminar in 1970-71 emphasizes these latter specific objectives even more.

### Planned Work for Fiscal Year 1970-71

The general plan for conduct of the International Interdisciplinary Seminar on Water Resources Management in 1970-71 calls for three types of seminar presentations with approximately ten of each type:

1. Interdisciplinary seminar papers prepared by faculty-student teams on major interdisciplinary problems in water resources management. The ten topics and the team leaders for preparation of each paper have been tentatively designated.
2. Country by country presentations on cultural and institutional factors pertinent to water resources management

with particular focus on change from traditional to modern agriculture. A tentative list of countries and possible contributors of papers has been developed.

3. Outstanding speakers on topics particularly pertinent to the concerns of the Seminar. A tentative list of such speakers has been developed.

As in 1969-70, no academic credit will be given for participation by graduate students in the seminar itself. Nevertheless, it is expected that academic credit will be given by the departments concerned for participation in the preparation of the interdisciplinary papers that will be presented to the Seminar.

## PUBLICATIONS AND THE WATREMAN BROCHURE AND RESPONSE

### Publications

During the fiscal year of July 1969 to June 1970, slightly over half of the entire collection of approximately 750 publications were collected for the Water Management Program Library. Approximately 80 per cent of the library is composed of published works and the remainder is reports and various unpublished papers and theses. The library now has subscriptions for a total of nine periodicals. Most publications are requested by faculty members, and in some cases faculty members have donated articles to the library. The Water Management Program Library is located in the Program Office, Room C105 of the Social Sciences Building.

The publications are divided into 16 general subject categories, the largest of which are: Agriculture, Economics, Engineering, Sociology, and Water Resources. Faculty members have ordered the books they want, and a large number of the publications have been brought back from Pakistan by Project participants. Approximately two people per week check out materials from the library and approximately 20 per cent of all of the publications are checked out at one time.

Publications added during 1969-70 and the 16 general subject categories and their code designations are listed in Appendix B, Sec. III, "Publications Added to Library During 1969-70 Fiscal Year."

### WATREMAN Brochure and Response

A brochure was prepared describing the multidisciplinary international educational and research program in water resources management at CSU. The team that developed the brochure included Professor M. L. Albertson, Civil Engineering; Professor Henry P. Caulfield, Political Science; Mrs. B. L. Frantz, Administrative Assistant; Mrs. A. Nelson, Secretary; Mr. P. G. Smith, Printing and Publications; and Professor G. L. Smith,



Civil Engineering. Text material for the brochure was submitted by the department project leaders for the AID supported Water Management Research project.

The purpose of preparing and distributing the brochure was to recruit well qualified graduate students, both foreign and U. S., interested in pursuing graduate study in disciplines associated with water resources management in developing countries. Students were not only being sought for the Institutional Development Grant Program, but also for other opportunities that existed in the various departments.

More than 90,000 brochures were sent to individuals in the United States and abroad. The mailing list included the American Society of Civil Engineers, American Economic Association, American Geophysical Union, Peace Corps, Universities Council on Water Resources, CSU Engineering Research Laboratory, CSU Campus Newsletter, Hispanic Foundation, American Society of Agronomy, CSU Office of International Programs, United Nations, World of Learning, Society of International Development, Rural Sociological Society, Agricultural Engineers, Soil Conservation Society, and Range Management Society.

The brochure was distributed during 1969 and by June 30, 1970 more than 400 responses were received. Each individual responding was sent a letter and appropriate application forms for entrance into CSU and for GRA support. Copies of correspondence were sent to Department Heads of the discipline in which the individual expressed an interest. Sixty-five application forms were completed and returned to CSU, and each was forwarded to the department or college of the individual's interest. Thirteen forms were forwarded to Agricultural Engineering, 16 to Civil Engineering, 7 to Forestry, and 14 to the Social Sciences. Fifteen applications specified interest in two or more colleges. Ten graduate students were supported by grant funding during the 1969-70 fiscal year, and this number will be increased to thirteen in 1970-71.

## COMPLEMENTARY ACTIVITIES SUPPORTED BY OTHER FUNDS

Several activities at CSU related to the grant were completely or partially supported by other funds. These activities are discussed in greater detail elsewhere in this report, but are summarized in this section for easy review.

Publications are added to the Water Management Program Library on a regular basis as indicated in the preceding section. About 20 per cent of the cost of new publications was supported by grant funds, and about 70 per cent by CSU-AID Water Management Research project. Other sources of funding for the library were individual contributions and the AID-CSU Asian Institute of Technology project.

Two graduate students in Agricultural Engineering, Messrs. Tsu Yang Wu and Va-Son Boonkird, are undertaking research on irrigation structures. This research is designed to complement grant activities directed by Professor G. V. Skogerboe. They are AID participants programmed through the U. S. Department of Agriculture, and are not supported by grant funds.

The Agricultural Engineering Department conducted an "Irrigation Practices Training Course," during June, July, and August of 1970, which was supported by AID funds (other than grant funds) for foreign engineers and agronomists working in irrigation and drainage.

Dr. Bashir Malik, a visiting Professor in the Agronomy Department from West Pakistan, will be available during 1970-71 to conduct seminars and advise graduate students on matters related to grant activities. Dr. Malik is being supported entirely by CSU-AID Water Management Research Project funds.

A Ph. D. training program with the Ministry of Agriculture of Iran is being planned with a student from Iran, Mr. M. Monadjemi. The program is being supported under the CSU-AID Water Management Research project.

Professor G. L. Smith of the Civil Engineering Department submitted a course on water resource systems engineering for acceptance as a scheduled course to the Civil Engineering Department. It was accepted and will be taught as CE545. The development of the course was supported by CSU funds, but it was an outgrowth of work supported by grant seed money. Also under CSU funding, Professor Smith developed a course on special studies in water resources engineering for Colorado SURGE, a program providing graduate-level education through video tape. Again, the seed money for this course can be traced to grant funding.

