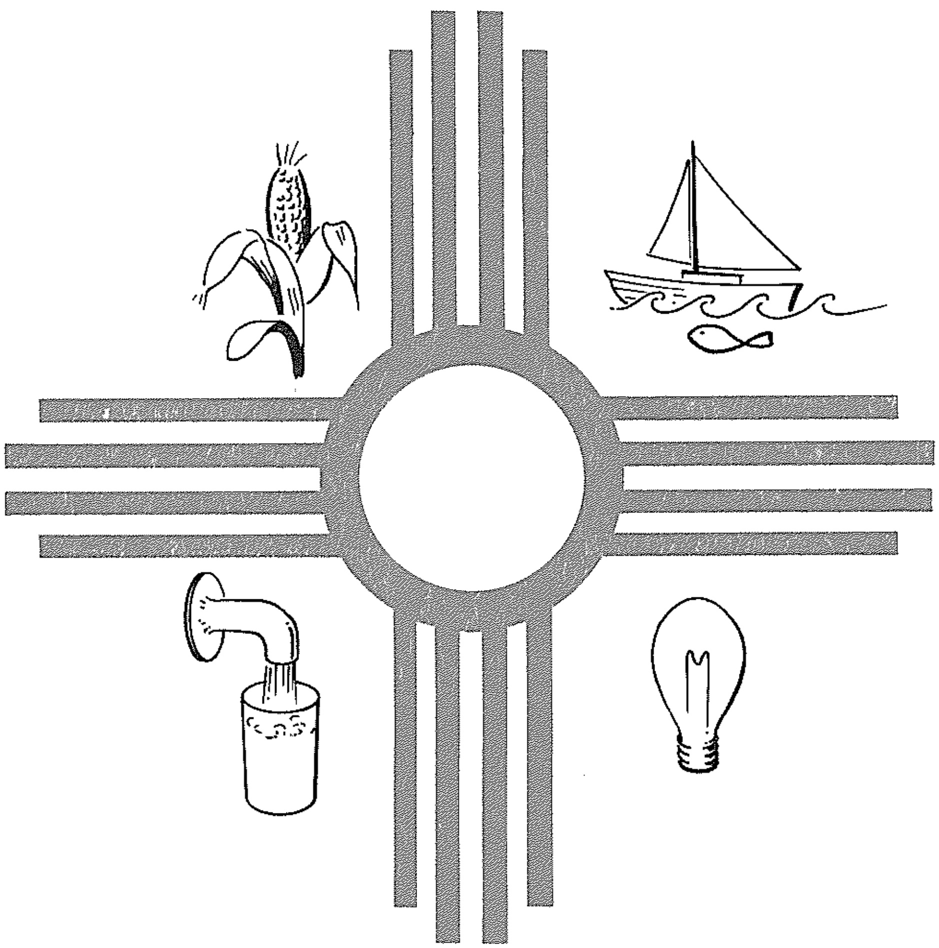
August 1980 WRRI Report No. 124

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL NEW MEXICO WATER CONFERENCE

A Quarter Century of Water Research

April 24-25, 1980



New Mexico Water Resources Research Institute

New Mexico State University • Telephone (505) 646-4337 • Box 3167, Las Cruces, New Mexico 88003

A Quarter Century of Water Research

Proceedings of the Twenty-Fifth

Annual New Mexico Water Conference

New Mexico Water Resources Research Institute
New Mexico State University
Las Cruces, New Mexico

April 24-25, 1980

PREFACE

The 25th Anniversary Water Conference was held on April 24 and 25, 1980. This silver anniversary conference had as its theme, "A Quarter Century of Water Research." The papers presented were divided into three sessions. The first session was devoted to past research accomplishments and to the history of our current water use practices. We were fortunate to have speakers for this session who have been active in water resources for the whole quarter century.

