

**BIBLIOGRAPHIC DATA SHEET**

1. CONTROL NUMBER

PN-AAK-947

2. SUBJECT CLASSIFICATION (695)

AP10-0000-0000

3. TITLE AND SUBTITLE (240)

Water management research in arid and sub-humid lands of less developed countries; annual report

4. PERSONAL AUTHORS (100)

Skogerboe, Gaylord V.      Kemper, W. Doral

5. CORPORATE AUTHORS (101)

Colo. State Univ. Engineering Research Center

6. DOCUMENT DATE (110)

1976

7. NUMBER OF PAGES (120)

21 p.

8. ARC NUMBER (170)

9. REFERENCE ORGANIZATION (130)

COLO. STATE

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

13. PROJECT NUMBER (150)

9310489

14. CONTRACT NO. (140)

AID/ta-c-1100

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

## INSTRUCTIONS

1. **Control Number** - Each document shall carry a unique alphanumeric identification number. Use uppercase letters, Arabic numerals, and hyphens **only**, as in the following example: PN-AAA-123.
2. **Subject Classification** - Each document shall carry a valid subject classification code used to classify the research/technical document under a general primary subject, secondary subject, and/or geographic index code. Use uppercase letters, Arabic numerals, and hyphens **only**, as in the following example: AA23-0000-G518.
3. **Title and Subtitle** - The title should indicate the main title of the document and subordinate subtitle (if any).
4. **Personal Authors** - Enter the author's name(s) in the following sequence, **last name, first name (or initial), middle initial**.
5. **Corporate Authors** - Enter the corporate author(s) name.
6. **Document Date** - Enter the document publication year(s) as follows: 1979 or 1978 - 1979.
7. **Number of Pages** - Enter the total number of pages followed by 'p' for pages and a period, i.e. 123p.
8. **ARC Number** - Enter the AID Reference Center catalog number.
9. **Reference Organization** - The reference organization must be a valid reference organization. Enter the name, acronym, or abbreviation.
10. **Supplementary Notes** - Enter any useful information about the document that is not included elsewhere. Each note should be enclosed in parentheses.
11. **Abstract** - Include a factual summary of the most significant information contained in the document.
12. **Descriptors** - Select the proper authorized terms that identify the major concept of the research/technical document and are sufficiently specific to be used as index entries for cataloging.
13. **Project Number** - This is a unique number(s) composed of the AID project number followed by a sub-project suffix.
14. **Contract Number** - Enter the AID contract number under which the document was produced.
15. **Contract Type** - Enter the type of AID contract which funded the research/technical activity responsible for producing the document.
16. **Type of Document** - Enter a valid code representing the document type.

PN-AAK-947

9310989  
PN-AAK-947  
3/11/77

**WATER MANAGEMENT RESEARCH  
IN ARID AND SUB-HUMID LANDS  
OF LESS DEVELOPED COUNTRIES**

**ANNUAL REPORT**

**Colorado State University  
December 1976**

A. Annual Report Summary Sheet

Project Title: Water Management Research in Arid and Sub-Humid Lands  
of Less Developed Countries

Contract Number: AID/ta-c-1100

Principal Investigators: Gaylord V. Skogerboe and W. Doral Kemper

Contractor: Colorado State University

Contractor's Address: Water Management Research Project  
Engineering Research Center  
Colorado State University  
Fort Collins, Colorado 80523

Contract Period (as amended): April 1, 1974 to March 31, 1977

Reporting Period: November 1, 1975 to October 31, 1976

Total Expenditures <u>and</u> Obligations	567,019
Through Previous Contract Year:	April 1, 1975 to March 31, 1976
Total Expenditures <u>and</u> Obligations	588,918
for Current Contract Year:	April 1, 1976 to March 31, 1977

Narrative Summary

A review panel was established by AID/Washington for an "Assessment and Field Review of Water Management Research by Colorado State University." This field review took place during January and February of 1976 in Pakistan. Essentially, the review panel recommended continuation of this project and provided recommendations that will result in a sharpening of focus and objectives. This field review has been instrumental in dramatically increasing the morale of both the CSU Field Party in Pakistan and on-campus personnel.

Throughout the year in keeping with program objectives, special efforts have been made which have resulted in wide dissemination and utilization of research results. As credibility with the Government of Pakistan has been increased as a result of a wide range of project activities, interest in Pakistan from farmers to government officials has accelerated. The major results of project efforts described in more detail below are: 1) official approval by the GC<sup>7</sup> and USAID for a comprehensive On-Farm Water Management Pilot Project; 2) the training of a large number of host country personnel for research and development activities; 3) the institutionalization of water management research activities at research stations and with other organizations; 4) assistance to WAPDA master planning, the University of Agriculture, Lyallpur and other institutions in action oriented research and development activities; 5) increased focus on the role of women in farm water management improvement programs; 6) focus on the need to improve water laws and codes and the provision of incentives for farmers to organize for improving their farm irrigation systems; 7) increased linkages with international organizations active in Pakistan and elsewhere with a concern and focus for on-farm irrigation problems; and 8) utilization of project personnel for reconnaissance surveys to irrigated projects in other low income nations.

1

Annual Report  
WATER MANAGEMENT RESEARCH PROJECT

B. Background

1. General

Inadequate water is the primary constraint on agricultural production in a large portion of the developing countries. The technology for using available water supplies most efficiently is either lacking or not adapted to the available resources, in many of these countries.