A student in Political Science, Mr. Robert Dildine, was supported by the National Science Foundation to conduct research on personnel problems of water management agencies in West Pakistan. Also, Mr. Robert F. Schmidt completed a master's thesis in May 1970 on "Water Management in West Pakistan." Mr. Schmidt was supported by the CSU-AID Water Management Research project. Professors Foss, Hill, Meek, and Straayer participated in consideration of problems related to water and developing countries under CSU funding.

A faculty-student field trip to the Lower Balsas River Basin Project in Mexico was taken in June 1970 by two CSU professors and eight graduate students. About 20 per cent of the financial support for the trip was obtained from the grant and the remainder was financed through student-body and personal funds.

Text material for the WATREMAN brochure was submitted by project leaders of the AID supported Water Management Research project. Funds for printing and mailing the brochure, and putting the material together for the brochure were provided by the grant. About 20 per cent of the cost of the brochure was provided by funds other than the grant.

## TRAVEL REPORT

### International Travel

The amount charged to the grant for foreign travel in FY 1969-70 was \$1,290.19. This amount does not include \$6,530.25 for air fare and excess baggage which was paid directly by the AID Mission and will eventually be billed to CSU by AID Washington. A summary of the foreign travel follows:

1. David Freeman, Sociology Department  
West Pakistan  
22 August to 21 September 1969  
\$455.65 (Does not include air fare and excess baggage)

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
- d. University of East Pakistan, Dacca, East  
Pakistan

In addition to university personnel, discussions were also held with personnel of other agencies concerned with water resources and agricultural production.

It was tentatively concluded that the staff of the sociology department of West Pakistan Agricultural College in Lyallpur, West Pakistan, was most capable of, and interested in the prospects of a collaborative project with the staff at CSU. Appropriate materials



were collected regarding the West Pakistan Agricultural College staff interests and publications, together with published materials pertaining to the proposed research.

2. W. R. Schmehl, Agronomy Department

West Pakistan and Iran

9 September to 4 October 1969

\$114.05 (Does not include air fare and excess baggage)

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. The research will be conducted under the AID Water Management Research Project, Grant AID/csd 2162. 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  
\$274.85

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  
\$173.96 (Does not include air fare or excess baggage)

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  
\$69.00

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, Iran  
30 August to 7 October 1969  
\$202.68

The cost of Dr. Albertson's trip was only partially supported by grant funds. Other support was derived from the CSU-AID Water Management Research Project and the CSU-AID Asian Institute of Technology Project. The portion of the trip supported by grant funds is as follows:

- a. 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.
- b. 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.

- c. 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.
- d. In Teheran, Iran, Dr. Albertson visited with U. S. 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 later firmed up by Dr. Schmehl, Professor of Agronomy at CSU, in June 1970.

#### U. S. Travel

The amount expended for travel in the United States during FY 1969-70 was \$3,061.15. This included the attendance at the following conferences and meetings: Council on Water Resources, International Seminar for Hydrology Professors, 5th Annual American Water Resource Conference, National Meeting of the Operations Resource Society. American Assembly Conference, CUSUSWASH meeting, American Association on World Hunger, National Water Commission Conference, Council on International Engineering, and local trips in Colorado to obtain data, pick up speakers, and meet with people regarding information for course development or research.

Persons involved in U. S. travel were: M. L. Albertson, Professor of Civil Engineering and Program Director of AID Institutional Development Grant Program; D. C. Taylor, Research Assistant in Civil Engineering; E. C. Vlachos, Associate



Professor of Sociology; L. L. Hodgon, Professor of Sociology; D. Freeman, Assistant Professor of Sociology; H. Caulfield, Professor of Political Science; R. Whedbee, Director of Office of International Programs; E. V. Richardson, Professor of Civil Engineering; G. L. Smith, Associate Professor of Civil Engineering; L. S. Tucker, Research Associate in Civil Engineering; Daniel Hoggan, W. Fairchild, and Eugene Weber, who were guest lecturers for the International Interdisciplinary Seminar; M. Malik, Soil Scientist from Pakistan; and Tom Mannenin, Research Assistant in Political Science.

## EXPENDITURES

The actual and estimated expenditures for fiscal year 1969-1970 in the line item categories are stated in Table 1. These expenditures are through 30 June 1970 and are in balance with the Monthly Status Reports received from the CSU Accounting Office.

Due to the requests made by the various departments, more funds were expended for faculty salaries than originally budgeted. A lesser amount than budgeted was spent for graduate research assistants stipends in order to cover the faculty salary costs. This is reflected in the line item expenditures and in this report by the number of new courses which were initiated this fiscal year ("Departmental Activities, Accomplishments, and Plans," section) and the number of faculty who assisted in organizing and participating in the International Interdisciplinary Seminar (section on "International Interdisciplinary Seminar on Water Resources Management. ")

The use of funds for equipment was small due to the large amount of funds which were used for the cost of the WATREMAN brochure, described in the section on "Publications and the WATREMAN Brochure and Response. "

The funds budgeted for office expense and computer time were used to cover the cost of clerical help and miscellaneous office expense. No computer time was used this fiscal year, but it is anticipated that this computer time will be utilized next year with the additional number of graduate students assigned to the grant.

The proposed budget allocations for fiscal year 1970-71 will continue as proposed in the original budget plan as outlined in Table 2.