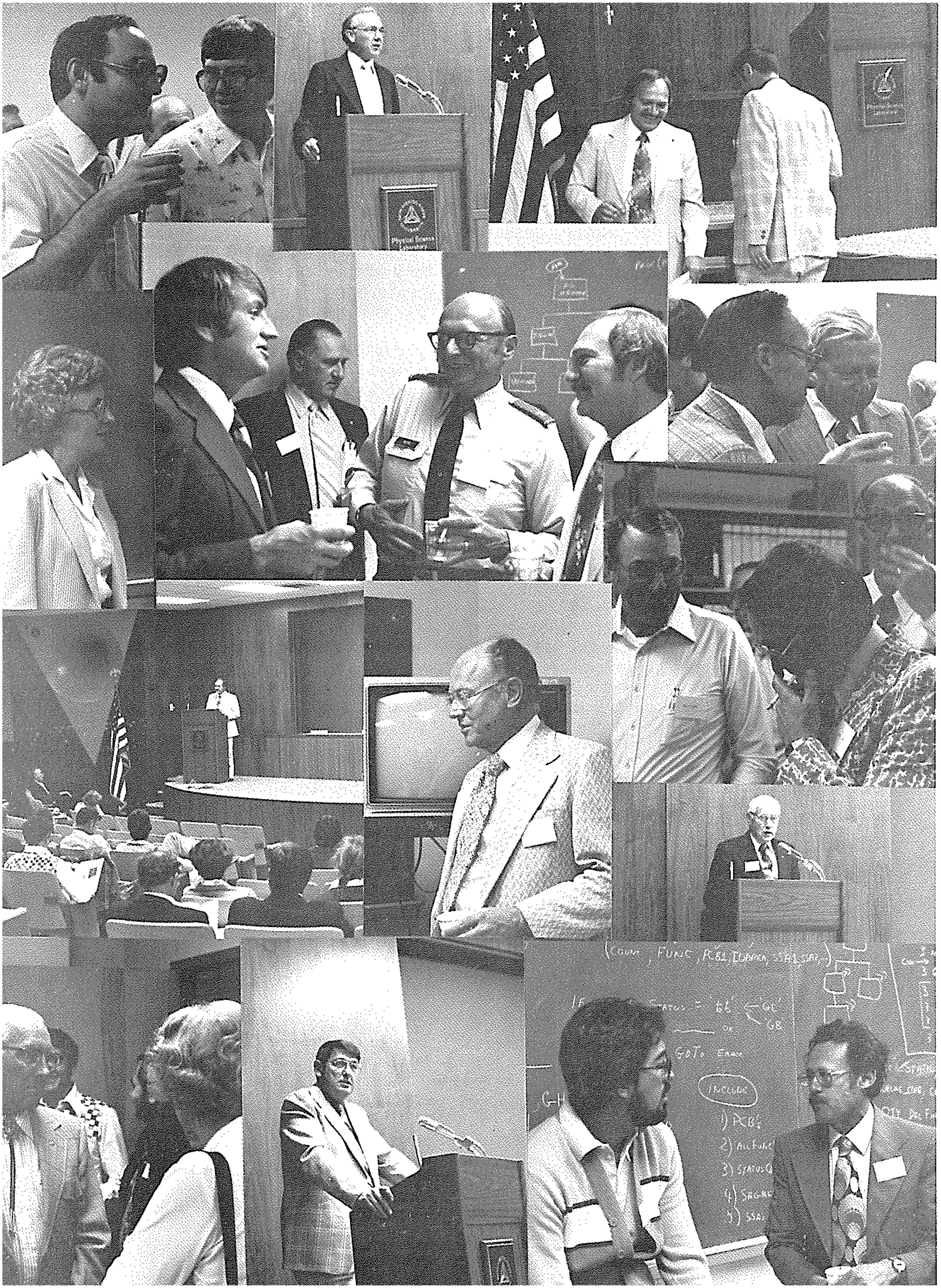
The afternoon session of the first day covered current water resources activities. Faculty and student scientists presented research reports on Institute-sponsored projects. The participants were also briefed on the current activities of several key federal water agencies. Other groups presented displays in the Stucky Hall conference room. That evening, Pat O'Meara of the National Water Resources Association gave an entertaining and informative talk following the banquet.

The next morning was devoted to looking into the future. The future relationships between water and energy, federal programs, agriculture, municipal use, and mining were examined.