Recognizing that these water management problems were common to many countries, it was apparent that solutions gained in one country should be, to some degree, transferable to others. Consequently, it was decided that a coordinated effort should be made to build up a fund of transferable water management technology. A consortium of universities was formed to develop this fund of water management information and gain experience in the factors limiting or accelerating its adaptation in new countries. CSU was initially assigned the Near East-South Asia, with Pakistan and Vietnam as the study areas in which on-farm water management principles and concepts would be developed and adapted to resources similar to those available in many other developing countries.

2. Pakistan

The irrigation system of Pakistan represents one of the largest modern conveyance systems in the world and is a marvel of engineering skill and technology. The hydraulic features, dams, barrages, canals, distributaries, structures, and appurtenances have been fully described in other publications. There is however a paucity of information and, indeed, a lack of understanding of that portion of the irrigation system with which the farmer deals. This refers to the system from the canal outlet (mogha) through the irrigated field. The farmer operates and manages this water with little or no governmental assistance. The procedures, rules, resources and constraints at his disposal determine his on-farm water management practices, which in turn determine the crop production per unit of irrigation water.

A modern irrigation conveyance system was constructed by the British in the late 1800's and it is one of the largest in the world. There are about 40,000 miles of canals which command a gross area of over 33 million acres of fertile soils. About 25 million acres actually receive surface water. The system is not only large with a vast potential but it is unique in several other aspects. One disappointing feature, however, is the present low production in light of the apparent highly suitable soil, water and climatic resources. These factors suggest a production potential many times greater than presently achieved. The "green" revolution increased production appreciably, but even this appears to be far below potential and in many respects this so-called revolution today is stalled.

Many experts agree that the farming practices, including irrigation water management, must be modernized in order to achieve higher production. There are important reasons for the low crop yields and lack of agricultural production, including insufficient water supply, lack of proper land leveling, lack of irrigation water control, lack of salinity control, lack of water management extension services, use of ancient cropping systems with ancient tools, or, in other words, there is a need for a much improved on-farm management system. The potential for increasing production through improved water management is great.

### C. Project Objectives

#### 1. General Objective for the Water Management Research Project

To increase food production in the arid and sub-humid lands of the less developed countries through the improvement of water management practices and the integration of these with other good management and cultural procedures with appropriate consideration given to increasing employment in the rural sector and utilizing local resources.

#### 2. Specific Objectives of the Water Management Research Project

1. Development of knowledge and data on how best to conserve and utilize water falling on the land as rain and the most efficient means of supplementing needed soil moisture by limited amounts of irrigation water.
2. Development of knowledge and data that can be used for the economic design and construction of water conveyance and delivery systems including structures for control and measurement of irrigation water, especially on the farm.
3. Development of surface and subsurface water removal systems to minimize the hazards resulting from surface flooding, high water tables and salt in the groundwater.
4. Identification of important factors to be considered in land preparation and leveling of the various irrigated soils in the major climatic zones and the relationship of these factors to water management, erosion, water infiltration, and good land use and cropping practices.
5. Development and adaption of methods of water application, including time and amounts, which are suitable and efficient for different soils of varying physical properties (water-holding capacities, intake rates, etc.) with major crops.
6. Integration of these water use factors into a productive cropping system consistent with farm size and available farming practices.
7. Where water quality, soil salinity and exchangeable sodium are problems, means will be developed for increasing crop production by using amendments and management practices which

will improve water and soil properties and by using salt-tolerant crops.

8. The identification of institutional and policy factors (legal, social, economic, religious, manpower, credit, education, etc.) which influence efficient distribution and management of water on the farm level.

#### D. Continued Relevance of the Objectives

Our research findings, surveys in Pakistan, and consultation with experienced water management personnel from USAID, FAO, the World Bank and several developing countries indicate that accomplishment of the original objectives will benefit the developing countries and contribute substantially to the fund of transferable water management technology. Survey of the resource positions of farmers in Pakistan and several other developing countries show that the average farmer is unable to make a large capital investment in technology. Consequently, variants of our water management technology package should be developed which will be labor intensive and within the means of the small farmers. This will not necessitate change in our overall objectives, but will require our continuing attention to ensure that the technology which we help produce can be used to increase productive work opportunities, as well as produce more food.

The first field review of the CSU Water Management Research Project was conducted in Pakistan during January and February of 1976. The conclusions and recommendations from this field review are cited at the beginning of the next section. This field review will lend to a sharpening of the research focus, both in the field and on campus.

#### E. Accomplishments During the Reporting Year (Nov. 1, 1975 to Oct. 31, 1976)

##### 1. General

A review panel was established by AID/Washington for an "Assessment and Field Review of Water Management Research by Colorado State University." The review panel consisting of Howard Haise, Team Leader, John Phelan, and Douglas Caton conducted an assignment of research content and design, progress from inception to date and prospective results of the CSU Water Management Research Project in Pakistan together with the supporting research being conducted on the CSU campus. Dr. Haise is a senior Agricultural Engineer-Agronomist formerly with the Agricultural Research Service, USDA; Mr. Phelan is a senior Agricultural Engineer, formerly Director of Engineering of the Soil Conservation Service, USDA; and Dr. Caton is Senior Agricultural Economist, AID, Washington, D.C.

The panel assembled in Islamabad, Pakistan, Tuesday, January 27, 1976 and continued its review and report preparation through February 13, 1976, ending with a discussion of findings and reporting procedure with USAID Pakistan staff, CSU team members and Dr. D. L. Plucknett, Chief, Soil and Water Management Division, TA/AGR; and Mr. Charles Antholt, Asia/TD/DR, on February 12. The panel assessed program progress and relevance by reviewing the annual reports, the present work plan, project agreements, the status of the field projects, utilization of research results, and reactions from the Mission and host country officials.