TABLE 1

TOTAL EXPENDITURES FOR 1969-1970  
ON AID 211 (d) GRANT

Item	Actual and estimated expenditures	Total
<b>I. FACULTY SALARIES</b>		
Administration		
M. L. Albertson		
L. S. Tucker		
	<u>\$6,295.17</u>	\$6,295.17
Agricultural Engineering		
G. Skogerboe	1,283.31	
Agronomy		
J. Reuss	1,200.00	
Civil Engineering		
A. Mercer		
E. Schulz		
H. Morel-Seytoux		
M. Skinner		
G. Smith	10,075.00	
Economics		
H. Biggs		
L. Hartman		
K. Nobe	7,061.12	
Political Science		
H. Caulfield	8,770.00	
Sociology and Anthropology		
B. Ellenbogen		
D. Freeman		
T. Harblin		
L. Hodgdon		
E. Sharp		
E. Vlachos		
	<u>16,804.94</u>	45,194.37

(continued)

(Table 1 continued)		Actual and estimated expenditures	Total
Item			
II. GRADUATE RESEARCH STIPENDS			
Agricultural Engineering			
	V. Somoray	2, 957. 50	
Agronomy			
Civil Engineering			
	L. Cepeda		
	M. Chaudhry		
	S. Doddiah		
	P. Hosterman		
	J. Millan		
	E. Rios		
	D. Taylor		
	F. Wu	12, 960. 00	
Economics			
Political Science			
	T. Manninen	2, 115. 00	
Sociology and Anthropology			
	J. Ford		
	Labor - Harley Bryant	1, 494. 80	
Consultant or Honorarium			
	Consultants	2, 450. 00	21, 977. 30
	PERA	3, 970. 11	3, 970. 11
III. TRAVEL			
International Travel			
	Dave Freeman		
	W. R. Schmehl		
	V. Yevjevich		
	E. Richardson		
	D. B. Simons		
	M. L. Albertson	1, 290. 19	
		3, 061. 15	4, 351. 34
IV. EQUIPMENT			
	Interdepart. storage cabinets	212. 80	212. 80

(continued)



(Table 1 continued)

Item		Actual and estimated expenditures	Total
V. OFFICE EXPENSE			
Clerical		-----	
Labor		-----	
Misc. expense		-----	
Tele., Xerox, etc.			
Computer time	-0-	<u>13,132.16</u>	13,132.16
VI. LIBRARY AND PUBLICATIONS			
Brochure			
Printing		-----	
Mailing		-----	
Labor		-----	
Library		<u>6,076.74</u>	<u>6,076.74</u>
GRAND TOTAL			<u>\$101,209.99</u>

\*Outstanding incumbrance on travel issued on GTR's to be billed by AID Washington - \$6,530.25

TABLE 2  
DETAILED BUDGET (in \$1,000's)

	Year					
	1	2	3	4	5	Total
<u>Salaries</u>						
Professors: 80 months at \$2,000	24	28	32	36	40	
Ass't. and Assoc. Professors: 80 months at \$1500	18	21	24	27	30	
Total						280
<u>Stipends</u>						
M. S. candidates: 40 years at \$3,000	18	21	24	27	30	
Ph. D. candidates: 40 years at \$4,000	24	28	32	36	40	
Total						280
<u>Travel</u>						
24 trips to South and S. E. Asia at \$1,500	6	7.5	7.5	7.5	7.5	
11 trips to So. Am. and Africa at \$1,000	1	2	2	3	3	
40 trips in U. S. at \$150	1	1	1	1	2	
1500 days per diem at \$18	4	5	6	6	6	
Total						80
<u>Equipment</u>	10	9	8	7	6	40
<u>Office expense and computer time</u>	9	10	10	10	11	50
<u>Library and publications</u>	3	4	4	4	5	20
TOTALS	118	136.5	150.5	164.5	180.5	750

## PERSONS AVAILABLE FOR CONSULTING

There are many individuals at CSU available for consulting activities regarding water problems in developing countries. A few persons are listed in this section from each department to illustrate this competence. The resumes of all individuals noted in this section are included in Appendix B, Sec. II, "Some Biodata Indicating CSU Consulting Competence." These individuals are not the only persons available for consulting. For special consulting needs, the Program Director should be contacted and he in turn will refer the request to the Department involved.

In the Agricultural Engineering Department, Professors A. T. Corey and G. V. Skogerboe are cited to illustrate consulting competence. Professor Corey has served as a consultant for the Petroleum Research Corporation of Denver, and has been a physicist with the Gulf Research and Development Company conducting research on multi-phase flow in porous rock, in addition to his 14 years on the CSU faculty. Professor Skogerboe has worked with the Utah Water and Power Board and the Utah Water Research Laboratory in addition to his two years at CSU. He has had considerable experience testing and developing small irrigation and hydraulic structures.

Professors W. R. Schmehl and J. O. Reuss are cited from the Agronomy Department. Professor Schmehl's major areas of interest are in soil fertility, clay mineralogy, and soil management. He has been a professor at CSU since 1948. Professor Reuss has been involved in areas of restoring productivity of subsoil exposed by land leveling, iron responses in field crops, reclamation of saline and sodic soils, chemical nitrogen transformations in soils, as well as general soil fertility. He has been with CSU since 1961.

In the Department of Civil Engineering, Professors M. L. Albertson, E. V. Richardson, and D. B. Simons are listed to illustrate consulting competence. Professor Albertson has had

over 25 years experience in fluid mechanics, hydraulic engineering, water resources research, and international development engineering. He joined the CSU staff in 1947. Professor Richardson's major fields of interest are experimental fluid mechanics, open channel flow, fluvial hydraulics, and stream morphology. The principal fields of interest of Professor Simons are hydraulics, river mechanics, hydraulics and river modeling, channel design, and stabilization, hydrology, and water resources development. He has been with CSU since 1963.

Professor H. H. Biggs from the Department of Economics has had experience in economic development, agricultural economics, economic theory (macro and micro), Latin American studies, and statistics. Also from the Department of Economics, Professor M. D. Skold has specialized in agricultural economics, regional economics, and resource economics.