The water conference was once again a success due to the contributions of both speakers and participants. In addition to the formal presentations, the conference provided a meeting place for people interested in water to get together and discuss important issues. Photographs on the next page show some of the conference activities. The papers which follow give a perspective of a quarter century of water research, past, present, and future.

Thomas G. Bahr
Director

Funds required for publication of the Proceedings were provided by registration fees, the United States Department of the Interior, Office of Water Research and Technology, and by State appropriations to the New Mexico Water Resources Research Institute.



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J. W. Pat O'Meara

THE TWENTY-FIFTH ANNUAL NEW MEXICO WATER CONFERENCE
PROGRAM

THURSDAY - APRIL 24, 1980

8:00 - 9:00 REGISTRATION

Stucky Hall
Water Resources Research Institute

9:15 - 9:35 OPENING REMARKS AND INTRODUCTION

Donald C. Roush
Acting President
New Mexico State University

SESSION ONE: THE PAST 25 YEARS

Moderator: Thomas G. Bahr
New Mexico Water Resources Research Institute

9:35 - 9:55 WATER RESOURCES RESEARCH - THE EARLY YEARS

H. Ralph Stucky
Professor Emeritus
New Mexico State University

9:55 - 10:20 A HISTORICAL PERSPECTIVE OF WATER MANAGEMENT IN NEW MEXICO

Steve E. Reynolds
New Mexico State Engineer

10:20 - 10:40 WATER BREAK

10:40 - 11:05 THE IMPORTANCE OF CROP PRODUCTION FUNCTIONS IN EVALUATING CONSUMPTIVE USE OF WATER

Eldon G. Hanson
Professor Emeritus
New Mexico State University

11:05 - 11:30 WATER RESOURCES OF THE RIO GRANDE - AN INTERDISCIPLINARY APPROACH

Robert Lansford
Professor of Agricultural Economics
New Mexico State University

11:30 - 1:30 LUNCH - HOLIDAY INN

SESSION TWO: CURRENT ACTIVITIES

Moderator: Garrey Carruthers
New Mexico State University

1:30 - 1:45 SALINE WATER UTILIZATION - AN INTERNATIONAL PERSPECTIVE

George O'Connor
Associate Professor of Agronomy
New Mexico State University

1:45 - 2:00 RESULTS OF COMPUTER MODELING OF GROUNDWATER FLOW - THE CALCIUM CARBONATE AQUIFER OF THE CENTRAL ROSWELL BASIN

Kenneth R. Rehfeldt
Graduate Student
New Mexico Institute of Mining and Technology

2:00 - 2:15 WATER CONSERVATION THROUGH PLANT BREEDING - ALFALFA

Marvin Wilson
Bill Melton
Professors of Agronomy
New Mexico State University

2:15 - 2:30 U.S. GEOLOGICAL SURVEY: UPDATE ON CURRENT ACTIVITIES

James F. Daniel
District Chief
U.S. Geological Survey
Water Resources Division

2:30 - 2:40 WATER AND POWER RESOURCES SERVICE: UPDATE ON CURRENT AND PROPOSED ACTIVITIES

Warren Weber
Water and Power Resources Service

2:40 - 2:50 THE SIX-STATE HIGH PLAINS-OGALLALA AQUIFER AREA STUDY: 1979-1982

Joe B. Harris
Resource Economist
High Plains Associates

2:50 - 3:00 160-ACRE LIMITATION: CURRENT STATUS

Frank DuBois
New Mexico Department of Agriculture

3:00 - 5:00 POSTERS AND EXHIBITS

Stucky Hall

THURSDAY - APRIL 24, 1980 - EVENING SESSION

7:00 BANQUET

Featured Speaker: Pat O'Meara
National Water Resources Association

FRIDAY - APRIL 25, 1980

SESSION THREE: WHAT DOES THE FUTURE HOLD?

Moderator: Lucy Fox
New Mexico Energy and Minerals Department

9:00 - 9:20 THE IMPACT OF ENERGY DEVELOPMENT ON WATER RESOURCES

Larry Kehoe, Secretary
New Mexico Energy and Minerals Department

9:20 - 9:40 MINE DEWATERING

Michael B. Campbell
Campbell and Black, P.A.