The following conclusions were reached by the review panel:

1. The CSU research has been a process of evolution leading to an experimental pilot watercourse program:
  - a. The work has now evolved to the point where it can begin to document costs and benefits, and indicate payoffs.
  - b. The project has also reached the point where it can begin to help evolve a Pakistani institution(s) to take over the research and extension responsibility.
2. To gain these benefits, the CSU program should be continued, with the research feeding more and more into development:
  - a. To have research at this stage of identifying problems and ranking research priorities it has been necessary to build an experimental pilot watercourse and management program.
  - b. This process has also been necessary to be able to establish criteria to infuse and involve Pakistani institutions in this process.
3. For a number of sufficient reasons, the learning process has favorably affected the CSU personnel on the program, and more favorably affected on-campus attitudes and participation:
  - a. The relevancy of what happens on the campus has increased as more people gained field experiences, on TDY, or through returnees to Fort Collins.
  - b. Campus support activity is becoming less a residual and more an integral of a total program.
  - c. CSU is learning that some things, modelling and data analysis, can better be done on campus because of field time constraints and facilities.
4. As the GOP-USAID demonstration pilot program on water management of command areas develops they are going to want to have someone supply these inputs, for which CSU is the most qualified resource.
  - a. Unless the GOP has an organization which has the training and the water management knowledge and can also reach the farmer with a broad water management, precision land leveling, and cropping system program the loan effort may fail.
  - b. The experimental pilot watercourse from Tubewell 56 will be a valuable data resource. CSU can also help by their knowledge of the jobs that need to be done, and how the people in the jobs should be organized (and trained) and related to farmers' water management problems.

- c. Unless trained people are made available, and the total water management effort is institutionalized in Pakistan the long term potential food output and water savings benefits may not be realized.
  - d. Saving 1 percent of the water for use in the root zone is equivalent to increasing water supplies at the barrage by 1 million acre feet.
5. The CSU research will be important to developing a better regional food system, and a national system from the pilot project results.
- a. This possibility will depend upon how well a way is found to feed the results into the loan program demonstration pilot project and to farmers.
  - b. It will also depend upon how well and how soon a follow up program is developed to diffuse the demonstrations regionally and nationally.
  - c. The extension follow up will need organization, specialists, incentives, credit, and so forth.

Based upon this review, the panel recommended continuation of the CSU program in Pakistan on the following components:

1. Techniques to reduce losses from watercourses
  - a. Schedule to develop recommendations by March, 1977.
  - b. To continue monitoring and evaluating watercourse rehabilitation in the USAID Loan Pilot Project.
  - c. Recommend alternative uses of underground pipeline distribution systems.
2. Experimental Pilot Watercourse Program at Tubewell 56
  - a. Covers water management, precision land leveling practices, cropping practices, and irrigation advisory service (scheduling).
  - b. To June, 1980.
3. Farmer maintenance and monitoring of precision land leveling
  - a. To cover farmer utilization of land leveling by following farmer practices and maintenance.
  - b. To June 30, 1980.

4. Land Shaping, Cultural and Agronomic Practices

- a. To cover cultural practices such as bedding, furrow, irrigation, cropping techniques, and fertilization to improve stands and yields.
- b. An opportunity exists to tie in with the IRRI farm Machinery program to be located in Pakistan headed by Amir Khan.
- c. To June 30, 1980.

5. Demonstration Pilot Watercourse Loan Program

- a. Could be involved as part of evolution, institution building and forward planning (not the place to discuss details but must spell out in definite terms what can be expected from technical specialists employed).
- b. 2 man/years 1976 forward (indefinite).

6. Skimming Well Program

- a. Acceptable data is now being collected to complete modeling program at CSU.
- b. Planned second phase of program is to be by-passed with direct application of findings to wells that have failed in the Mona area.
- c. Training of individuals to analyze well salinity profiles and to recommend the modifications of old wells and design of new wells necessary to produce water of satisfactory quality.
- d. To June 1977.

7. Physical and Socio-Economic Survey of Watercourses

- a. This mission project has taken roughly 2 man/years of professional TA/AGR time, plus secretary time, and the time of 2 assistants
- b. To April 30, 1977.

8. Watercourse Maintenance

- a. How to demonstrate to farmers how to organize themselves and maintain watercourses.
- b. Should be integrated into the water management loan program.
- c. To June 30, 1980.

## 9. Training and Institution Building

- a. CSU can provide information, train water management specialists to help organize farmers to assist themselves.
- b. It would be reasonable to expect those trained and experienced on country problems to be called upon.
- c. CSU has developed the start of an experimental pilot water management program. Their research will show how to work it, and how to get the results out to farmers.
- d. To June 1980 (include on-campus report writing, TDY backstopping, and graduate assistantships at CSU, etc.).

## 10. One Year On-Campus Publication and Project Coordination Assistance

- a. Returnees should be relieved of on-campus responsibilities for at least one year to prepare necessary technical and training documents to gain full benefit of the field work.
- b. These documents and training tools are needed now in Pakistan and elsewhere in the arid and sub-humid areas of the LDC's.
- c. Some of this time could well be spent on data coordination with Utah and Arizona.
- d. To be paid for from project funds to June 30, 1980.