Professors H. P. Caulfield and G. N. Jones are noted from the Political Science Department. Professor Caulfield's major areas of interest are economics and administration of natural resources, and water resources in particular. He was Executive Director of the Water Resources Council from 1966 to 1969, before he joined the CSU staff. Professor Jones just joined the CSU staff in June 1970. His major research interests are planned organizational change, comparative study of Pakistan and Indonesian bureaucracy, and modernization of financial management. He has had over 10 years foreign experience in Pakistan and Indonesia.

In the Department of Sociology, Professor C. W. Birky has had considerable experience in evaluating projects in developing countries. He joined CSU in 1946. Professor B. L. Ellenbogen, Professor and Head of the Department of Sociology, served as a consultant in several overseas projects. Included in his overseas consulting experiences are 12 months in Venezuela, 6 weeks in Brazil, and 18 months in Brazil.



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August 31, 1970

# SUMMARY UTAH STATE UNIVERSITY

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## SUMMARY OF CONTRIBUTIONS TO THE UNIVERSITY CAPABILITY

### General

In assessing the contributions from the Grant 211(d) during the first year, it is evident there were many material benefits to Utah State University. There were also some that were relatively intangible and others of the accomplishments were of a subtle nature. The program has increased the overall competence far beyond that indicated by dollar input from the Grant. In giving support to the program, it was necessary for the University to invest some of its thinking, attention, and resources that would not otherwise have been directed to the water management program. These benefits are reflected in the new course offerings, library holdings, and services available to all students, the favorable influence on the professional attitude of the staff and an increase in their confidence and competence. The program has had a striking influence in establishing a close cooperation among staff members from different disciplines and departments as well as among their administrators. An advisory council composed of individuals from different disciplines assist in the direction of the program. The net effect is that the University is becoming a more attractive place for foreign and national students to come for this specialized training.

SUMMARY OF CONTRIBUTIONS TO THE

The plan envisioned for the year under review anticipated a major effort toward increased competence in teaching, research, and services rendered by the University and its staff. It was realized that some of the programs such as teaching and research would develop slowly whereas others including consulting, library, and services would be implemented rather quickly. The following is a brief summary of the progress made in the past year toward increased competence in "On-Farm Water Management for Increased Agricultural Production" at Utah State University in the Teaching, Research, and Consulting and Services programs initiated under the Grant.

### Teaching

As a direct result of the Grant, the course offerings in irrigation and soils were evaluated and are in the process of being revised. Evaluations of staff needs for teaching were made and a search begun for competent persons to fill these needs. As a result, Drs. David James and Eddie J. Middlebrooks were employed. To date, Dr. James has revised two courses, rewritten laboratory manuals, and begun the development of a text book. Dr. Middlebrooks will arrive early next fiscal year. Dr. Jose F. Alfaro, an irrigation engineer from South America, is expected to be involved in the program next year. Dr. Alfaro was trained in the United States and has acquired citizenship. He will be especially prepared to instruct the many students from Latin America that come to Utah State to



study irrigation, soils, or water management.

Negotiations are under way for additional staff of recognized teaching ability and experience.

### Research

Increased competence in research accompanies improvement in teaching. The new staff members employed will teach, conduct research, and direct the research of graduate students. Two new staff members, Dr. James and Dr. Middlebrooks, are excellent examples of good teachers and impressive researchers. Three graduate students are conducting their research under the direction of Dr. James. One is Adel Gonzalez, Dean, Faculty Agronomia, Palmira, Colombia. Dr. James is also instructing in a seminar for staff members being assigned to research projects in Latin America.

Five graduate students are supported by the Grant. Two are now prepared to go to Colombia and Bolivia or Ecuador to conduct their own research. They have completed their course work and language training.

### Consulting and Services

The Grant has contributed directly to increased competence in consulting, library, and services rendered by Utah State University as follows:

### Consulting

Consulting has been encouraged, especially those consulting assignments concerned with land and water resource utilization in the developing countries. Six staff members experienced in foreign service are preparing graduate students for research experience in Latin American countries. The addition of William I. Palmer, an experienced international consultant, has greatly increased the breadth of our capabilities.

### Library

Library activities and acquisitions have been greatly stimulated. Improved library holdings and services are acknowledged as direct benefits to the teaching, research, and consulting capabilities of the University. It was planned that the library holdings in irrigation, drainage, and related fields would be increased. Accordingly, the library staff first made a detailed inventory of the holdings in books, journals, and reference materials. It developed criteria for selecting new acquisitions, and began to procure these and the missing issues of the current holdings. In April, when William I. Palmer joined the program, he began working with the library staff and the research and teaching faculty in determining the acquisitions that are to be made. As of June 1, about \$4,000 of Grant funds had been expended on the library program. The Library Director has reported the University spent approximately \$10,000 in support of the program.

### Language

Language competence of the staff is a direct benefit to the research and consulting services rendered by the University in Latin America. The Grant provided partial support to an intensive Spanish training program. Daily instruction was given, four hours per day, five days per week for staff and graduate students with little or no knowledge of the language. The course was repeated three quarters during the regular school year. During the winter and spring quarters, a less intensive course of five hours per week was given at an intermediate level for those that had completed the elementary course. A total of 17 different persons participated in the program, with eleven completing the second level course. Included were several wives of staff members accepting foreign assignments.

All of the improvements in teaching, course revisions, consulting, library holdings and services, staff additions, etc., increase the capabilities of the University to render services to individuals, government agencies, private companies and students from foreign countries.