9:40 - 10:00 FEDERAL WATER LEGISLATION

Harold Brayman
Senate Committee on Environment and Public Works

10:00 - 10:20 THE IMPACT OF DESALTING ON WATER SUPPLY - ALAMOGORDO, NEW MEXICO

Don Des Jardin
Consulting Engineer
Gordon Herkenhoff & Associates

10:20 - 10:30 QUESTION AND ANSWER PERIOD

10:30 - 10:50 WATER BREAK

10:50 - 11:10 THE FUTURE OF WATER QUALITY

Peter Krenkel, Director
Nevada Water Resources Center

11:10 - 11:30 FUTURE ROLES FOR THE CORPS OF ENGINEERS

Col. Bernard J. Roth
District Engineer
U.S. Army Corps of Engineers

11:30 - 11:50 THE FUTURE OF AGRICULTURAL WATER USE IN NEW MEXICO

George Dawson, Head
Department of Agricultural Economics
and Agricultural Business
New Mexico State University

11:50 - 12:00 QUESTION AND ANSWER PERIOD

12:00 - 2:00 STATEWIDE WATER CONFERENCE ADVISORY COMMITTEE MEETING

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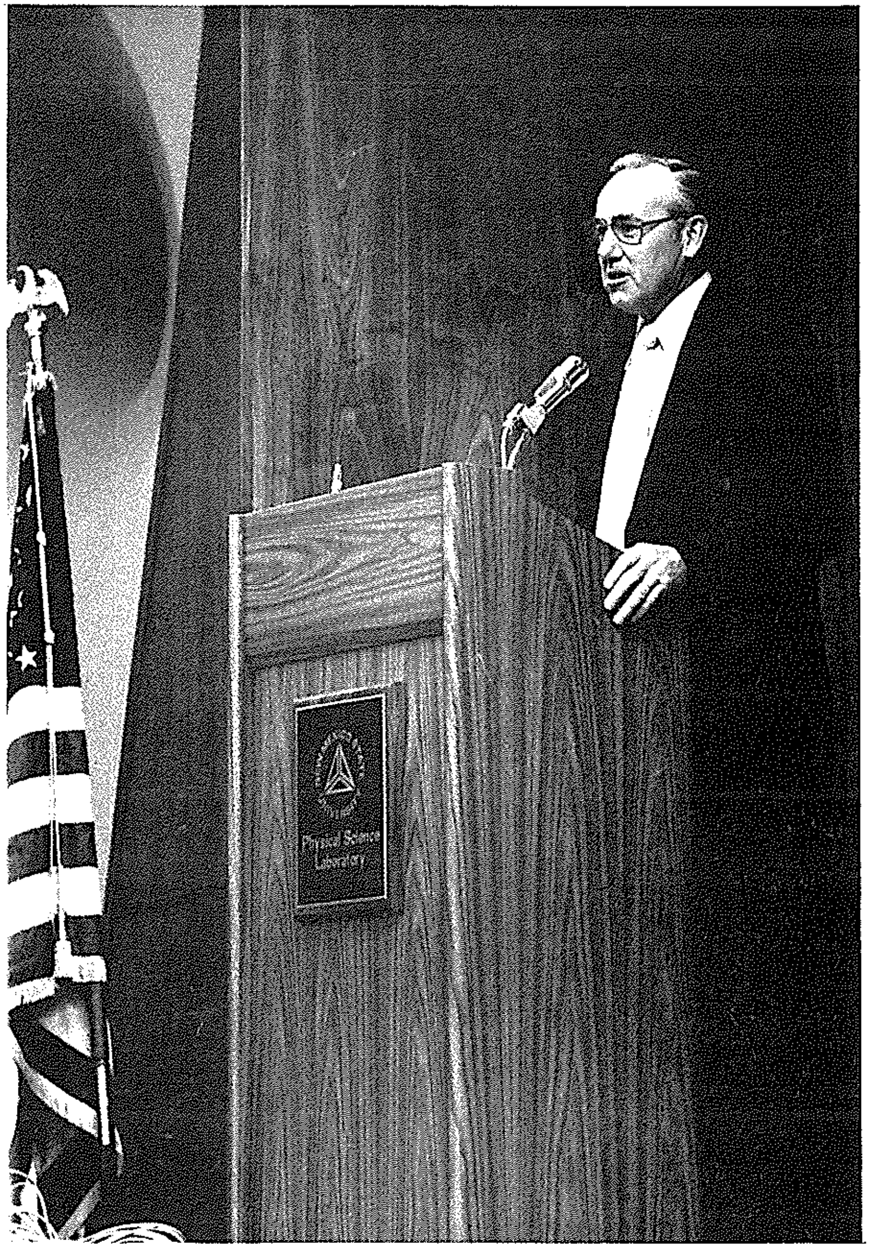
Editorial Assistant: Cheryl Crawford
Photographs: Jim Carr