## 2. Pakistan

Among the most significant accomplishments during this report year are: (1) continuation of field studies with WAPDA at the Mona Reclamation Experimental Project (MREP); (2) participation with the USAID Mission to Pakistan in completing the loan paper for the On-Farm Water Management Pilot Project; (3) continuation of watercourse surveys, including physical and socio-economic aspects; (4) initiation of cooperative efforts with the Department of Agriculture in the three provinces of Punjab, Sind and North West Frontier in order to implement the On-Farm Water Management Pilot Project; (5) development of proposal for field studies in cooperation with the University of Agriculture, Lyallpur (UAL) regarding alternatives for organizing farmers in order to improve on-farm water management; and (6) development of training materials, initial training of trainers, and training watercourse engineers. Significant progress has been made towards problem

identification, development and demonstration of technological alternatives, and identifying processes for implementing such technological solutions.

The following five personnel have served during this entire report period: Dr. W. Doral Kemper (Agricultural Engineering and Agronomy), who has served as the Chief-of-Party; Dr. Alan C. Early (Agricultural Engineering), Dr. John O. Reuss (Agronomy), Dr. Sam H. Johnson III (Economics), and Dr. Sidney A. Bowers (Agronomy). Dr. C.J. deMooy (Agronomy) was a member of the CSU Field Party until mid-February, 1976 when he returned to campus. Two Ph.D. students were located in Pakistan during this report year; namely, Mr. Larry Nelson (Agronomy) in June, 1976 and Mr. Tom Trout (Agricultural Engineering) in September, 1976. At the end of the report year, the CSU Field Party consisted of seven personnel.

Besides the research programs with WAPDA and the provincial departments of agriculture, the CSU Field Party is working with the major agricultural research centers in Pakistan on significant research pertaining to wheat, rice, cotton and corn. Besides other Government of Pakistan institutions, the CSU Field Party has joint efforts with the University of Agriculture at Lyallpur and Quaid-i-Azam University (formerly the University of Islamabad).

Developing the Loan Paper. In 1975 Eckert, Dimick and Clyma analyzed the benefits and costs of various types of watercourse improvement in a report based on CSU watercourse improvement studies. This was one of the primary documents justifying a watercourse improvement component in the proposed loan program between U.S.AID and the Government of Pakistan to be titled "On-Farm Water Management Pilot Project." The official title used by each of the three provinces (Punjab, Sind and North West Frontier) is "On-Farm Water Management Development Project." A report titled "Helping farmers identify and achieve their potential for watercourse improvement" by the CSU and Mona Reclamation Experimental Project (MREP) staff outlined the first full scale pilot watercourse improvement program, which demonstrated farmer acceptance of and participation in the type of earthen improvements proposed, and showed a 50 percent increase in supplies of water to the farmers' fields. The preliminary reports of the Lowdermilk-Early surveys indicated that watercourse losses of 50 percent, found earlier in the Northern and Central Punjab by Clyma, were common throughout the rest of the Indus basin.

The services of Eckert and Lowdermilk were requested, on TDY's, to help write the economic, sociologic, training and extension components of the proposal. Field Party members drafted most of the section dealing with the procedures to be followed in motivating farmers to participate in watercourse improvement programs and the section on how to achieve the improvements.

As the pilot watercourse improvement program was further tested, a steady stream of at least 1000 visitors from the provincial and federal government, USAID, FAO, the World Bank and several other countries have visited the projects, talked to the farmers and seen the improvements. These visitors included the General Manager of Master Planning, WAPDA, the Special Assistant to the Prime Minister for Agriculture and representatives from the Sind, Punjab and NWF provinces and the Federal Government involved in planning. This on-site inspection has been reported as a major factor helping bring about the acceptance of the water management program by these various components of the Government of Pakistan.

Training of Watercourse Improvement Trainers. The SCS, CSU, MREP and the Governments of the respective provinces decided jointly that the experience gained in these pilot watercourse improvement projects should be transmitted to the persons in the Sind, Punjab and North West Frontier Provinces (NWFP) who would be training personnel to help farmers carry out essentially this type of program in the loan financed development projects in their own provinces.

Mr. Mushtaq Gill and Sadiq Shafiq who had also completed a successful watercourse improvement project under the Integrated Rural Development Program (IRDP) water management improvement project near Lahore were requested to help in this training activity. The Mona personnel plus Mr. Shafiq and Mr. Mushtaq met with CSU advisers to plan the training and make assignments. Mona staff were asked to draft sections for this training as follows:

- (a) How to measure water supply - M. Akram
- (b) Effect of high water in watercourse supply - M. Iqbal
- (c) How to measure water losses in watercourses and fields - M. Afzal and M. Yasin
- (d) Agreements with farmers at the time of selecting the watercourse (before the work starts) - M. Azeem

- (e) Topographic survey and mapping - M. Azeem
- (f) Alignment of watercourse - M. Akram and M. Azeem
- (g) Watercourse design - M. Iqbal
- (h) Aids for watercourse design - CSU team
- (i) Watercourse construction - M. Akram and M. Azeem
- (j) Evaluation following improvement - M. Yasin
- (k) Cleaning and maintenance of watercourses - Javaied Iqbal and M. Afzal
- (l) Irrigation advisory service - S. M. Saeed
- (m) Pakka structures for improved watercourses, their design, construction and use - M. Akram, W. D. Kemper, Iqbal Hussain, W. E. Hart, Bashir Ahmad, S. A. Bowers, J. Iqbal, Moh'd Azeem
- (n) Motivating farmers - Mohsin Wahla, S. A. Bowers and W. D. Kemper

These drafts were extensively "reviewed" by the CSU advisers, but the first drafts were prepared largely by our Pakistani cooperators as part of their "training for report writing."