## OBJECTIVES AND SCOPE

For many years Utah State University has maintained a vigorous and expanding program in irrigation engineering, irrigation science and fields related to On-Farm Water Management for Increased Agricultural Production. The University has kept the focus on building on its long tradition of teaching, research and service regarding irrigation problems and in recent years has intensified its concern for strengthening the competence of the University in this area. This concern resulted in the generation of a proposal for AID Institutional Grant Support resulting in Grant No. AID/csd 2459 (see Appendix I). A listing of the objectives contained in the proposal are as follows:

The major objective of the Grant program is to increase and expand the existing competence of Utah State University in the science and technology concerned with "on-farm water management" with emphasis on the moisture environment on the farm, as related to the special characteristics and problems of the less developed countries. Increased competence will be developed in the teaching and research activities as follows:

1. Expand its full-time professional core staff which will focus its teaching and research activities on the technical disciplines which relate to maintenance of a proper moisture environment on the farm under less developed country conditions. These include irrigation and surface and subsurface drainage. Irrigation and drainage are complex arts requiring the application of the best knowledge of water, soil, climate, and crop sciences and engineering. Existing courses in this area will be re-evaluated



and restructured as appropriate. New graduate courses, special short courses, and seminars will be developed as required.

2. Expand its research in less developed countries to increase the knowledge and understanding of subjects such as water requirements of crops, moisture-fertilizer-crop response, management of irrigated soils, drainage requirements, salinity, water quality, movement of water in soils, methods of water application, management of irrigation water, and water-crop-soil system analysis.
3. Expand its total library holdings in irrigation and drainage and related disciplines, especially, foreign and international publications, so as to become a center of information on world irrigation and drainage practices.

While Utah State University has considerable ongoing competence in these areas at the present time, the expanded full-time professional staff, courses of study, library information, and research will enable the University to respond much more adequately than heretofore to requests concerning agricultural related water management problems from such entities as: USAID/ Washington, USAID Missions, other state and federal agencies, other universities, educational groups, foreign governmental agencies, foreign water management institutions, local irrigation and drainage institutions, various business groups, various farm groups, and interested private citizens.

The increased interrelated teaching and research competence will include, but not be limited to, the following subjects as they relate to problems of the less developed countries:

1. Irrigation Practices. The theory and practice of maintaining the optimum moisture environment for plant growth by irrigation and

drainage within the complex physical and institutional systems involved.

2. Drainage Theory and Practices. The investigation, design, and operation of drainage systems to assure the optimum soil-moisture environment and avoid or reduce flooding.
3. Water Resources Systems Simulation Engineering. Simulation of multi-purpose projects to provide adequate service for irrigation, drainage, flood prevention, and other purposes as related to on-farm water management.
4. Irrigation Science Research. The basics of consumptive use, infiltration, water physics, water quality, water-salt-soil interactions, within the framework of "on-farm water management" for maximum efficiency and economic returns.
5. Irrigation Economics. The economics of changing water management practices, costs, and economic efficiency of water utilization including the incremental value of water application and water application systems.

## MAJOR ACCOMPLISHMENTS

Immediately after receiving word that a grant had been made to increase the competence of Utah State University in the area of "On-Farm Water Management" members of the Department of Agricultural and Irrigation Engineering began an inventory of manpower needs and program innovations required within the department to accomplish the objectives of the program. The negotiations for the Grant were carried out under the leadership of the Department of Agricultural and Irrigation Engineering at Utah State University and the responsibility for directing the program was naturally delegated to this department. Interdepartmental meetings were held with related departments on campus to develop the interdisciplinary aspects of the program. Several meetings were held with the Departments of Soils and Meteorology, Civil Engineering, Agricultural Economics, Plant Science, Division of International Programs, and members of the Utah Water Research Laboratory. Each of these units gave consideration to all phases of the program including the training of graduate students so as to focus on the problems of on-farm water management. Active programs are under way and will be discussed in other sections of the report.

In the initial phases of implementing the 211(d) program, it was thought that the appointment of an advisory committee consisting of knowledgeable and informed people would help to implement the program by establishing campus policies and

procedures and to serve as a review committee to look at accomplishments and to recommend realignments for continuing aims and objectives. This advisory committee was appointed and the following people agreed to serve: A. Alvin Bishop, Chairman; H. B. Peterson, Project Leader; Jay Bagley, Clark Ballard, Allen LeBaron, R. L. Smith, Members; Bruce H. Anderson, Dean F. Peterson, and D. Wynne Thorne, Ex Officio Members.

A major objective for the first year was to increase the service and holdings of the library in the area of water management. Meetings were held with the University librarian and his staff, and plans were immediately put into operation for a strong program to build the competence of the library. The library program initiated has a double objective: (1) to increase the library holdings, and (2) to build the competence of the staff.

Consideration was given to the appropriate programs to be developed within the framework of the project and the following activities were given high priority. Identify, recruit, and employ new staff having outstanding knowledge, reputation, and prestige. Improve course offerings and teaching in all departments, strengthen research, organize and conduct seminars, develop publications and text books, make site visits to facilities of related institutions, confer with the faculty of other universities, improve the library, conduct language training, and introduce special services including T. V. programs, tapes, micro-filming, microfiche, computer, and related service.



The major accomplishments during the year have been subdivided into four groupings as suggested by Dr. Erven J. Long as follows: (a) Development of Teaching Competence, (b) Development of Research Competence, (c) Development of Competence for Consultations and Services, and (d) Involvement of Other University Resources. A discussion of each category is contained in the following report.

#### Development of Teaching Competence

A major effort was made to identify and obtain those capable and qualified individuals who would complement the existing staff members and increase the overall competence of the University in the area of on-farm water management for increased agricultural production. Leaders in the field were identified and contacts were made with a number of these people to determine their interest in becoming a part of the Utah State University program. Those identified and contacted include Dr. Marvin E. Jensen, Dr. Warren A. Hall, Dr. Wayne D. Criddle, Dr. Lyman S. Willardson, Mr. William I. Palmer, Dr. Eddie J. Middlebrooks, and Dr. David W. James. Dr. James and Mr. Palmer have joined the staff and Dr. Middlebrooks will arrive in August. The curriculum vitae for Dr. James, Dr. Middlebrooks, and Mr. Palmer are included as Appendix C, Section II. Negotiations are still pending concerning others mentioned. Other individuals have been identified as having outstanding competence in this

general area and will be approached. It is hoped to obtain the services of Dr. Jose F. Alfaro, a native of South America with U. S. citizenship, some time near the end of 1970.