Dr. Donald C. Roush, Acting President of New Mexico State University, delivered the welcoming address at the 25th Annual New Mexico Water Conference.

OPENING REMARKS

Dr. Donald C. Roush
Acting President
New Mexico State University

Thank you very much, Tom Bahr. Your introduction was longer than my talk this morning! Well, welcome to warm, sunny, lovely Las Cruces. Sorry that the weather has turned bad for this conference.

It is a real pleasure to welcome all of you to the 25th Annual New Mexico Water Conference on the campus of New Mexico State. As Tom told you, I have been the Acting President since January 1 and have until July 1 to go, so I'm a little better than halfway through now. I told some folks the other day that I thought I could see the light at the end of the tunnel and they said, "Yeah. I hope it's not another train coming through." So if we do not have "too many trains coming through" between now and July 1, I think we will be OK.

The comments I receive as Acting President are not nearly as bad as those sometimes received as the Vice President. One day I was walking across the campus as one of our retired professors was strolling along. I overtook him and struck up a conversation. I said, "My, you look just fantastic!" He said, "Well, thank you, Don. I'm feeling well." I said, "Do you really like retirement?" "Oh," he said, "I just love it. It's far better than anything I ever expected." I said, "I sure am looking forward to the day when I can retire." And without hesitation he said, "Yeah, Don, there are a lot of other people around here looking forward to that day, too!"

It seems appropriate after a quarter century of water research to say a few words about New Mexico and New Mexico's heritage in solving water problems through research.

Of course, the first name that comes to my mind is Ralph Stucky. Dr. Stucky organized the first water conference eight years before the federal government recognized the need to promote water research by the Water Resources Research Act of 1964. Senator Clinton P. Anderson and Representative Tom Morris of New Mexico, whom I am sure many of you remember, were instrumental in the passage of this federal legislation. Ralph Stucky will probably go into more detail about the early history of the Institute in his talk, so I will say no more about that.

The 1964 act authorized the creation of water resources research institutes in each of the states. Congress initially provided funding to create 14 state institutes. Because of the active program already in place in New Mexico and Senator Anderson's interest, the New Mexico Water Resources Research Institute was the first in the country to be approved and has gone on to register significant accomplishments.

You will be pleased to learn that our state's water institute led the nation in Office of Water Research and Technology Matching Grants this year; and this is a great credit to Tom Bahr and his team of people, and our statewide council. We were in the top ten in total OWRT research funding, in competition with such populous states as New York and California. Quite an achievement indeed. It is fitting, in this 25th anniversary year that we not only review our past leadership, but also examine our productive present, and look ahead to our promising future. It pays to plan ahead. Remember, it wasn't raining when Noah built the Ark.

It is also fitting and most thoughtful of Governor King to issue a proclamation recognizing the quarter century of progress of water research which he has asked me to present at the start of this conference today.

I quote from the proclamation:

"WHEREAS, water is the life blood of the state of New Mexico and the state's future social, economic and cultural development depends on a continuing supply of good quality water; and

WHEREAS, the limited water resources of New Mexico must be used in a judicious manner and their care, use and development should be the responsibility of all the citizens of the state; and

WHEREAS, this is the Silver Anniversary of the New Mexico Water Conference, which annually focuses on water resource problems and seeks ways to protect the present level of quality water and reclaim and reconvert water; and

WHEREAS, to afford official recognition of the importance of water to the welfare of all people of New Mexico;

NOW, THEREFORE, I, BRUCE KING, Governor of the state of New Mexico, do hereby proclaim the week of April 20 through 26, 1980, as:

'WATER FOR NEW MEXICO WEEK'

and urge all citizens of our state to pay special attention during the proclaimed week to the importance of our present and future water supplies.