The SCS team helped the governments of the respective provinces select their men to come to a watercourse improvement training session which was held from Sept. 1 to Sept. 21, 1976. The trainees from the different provinces included: North West Frontier Province - Javed Mirza, Abdul Hamid Shah, and Mohammad Yousaf; Sind Province - Khan Ashraf Saeed, S. Irfan Ahmed Naqvi, Agha Umer Daraz, and Azfar Hussain; Punjab Province - Riaz Ahmed, Gulzar Muhammed Choudhry, Rab Nawaz and M. Hanif.

The SCS advisers for each province each came to the sessions for one week and also contributed in many ways to the training.

Intense rain during the first four days prevented field activity and sessions were primarily lectures by the respective authors on the subjects of the training materials after these written materials were handed out. These sessions and the response were not completely satisfactory. An evaluation by the SCS, Mona and CSU staffs indicated that some of the problems were:

- (1) The young Mona engineers had essentially no teaching experience, gave brief discussions of the subjects, and assumed the trainees would read the written materials and ask questions.
- (2) The trainees expected more extensive and sophisticated lectures and most of them did not understand that it was their responsibility to read and understand the written materials and ask questions.

- (3) The CSU advisers had some emergencies, were able to attend only part of the time and during their absence, the discussions were not properly "catalyzed."

Consequently,

- (1) The trainees were informed that they would be given a test on the written materials and should take the opportunity of asking questions of the various "trainers" on anything they didn't agree with or didn't completely understand.
- (2) The trainers were asked to encourage more questions and expand their presentations in more detail.
- (3) The schedule was made flexible so the activities could go to the field whenever it was not raining and a new watercourse, reachable by paved road near the project headquarters, was chosen for improvement as the core of the field training.
- (4) Arrangements were made for CSU personnel to be there all the time and SCS personnel were invited to play a more active part in making comments, suggestions and generating discussion.

The rains diminished, the trainees were taken to the field where they participated in the measurements and surveys prerequisite to design, they helped design the new watercourse and participated in sessions with farmers where the farmers requests and the design criteria were mutually adjusted to provide a satisfactory design.

The report on the improvement of the watercourse at Tubewell 56R gives more of the details of the improvement.

Three of the trainees were fasting during the daylight hours in observance of Ramazan and the weather was hot and humid which curtailed the field activities somewhat. However, the trainees developed more interest as the training progressed (and the examination approached) and worked with Mr. Akram, Mr. Iqbal, and Mr. Azeem of the Mona staff until after midnight in informal sessions to learn more of the details of design.

Mr. Sadiq Shafiq and Mr. Mushtaq Gill, who had taken a year of training at Colorado State University during the previous year and had conducted a watercourse improvement program at Shadab as part of the studies leading to their M.Sc. theses, also participated in these sessions (including the late evening sessions). They played a major role in training and in checking the design aspects.

Before the trainees left they were asked to give their suggestions for improvement of the training and these centered primarily on improving the housing facilities. If training is to become a regular part of the Mona program additional housing for the trainees is definitely needed.

The SCS will now work with these watercourse trainers to develop the training needed in the provinces. They will use the material written up by the Mona Engineers, SCS experience and guidelines, the findings of

Mr. Shafiq and Mr. Mushtaq, and continuing information from the Mona research studies to develop the written guidelines for the watercourse improvement engineers. CSU will assist as requested.

Training Water Management Advisors. Saving water in watercourses is not productive unless the water is used effectively to increase crop production. CSU has been asked to work with the University of Agriculture at Lyallpur in developing a training program which will prepare one Water Management Advisor for each water management development team under the On-Farm Water Management Pilot Project. His responsibility will be to help farmers improve their production through better management of his expanded water supply, leveled land and other essential inputs (seed, fertilizer and weed and pest control). Dr. Early, Dr. Lowdermilk and Dr. Johnson developed an outline for this training which has served as the basis for a training agreement between the Punjab Government and the University of Agriculture at Lyallpur.

Hopefully, the Sind and NWF Provincial governments will develop similar agreements with the University of Agriculture at Lyallpur. CSU will help develop training materials that can be used by all three provinces, and will assist to the extent of available personnel and as requested by the respective provincial governments.

In the Punjab, a cooperative research and training program between the Department of Agriculture Water Management Development Project and the University of Agriculture at Lyallpur will be encouraged which will include: (1) improvement of several watercourses in the Lyallpur area as part of the development program, but with some innovations as deemed advisable for research purposes and with university faculty cooperating in the improvement; (2) careful evaluation of the costs and benefits of these improvement programs and the use made of the increased water supply; and (3) the development of sufficient credibility with farmers on these watercourses that they will become cooperators, willing to test the new and improved methods of water management and crop production suggested by the research-cum trainers and their trainees.

Water Users Association studies. The first pilot watercourse improvement project was carefully selected on the basis of leadership and organization being inherent in the farmers group which would allow them to complete the improvement successfully. However, studies by Mirza and Freeman and by Lowdermilk indicate that water users on most watercourses are divided by long standing disputes, caste differences, and other factors, to the extent that the degree of cooperation and organization is a primary factor limiting watercourse cleaning, maintenance and improvement projects. Radosevich has studied and outlined the types of water user organizations effective in managing water in the primary irrigated areas of the world and has suggested organization guidelines, rules and policies which appear to be adapted to Pakistan's physical and cultural characteristics. It is probable that implementation of some of these guidelines, rules and policies may provide the foundations of cooperative organizations, which have had a profitable experience in watercourse improvement and maintenance, and will have sufficient credibility and prestige to help the farmers cooperate in ownership of equipment, tractors, tubewells and other

activities, thereby allowing these farmers with small acreages to participate in the new technologies previously available only to those with larger holdings.