The orientation of new and existing staff concerning the aims and objectives of the Grant has progressed so as to concentrate their efforts on a comprehensive review of the existing courses being offered and emphasize other aspects of the program. New staff have provided needed supervision for graduate students including those already on campus and those being added as trainees. Some release time for existing staff members has been provided so that they can concentrate on the areas of curriculum improvement and to give thought to developing publications and text books. Under this program a slide service on sprinkler irrigation has been prepared. Dr. Keller is preparing circulars for use in seminars and training courses. One completed is, "Determining When to Irrigate Wheat." He has also started preparation of a text on methods of water application. This part of the program has progressed on a limited basis during the year, but is expected to be increased manifold during the next year or two.

Some travel has also been accomplished under the program. The Director made a trip to the universities of the California system for the express purpose of talking with staff members and inspecting laboratories and facilities in order to determine the strength and weaknesses of the program at Utah State University.

Contacts were made at the University of California at Los Angeles, the University of California at Riverside, the University of California at Davis, and Stanford University. The project Director also made a recruiting trip to Austin, Texas, to confer with people attending the Irrigation and Drainage Specialty Conference to determine their interest in being identified with the Utah State University program. Mr. Lloyd Myers, Chairman of the Executive Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers, was contacted along with a number of members of the American Society of Civil Engineers in attendance at the Conference. The Dean of Engineering, Dr. Dean F. Peterson, and the Vice President for Research, Dr. D. Wynne Thorne, each made separate foreign trips, in connection with other international travel, to develop background information for various phases of the program (Appendix C, Section III).

During the year, particular emphasis has been given to the problems of increasing the effectiveness of the library to better serve the general area of on-farm water management, both in the teaching and the research field. A very vigorous program was initiated in the library by appointing Sally Lawler as a graduate assistant in the library staff to concentrate in this specific area of on-farm water management. Under the guidance of the University librarian and Carlo Mustonen of the library staff, a comprehensive inventory and listing of all library holdings in the

area of on-farm water management and related fields was made. With a comprehensive bibliography of the existing library holdings as a beginning point, plans were made to identify and acquire those additional vital publications in the field. Policies of acquisitions were established, and a vigorous program of acquisitions was under way by the close of the year. The recent addition of Mr. William I. Palmer to the staff of the Department of Agricultural and Irrigation Engineering gave considerable strength to the library program by bringing his knowledge and ability to aid in the identification, selection, and acquisition of library materials. In connection with the library program, the University pledged to budget a substantial amount to give the program increased flexibility and allow the acquisitions of those additional materials that may be more remotely connected to the general area, but of significant importance to the departments cooperating in the program. Cooperation by the library staff has been excellent and it is expected that this program will be an important part of the total emphasis in the next year (see library report Appendix C, Section IV).

#### Research Competence

Increasing the research competence of the University in the area of on-farm water management has been



integrated with the program to increase teaching competence in this same general area. Utah State University has a large program in research in the area of on-farm water management, including a sizeable contract with USAID, Contract Number AID/csd - 2167. Significant programs are also progressing under the general sponsorship of the Utah Agricultural Experiment Station and with Federal Water Quality Administration contracts concerned with water quality and irrigation return flow. These existing programs provide a substantial base for the training of graduate students who are being sponsored under the 211(d) Grant in research methods and ideas, especially, the Contract AID/csd - 2167 where the graduate students may actually become involved in work in the foreign countries concerned with water management research to increase agricultural production.

A major effort in the research area has been directed toward the selection of a competent staff to direct and train graduate students and to actively engage in the work of the research under way. Dr. David James has been added to the staff and Dr. Middlebrooks will be joining the staff under the program later this year.

The selection, advising, and training of graduate students in the problems of water management has received increasing emphasis. Three graduate students have joined the program during the past year, James Hardee, Thomas White, and Mike Moynahan. Additional graduate students have been

identified and are expected to bring the program to full strength by next year.

In order to increase the competence of both staff and graduate student trainees for research in foreign countries, especially South America, an intensive language training program was initiated early in the year. The staff receiving intensive language training include the following: Dr. E. C. Olsen, III, Dr. Bruce H. Anderson, Dr. David R. Daines, Dr. Bert Embry, Professor Richard E. Griffin (Portuguese), Dr. James H. Milligan, Dr. Earl Israelsen, and Professor Spencer H. Daines. Graduate students participating in the intensive language training program include: Kern Stutler, James Hardee, Darrell Watts, and Lloyd Austin. A more detailed account of the intensive language training program is contained in the Department Head's report (see Appendix C, Section V).

A major effort has been made to coordinate the work of the 211(d) program with that of the research contract in order to provide an opportunity for graduate students to work overseas. This has been accomplished in the past year with Mr. Kern Stutler working on the evapotranspiration and water requirement for crops phase of the research contract in Venezuela and Colombia culminating in his Master's degree work which is now completed. Mr. Darrell Watts is working on another phase of the research contract concerned with the drainage and salinity problems of the Atlantico 3 project in Colombia and it is expected from his work

he will develop an area for his Ph.D. dissertation. The research competence of the staff has also been increased by participating in seminars in Latin America presented by staff members as consultants to the AID research contract. Particular mention should be made of the research training seminar conducted in Brazil by Dr. H. B. Peterson, Professor Richard E. Griffin, and Professor Rex Nielson. Other members of the staff have been engaged in research consulting including Professor J. E. Christiansen, Dr. E. C. Olsen, Dr. David W. James, Dr. Allen LeBaron, etc.

#### Consulting

During the year the University has been able to give increased emphasis and encouragement to staff members to offer consulting advice and services in the field of on-farm water management and closely related areas. Although a major part of the consulting work has been in relationship to the AID Research Contract (AID/csd-2167) a considerable amount of consulting time has been spent in relationship to other work not related to the research contract. The following staff members have provided consulting services in the area of on-farm water management to foreign organizations, foreign countries, and the USAID research contract (AID/csd-2167). A brief listing of the staff and their consulting assignments follow.

Anderson, Bruce H. August 26 to October 5, 1969 (39 days) to Venezuela, Colombia, and Brazil. November 16 to December 2, 1969 (16 days), travel for OAS to Venezuela. April 5 to May 1, 1970 (26 days) travel for OAS to Venezuela, Colombia, Ecuador, Canal Zone, and El Salvador.

Bishop, A. Alvin. February, March, and April, 1970 (65 days) personal contract/AID on NESA Irrigation Practices Seminar. Visited Ceylon, India, Nepal, Pakistan, Afghanistan, Iran, Saudi Arabia, Jordan, Lebanon, Turkey, and Cyprus.

Christiansen, Jerald E. June 16 to July 30, 1969 (44 days) to Guatemala, San Salvador, Panama, Venezuela, Peru, and Chile. November 4 to December 12, 1969 (38 days) travel for OAS to Venezuela and Argentina. March 21 to April 2, 1970 (14 days) travel for OAS to Venezuela.

Daines, David R. May 4 to May 19, 1970 (15 days) to Bolivia.

Griffin, Richard E. February 24 to March 13, 1970 (17 days) to Venezuela, Colombia, and Brazil.

Israelsen, Earl. April 5 to 16, 1970 (11 days) travel for OAS to Venezuela and Brazil.

Keller, Jack. June 28 to July 4, 1969 (6 days) private consulting to Honduras. July 23 to August 21, 1969 (30 days) private consulting to Iran and Libya. February 25 to 28, 1970 (3 days) private consulting to Canada. May 15 to 28, 1970 (18 days) private consulting to Paraguay.



LeBaron, Allen.     October 9 to 23, 1969  
                    (14 days) travel for OAS to Venezuela. May  
                    30 to July 2, 1970 (34 days) to Bolivia, Ecuador,  
                    Colombia, and Venezuela.

Nielson, Rex.       August 26 to October 5, 1969  
                    (40 days) to Colombia, Venezuela, and Brazil.  
                    February 24 to March 13, 1970 (41 days) to  
                    Venezuela, Colombia, and Brazil.

Olsen, Edwin C., III.     June 17 to September 15,  
                            1969 (90 days) to Chile. March 17 to 28, 1970  
                            (11 days) to Colombia.

Peterson, Dean F., Jr.     June 30 to July 1,  
                            October 27 to 28, 1969 (4 days) to Paris as U.S.  
                            Delegate to UNESCO, International Hydrological  
                            Decade, and December 8 to 19 (11 days) to Paris  
                            Seventh Meeting of the Bureau of Coordinating  
                            Council (IHD). April 1970 (30 days) to Iran as  
                            Team Leader of U. S. State Department Team to  
                            report on Water Resources Planning for  
                            Government of Iran.

Peterson, Howard B.     August 26 to October 5, 1969  
                            (40 days) to Colombia, Venezuela, and Brazil.  
                            February 24 to March 21, 1970 (25 days) to Brazil,  
                            Chile, and Venezuela.

Thorne, D. Wynne.       September and October, 1969  
                            (30 days) private consulting for Parsons in India.  
                            For 211(d) travel see Section III Appendix.

Wennergren, E. Boyd.     May 16 to July 2, 1970  
                            (48 days) to Bolivia, Ecuador, Colombia, and  
                            Venezuela.

The increased effectiveness of the Utah State University consultants in the field of on-farm water management has been augmented by the language training program initiated as part of the Grant to offer intensive language training for staff members who intend to serve overseas on short or long term programs.

#### University's Contribution

During the first year of the Grant, the University has placed considerable emphasis on increasing its competence in the area of on-farm water management. A few of the University's contributions include:

1. Plans for modernizing the irrigation laboratory in the Department of Agricultural and Irrigation Engineering at a cost of some \$40,000. The laboratory requirements and needs have changed considerably in the last ten years, and the existing laboratories are too small and incomplete for the modern program now being offered. A new and larger room in the Engineering Building has been assigned for the development of a modern irrigation laboratory. The plans for the proposed remodeling work are nearly completed and work is expected to be finished for classes during the 1970-71 school year.

2. The University provided a special laboratory and work room in the Agricultural Science Building for the staff and graduate students in Agricultural Economics. This area is for

those directly related to the research and teaching program in water management.

3. The University realizes that a modern and complete library is essential to any program of competence, and the staff of the library and the resources of the institution have been pledged towards identifying and acquiring those essential writings, bulletins, texts, and other materials in the field of on-farm water management essential to a viable program. The library has budgeted matching funds for acquisition of library materials and has assigned staff to this particular program, and a vigorous program is under way as discussed above under "Development of Teaching Competence." The Director of the Library estimated a University contribution of \$10,267 (see Appendix C, Section IV).

4. Staff time has also been assigned to aid in the initiation of the Grant. The time of the Project Director and closely associated project leaders has been paid from University funds. In addition, office space, equipment, materials, etc., have been provided for the use of staff being employed or assigned to the project. The advisory committee, consisting of the University staff, has served without additional compensation to recommend plans and objectives for the project and to establish policies and procedures for augmenting the program to maximize the facilities of the University and the capability of the staff.

Associated departments have also contributed greatly, especially the Departments of Soils and Meteorology, Agricultural Economics, Civil Engineering, and Language. Personnel of the Utah Water Research Laboratory, and the Office of International Programs have devoted their time to assist in solving problems and given added support. In order to build a lasting competence, the University has provided budgetary support to pay part of the salaries of the new staff added under the Grant. The two men now employed on the project have half of their salary being paid from University funds or other sources. Additional financial support is provided to the trainees who have had their out-of-state tuition fees waived in order to reduce the cost of the program.