At the request of USAID/Islamabad, Colorado State University agreed to develop a research project to test and identify the organizations that might help farmers more efficiently use their water. Dr. Sam Johnson was put in charge of coordinating this project and Dr. Dave Freeman was invited to come to Pakistan for six weeks to organize the study.

Dave Freeman, working with Ashfaq Mirza and Ali Moh'd Chaudhry at the University of Agriculture, Lyallpur (UAL), developed a concrete project proposal and also prepared the survey instruments and statistical measuring techniques. In order to reduce the red tape, it was suggested that this study be submitted directly to the Agricultural Research Council (ARC) in the central (federal) Government of Pakistan and they in turn subcontract with UAL for the study. A meeting was also held with Chaudhry Sultan Ali, Special Assistant in Agriculture to the Prime Minister, in which an agreement in substance was reached for the ARC to support the project.

The proposal has now passed through the University review process and the ARC review process. However, the deputy director at ARC felt the project needed provincial clearance and diverted it to the Agricultural Research Review Committee for approval. Dr. Naseem, the Secretary of Agriculture, Punjab, felt that the study was quite relevant to the work of the new Department of Agriculture Water Management Cell and decided to integrate this study with the Water Management Cell.

This process will delay this project but it should be funded during early 1977 and be ready to go by April. It is planned that Drs. Radosevich, Lowdermilk and Freeman will come to Pakistan on TDY assignments to advise Mr. Ashfaq Mirza (faculty member at UAL, who received two years training at CSU under the Water Management Research Project) on this study.

Farmer involvement in improving watercourses. One of the most exciting developments in Pakistan is the cooperative efforts undertaken by farmers to improve their own watercourses. The first example of this cooperative effort is very well told by Mr. Khan Mohamad Chandawana, one of the participating farmers, in the Sept., 1976 issue of "War on Hunger" (the cover photo shows a Pakistani engineer measuring irrigation water with a Cutthroat flume, which was developed by CSU). This story is very descriptive in illustrating the process for obtaining farmer cooperation.

About half of the water supplied to farm watercourses in Pakistan is lost before it reaches the fields. This loss was found to be primarily through the upper porous portions of the banks and in the vicinity of junctions where banks are thin. Concrete and brick linings and steel slide gate control structures reduced the loss to as low as 10 percent, but are too expensive for general use. Earthen improvements such as making new compacted banks and compacting cores in old banks were found to reduce water losses to less than 25 percent of their value in old watercourses.

Farmers were motivated to organize themselves to build their own earthen improved watercourse (28,000 ft.) according to design specifications drawn up by young Pakistani engineers. Low cost concrete diversion structures were developed and installed at junctions to eliminate continued borrowing of soil. The improvements reduced losses to about one-half their previous values and provided the farmers with about 1 cusec of extra water. The cost was about Rs. 2/foot of watercourse improved, including farmers' labor.

The benefits to be gained within the first year equal the cost. Maintaining the benefits will require the investment of about 10 man-hours of labor per acre-foot of water saved. This is some of the least expensive water available in Pakistan. This type of improvement appears to be an ideal component for a development program which will increase crop production in other countries where rural labor has a low value during certain seasons. However, farmers require further information on how to use this water and other inputs to optimize crop production if they are to obtain full benefits from this extra water.

In another case, farmers were willing to support a labor intensive watercourse improvement program during the month of Ramazan. The laborers ate and drank during the working day, apparently on the assumption that the inherent virtue of the improvement project justified breaking their fast. The farmers' primary reason for wanting the improvement program was to provide a masonry section through the village where the occasional losses were an obvious nuisance and the intensity of auxiliary use (for washing clothes, washing vegetables, bathing, animal watering, etc.) was extremely high. The farmers realized the high cost of building such a masonry section and were willing to pay the complete costs of their control structures and provide all the labor for the earthen improvements as "part of the bargain" to obtain the masonry section through their village. When the government is paying for the check structures, farmers demand many more than are essential, which results in conflicts with the engineers. On this project, where farmers were paying for their own, they were very reasonable and worked in close cooperation with the engineers to reduce the number of check structures to a minimum. The manufacturer of the concrete control structures was willing to decrease his price by about 25 percent to farmers who paid an advance and completed payment on delivery; as compared to his price to government agencies where payment often requires months and extensive paper work. Involvement of project personnel in socio-legal decision-making and disputes between farmers can be minimized by clearly defining their role as technical advisors and supporting the water users Executive Committee as the decision-making body in these matters.

#### F. Dissemination and Utilization of Research Results

Throughout the year in keeping with program objectives, special efforts have been made which have resulted in wide dissemination and utilization of research results. As credibility with the Government of Pakistan has been increased as a result of a wide range of project activities, interest in Pakistan from farmers to government officials has accelerated. The major results of project efforts described in more detail below are: 1) official approval by the GOP and USAID for a

comprehensive On-Farm Water Management Pilot Project; 2) the training of a large number of host country personnel for research and development activities; 3) the institutionalization of water management research activities at research stations and with other organizations; 4) assistance to WAPDA master planning, the University of Agriculture, Lyallpur and other institutions in action oriented research and development activities; 5) increased focus on the role of women in farm water management improvement programs; 6) focus on the need to improve water laws and codes and the provision of incentives for farmers to organize for improving their farm irrigation systems; 7) increased linkages with international organizations active in Pakistan and elsewhere with a concern and focus for on-farm irrigation problems; and 8) utilization of project personnel for reconnaissance surveys to irrigated projects in other low income nations.

In May of 1976, USAID Washington approved an AID Mission to Pakistan proposal for a loan of over \$10 million to help Pakistan launch a comprehensive On-Farm Water Management Pilot Project. This five year project will cover 1500 watercourse command areas totaling about 600,000 acres of land and involving about 60,000 farmers. The major components of this Pilot Project (costing an estimated \$40 million) include watercourse rehabilitation, precision land leveling, and water management advisory services. The research data of the CSU program, and the particular vehicles by which these were transferred to farmer and official audiences, have convinced both the GOP and the USAID Mission that such a pilot project is both needed and feasible.

Early in 1975 Eckert, Dimick and Clyma conducted a cost-benefit analysis of various alternatives for watercourse improvements to show the economic feasibility of the project. CSU and Mona Reclamation Experimental Project staff, using both applied and adaptive research methods, demonstrated the technical as well as the social and economic feasibility of the program by improving watercourses with farmers. In the summer of 1975, Early and Lowdermilk began a problem identification watercourse survey in the Punjab to document the magnitude of watercourse losses and farmers constraints. These studies, which finally covered 40 farm irrigation systems from the northern Punjab to the southern Sind, also provided data along with other CSU research for the design of the Pilot Project. Eckert and Lowdermilk provided two man-months in providing assistance to the USAID Mission in writing the economic analysis, social soundness analysis, extension, and training components of the proposal. All CSU Field Party members participated in certain phases of technical aspects of program design. The CSU field team and campus staff have been requested to conduct further watercourse improvements to refine technologies and procedures and further document costs and benefits which will provide input into the five year Pilot Project. Also, CSU will be involved in the training of personnel, and the research and evaluation of various phases of the program.

The undergirding philosophy of the CSU Water Management Research Project from its inception has been the clear objective of building up host country capabilities in the water management related fields. All research and other program activities involve host country personnel--ranging from extension workers, engineers, agronomists, social scientists,

as well as officials in applied field training. The problem identification surveys in the Punjab and Sind Provinces alone resulted in field training of a group of about 30 individuals from disciplines including agronomy, economics, extension, and engineering. This state of the art study was done in cooperation with the WAPDA master planning group and all trained personnel have been employed by WAFDA for an intensive survey of 60 command areas which will require about \$10 million (UNDP and World Bank funding) and two years for completion.

CSU, in cooperation with the SCS team in Pakistan and the newly formed Water Management Cells in the Department of Agriculture of the Sind, Punjab, and NWFP provinces, have conducted a special training program for the trainers of engineers who will participate in the On-Farm Water Management Pilot Project. A training manual was designed for this field training and thus far 11 individuals have received training, who in turn will train the engineers required for the Pilot Project. These trainers were also carefully evaluated to ascertain if they had acquired the skills taught under actual farm conditions.

Another method of dissemination of research results was the special training program conducted by Dr. Bowers for agricultural research station personnel concerning the design and methodologies of conducting consumptive use studies.

Formal graduate training at the CSU campus was provided for Mr. Sadiq Shafiq, Mr. Nur Din, Mr. Mushtaq Gill, Mr. Ghulam Hussain, and Mr. Khalid Gill. An important innovation in this formal training is the requirement that after successful completion of course work, the candidate for a degree will return to Pakistan and conduct his thesis research on a relevant problem area in his respective field. The field research, data analysis, writing of the thesis, and final examination are all completed in-country under the guidance of CSU staff who compose the Field Party team.

Mr. Shafiq has successfully completed his M.Sc. in agricultural engineering and is presently active in training programs. Mr. Mushtaq Gill is near completion of his masters thesis also in agricultural engineering. The research of both these gentlemen was conducted on actual watercourse commands and result in findings which will advance technical and organizational procedures for water management improvement activities of farmers. Mr. Nur Din, who is a senior official of the Land and Water Reclamation Laboratory in Lahore has completed his M.Sc. in agronomy and course work for a Ph.D. Both Mr. Ghulam Hussain and Mr. Khalid Gill have completed course work at the Ph.D. level in agronomy and respectively will return to important research positions at the WAPDA-Mona Reclamation Experimental Project (MREP) and at the Punjab Agricultural Research Institute. They will complete the requirements for the Ph.D. degrees in soils at their respective institutes under CSU staff guidance.

Realizing the world-wide demand for expertise in on-farm irrigation related fields, the project has provided an opportunity for two state-side graduates to conduct field research in Pakistan. Mr. Tom Trout is a Ph.D. candidate in agricultural engineering and his research will result in a comprehensive technical design manual for improvement of farm

water conveyance systems. Mr. Larry Nelson is conducting his research at the Mona Station related to the problem of kharif season (summer) high soil temperatures and the germination and emergence of maize and cotton. Both candidates received much orientation at CSU prior to their research tour in Pakistan. They are expected to complete their work in 1978.

While not directly related to or sponsored by the CSU project, Field Party members have helped arrange research sites and provided guidance for two social anthropologists from The University of Pennsylvania and one economist from the University of Wisconsin. These three Ph.D. candidates are conducting their research on subjects relevant to Pakistan's irrigation problems.