## EXPENDITURES

The approximate expenditures during the year are indicated for the various categories, in Table 1. The exact amounts will not be available until the Controller's books are closed about July 1, 1970. Expenditures in each category were less than indicated in the original budget. Extreme caution was exercised during the first year to insure that proper policies and procedures were established and understood before obligations were made.

Expenses for professional services were far below estimates. This resulted for several reasons. In one instance a senior professional was selected, recruited, and all negotiations apparently completed when he accepted a special assignment for the U. S. Government. In another instance the man was employed, but his arrival date was delayed. In all instances, new positions have been supported only partially from the Grant with a maximum of one-half.

A minimum amount was expended for international travel. Most travel expenses were charged to other programs or shared in two instances. Dean F. Peterson spent \$47.65 on December 20, 1969, for a visit to The Netherlands University Foundation for International Cooperation in order to establish cooperative relations and obtain ideas for the improvement of the Utah State University program (see Appendix C, Section III). During September and October, 1969, while on an extended

EXENDITURES

assignment, Dr. D. W. Thorne made a visit to Rome and Tokyo in order to collect information related to farm planning management of small farms and equipment for use on small irrigated farms. He spent \$120.64. (See Appendix C, Section III for his report.)

There were no expenditures for capital items during the first year of the program. There will be a modest expenditure as soon as students are approved for specific research in Latin American countries.

## WORK PLAN AND BUDGET FORECAST

There has been no major change in the work plan presented in the original proposal. Expenditures the first year were less than anticipated primarily because we were overly optimistic about the rate at which the program could be implemented. It is expected that the rate of implementation of the overall program will be much faster the second year than during the initial period of the Grant.

The approximate expenditures during Fiscal Year 1969 are itemized in Table 1 along with the anticipated expenditures during the remaining years.

### Professional Staff

It is planned that additional staff members will be employed and the number of full time equivalents of four will be on duty. Selections have been made and negotiations are in progress. The new members are anticipated for the Departments of Agricultural Economics and Agricultural and Irrigation Engineering.

### Graduate Students

Three new graduate students will begin training. The University has increased the amount of its stipends which will make the program much more attractive to graduate students with

Table 1. Expended and anticipated expenditures, Utah State University Institutional Grant.

Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	TOTALS
Salaries and Wages						
Professional Staff	15,000	75,000	100,000	90,000	90,000	370,000
Sub-Professional	1,500	8,500	8,000	8,000	9,000	35,000
Stipends	3,550	28,000	32,000	32,700	33,350	129,600
Tuition and Fees	825	5,900	6,500	7,675	8,250	29,150
Travel						
Foreign	168	20,000	24,900	22,932	17,000	85,000
Domestic	463	1,900	1,837	2,400	1,600	8,200
Equipment	--	6,500	2,000	--	--	8,500
Supplies and Computer Use	350	11,000	12,500	13,500	10,650	48,000
Library and Publications						
Acquisitions	4,000	7,750	4,000	2,000	1,000	18,750
Publications	--	2,600	4,200	5,000	6,000	17,800
TOTALS	25,856	167,150	195,937	184,207	176,850	750,000



dependents. Stipends of \$2400 per year were not sufficient to attract qualified married students.

Plans have been completed for two of the present graduate students to conduct their research in Latin American countries during the first six months of the coming fiscal year. Arrangements will be made for the others in the program to conduct their research in foreign countries. (We have found by experience it is not possible to get approvals for students to study in foreign countries as readily as desirable for the student's schedule. This is one reason for our rather low expenditures and implementation of the student portion of the program.)

#### Language

The intensive language course will be continued about at the same level of expenditure as during the first year. Arrangements have been made with the Language Department for the continuation of the service for staff and students. This portion of our program was very successful during the first year. It certainly helped to prepare students and staff for research and consulting in Latin America.

#### Library

The original plan was to greatly increase the library acquisitions during the first and second years. This the library is prepared to do and so plans as indicated in the detailed report

prepared for the Program Director. Professor Palmer of the Department of Agricultural and Irrigation Engineering will work closely with the library and research and teaching staff of the university in the selection of new library holdings. The report from the Library Director (Appendix C, Section IV), indicates the plans for the next year's program.

### Seminars

A "Water Resources Planning Seminar with Emphasis on Developing Countries" was planned for June 8-20, 1970. The principal participant, Dr. Wiener, was not able to meet the schedule so this has been postponed for one year. The program as advertised is:

The seminar is built around a forthcoming book by Dr. Wiener entitled, "The Role of Water in Development." Dr. Wiener, a widely sought consultant in the field of water resources, will present a series of lectures during the seminar. These will be interspersed with presentations by the other principals as indicated below, although not necessarily in the order shown. A complete curriculum will be furnished separately upon request.

- A. A. Bishop, Ph.D., "Water Planning and Management for Agricultural Systems"
- D. G. Chadwick, "Hydrologic Monitoring Systems -- an Aid to Water Planning and Management"



- C. G. Clyde, Ph.D., "Optimum Operation of Desalting Plants as a Supplemental Source of Firm Yield"
- D. R. Daines, "Formulation and Administration of Water Codes in Developing Countries"
- E. C. Olsen, III, and J. Keller, "Sprinkler Irrigation for New Agricultural Projects in Developing Countries"
- W. Palmer, "Planning of Small Projects and Small Farm Units" and "Economic Standards in Project Planning"
- D. F. Peterson, Jr., Ph.D., "Broad Goals of Water Resource Development"
- J. P. Riley, Ph.D., "Hybrid Computer Simulation of Water Resource Systems"

In addition to the above seminar, there will be several short seminars for local staff and graduates as was the case during the past year. They deal with such topics as "Research Methods," "Social Problems," etc., for those working in developing countries.