Another training program which has evolved in relationship to both the Pilot Project and the concern of provincial agricultural departments is that for farm level extension personnel. It has been realized that saving water through reducing conveyance losses is only half the job; the farmer must also receive help to utilize his water more effectively for increased crop production possibilities. Lowdermilk, Early, and Johnson developed a proposal documenting training needs and outlining the methodologies and types of practical training required. The Punjab Agriculture Department and the University of Agriculture at Lyallpur have developed a cooperative agreement for this training program which will begin in early 1977. CSU staff will assist in developing training materials based on research and experience in Pakistan and will help establish the program and assist their trainers. Evaluative research methods will be used to improve both materials and training methodologies and to ascertain the success of the program. Finally, the Agricultural University at Lyallpur in cooperation with the Punjab Department of Agriculture is planning to conduct a research-development program including research comprehensive improvements on several watercourses. This effort if successful will move the university more into the application of knowledge to real farm problems.

All these training efforts have evolved with time from the objective to build-up host country capabilities and the philosophy that training, whether formal or informal, must focus on the acquisition of skills to solve real world problems at the farm level.

In the past year, the staff of the CSU Water Management Research Project has been in considerable demand by several international organizations and universities in various aspects of research and development problems. It has been and is our stated policy to provide assistance and develop improved linkages with these agencies and organizations to share research findings, experience, and expertise. The major formal contacts, linkages, and activities have been the following:

1. The CSU Field Party is almost continuously involved with meetings and presentations with not only Pakistani organizations, but also many international organizations such as the World Bank, FAO, UNDP, Ford Foundation, etc.
2. Jerry Eckert and Max K. Lowdermilk participated with the USAID Mission in Pakistan in developing the proposal for the Water Management Improvement Project in January and February.

3. David Freeman and Max K. Lowdermilk presented a paper on "Farmer Organization for Improvement of Irrigation Systems" at the annual meeting of the Asian Society in Toronto, Canada, in March of 1976.
4. In April, Wayne Clyma of the CSU Field Party and Willard Schmehl from campus participated in a review of on-farm irrigation problems at the invitation of the USAID Mission in Egypt and the Government of Egypt.
5. Max K. Lowdermilk was requested to assist the World Bank, Harza Engineers International and WAPDA in a design of a comprehensive watercourse survey, the evaluation of planning efforts, and the training of field workers.
6. Alan Early, Max Lowdermilk and David Freeman were invited to present a paper and participate in a workshop on Irrigation Systems with colleagues from other universities, sponsored by Cornell University in July of 1976.
7. George Radosevich, Max Lowdermilk, David Freeman, Jerry Eckert and Alan Early consulted with Utah State University in an exchange of research approaches and experiences in overseas research and development in July.
8. George Radosevich participated during August in the East-West Center Workshop on "Implementing Public Irrigation Projects."

#### G. Work Plan for the Coming Year

The present AID Contract (AID/ta-c-1100) terminates March 31, 1977. A work plan will be developed for the first year (April 1, 1977 to March 31, 1978) of the new contract during February, 1977 in Pakistan by the principal investigators, the CSU Field Party, Dr. Gilbert Corey, AID/TAB/AGR/SWM, who will be the AID Project Manager, and personnel of the AID Mission to Pakistan. Therefore, the work plan will be prepared as a separate document (copies will be available upon request).

#### H. Involvement of Minority Personnel and Women

A project was developed jointly with CSU and USAID to determine the effective role of rural women in deciding priorities in investment, especially for agricultural and water improvement projects. Dr. Sam Johnson is in charge of coordinating this project with Ms. Emily Datta, a graduate student from the University of California, Berkeley to do the actual field work. This project is to be funded by USAID/Islamabad with the end result to be a report to USAID describing the role of rural women in decision making and recommending steps to be taken to better reach this segment of the population. This project will start gathering data in the villages in the Mona and Lyallpur areas.

#### I. Notice of Research Project: Smithsonian Information Exchange

Since the current AID Contract terminates March 31, 1977, and because a work plan for the first year of a new contract will be prepared in Pakistan during February 1977, a Notice of Research Project will be completed and forwarded to AID/Washington when the new contract is initiated.

COLORADO STATE UNIVERSITY WATER MANAGEMENT RESEARCH CONTRACT

BUDGET SCHEDULE

Contract No. AID/ta-c-1100

	<u>Actual &amp; Estimated Expenses</u> 4-1-74 to 3-31-75	<u>Actual &amp; Estimated Expenses</u> 4-1-75 to 3-31-76	<u>Actual &amp; Estimated Expenses</u> 4-1-76 to 12-31-76	<u>Estimated Expenditures*</u> 1-1-77 to 3-31-77	<u>Total Estimated Expenditures*</u> 4-1-76 to 3-31-77	<u>Total Budget</u> 4-1-74 to 3-31-77
Salaries & Wages	\$267,255	\$286,767	\$219,428	\$ 80,622	\$300,050	\$ 854,072
Consultants	12,888	-0-	-0-	-0-	-0-	12,888
PERA	24,413	28,121	19,402	9,436	28,838	1,372
Overhead	124,432	137,772	94,577	33,760	128,337	390,541
Travel & Transportation	35,870	21,926	13,477	5,103	18,580	76,376
Allowances	38,851	43,188	30,315	4,897	35,212	117,251
Other Direct Costs	23,968	37,400	24,620	3,880	28,500	89,868
Equipment	19,575	-0-	4,578	265	4,843	24,418
Research Operations	<u>18,460</u>	<u>11,845</u>	<u>29,449</u>	<u>15,109</u>	<u>44,558</u>	<u>74,863</u>
TOTAL	\$565,712	\$567,019	\$435,846	\$153,072	\$588,918	\$1,721,649

\*Includes funds currently obligated for this period (\$542,981) + additional request of \$45,937.