DONE AT THE EXECUTIVE OFFICE
THIS 15TH DAY OF APRIL, 1980.

BRUCE KING, GOVERNOR"

Tom, it is a pleasure to present this proclamation to you on behalf of Governor King.

MEET THE SPEAKERS
25TH ANNUAL NEW MEXICO WATER CONFERENCE

SESSION I

H. RALPH STUCKY was appointed as the first Director of the New Mexico Water Resources Research Institute in 1964. A native of Montana, Dr. Stucky received a Bachelor's Degree in Animal Science from the University of Idaho, a Master's Degree in Agricultural Economics, and a Doctoral Degree in Economics and Political Science from the University of Minnesota. He came to New Mexico State University in 1954 as Head of the Department of Agricultural Economics from the position of Extension Economist with Montana State University.

Dr. Stucky served as Chairman of the Annual New Mexico Water Conference from 1956 through 1971, organized and directed the New Mexico Water Resources Research Institute during its formative years, authored more than 70 publications in the water resources field, served as Director of the National Universities Council on Water Research, and received a presidential commendation for outstanding National Contributions on Water Resources. The New Mexico State University Board of Regents named the Water Resources Research Institute building "Stucky Hall."

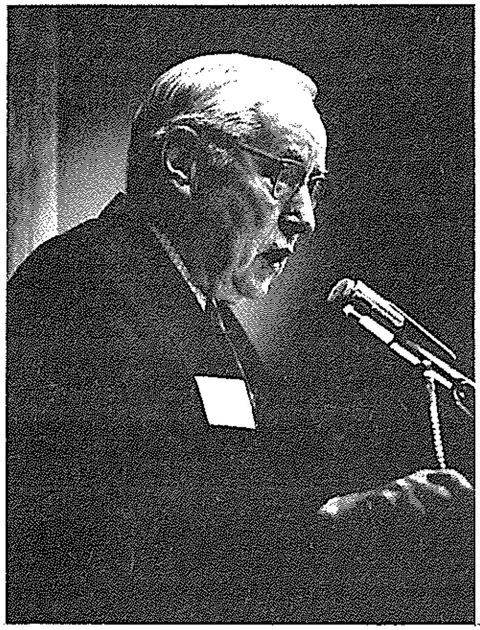
STEVE E. REYNOLDS has been the State Engineer of New Mexico since 1955. He has spoken at numerous Water Conferences, including the first one in 1956 when his topic was "The Effect of Interstate Compacts on New Mexico Water Supply." When a statewide research committee was established in 1966 to exchange information and research needs between the various agencies in New Mexico, including New Mexico Water Resources Research Institute, Reynolds was a member of the first committee.

He is the author of numerous papers in the field of water development, conservation, use and law, as well as having authored more than 20 papers in the field of thunderstorm electrification, precipitation mechanisms, and electrical effects associated with the freezing of dilute aqueous solutions. He is a graduate of the University of New Mexico, having a degree in mechanical engineering; he has also received an honorary degree of Doctor of Laws from New Mexico State University in 1977.

ELDON HANSON is Professor Emeritus of New Mexico State University. He was formerly the Head of the Department of Agricultural Engineering from 1951 to 1979. A pioneer in the field of consumptive use, Professor Hanson has been involved in numerous WRRI research projects.

ROBERT LANSFORD is Professor of the Department of Agricultural Economics and Agricultural Business at New Mexico State University. For the past 15 years he has been either a leader or a participant in ten interdisciplinary research projects. Because of his experience, he was appointed the coordinator on four interuniversity-interdisciplinary research projects dealing with water utilization in the Rio Grande Basin and the Southern High Plains of New Mexico. Lansford is a graduate of New Mexico State University, and has his Doctoral Degree from the University of Minnesota in Agricultural Economics.

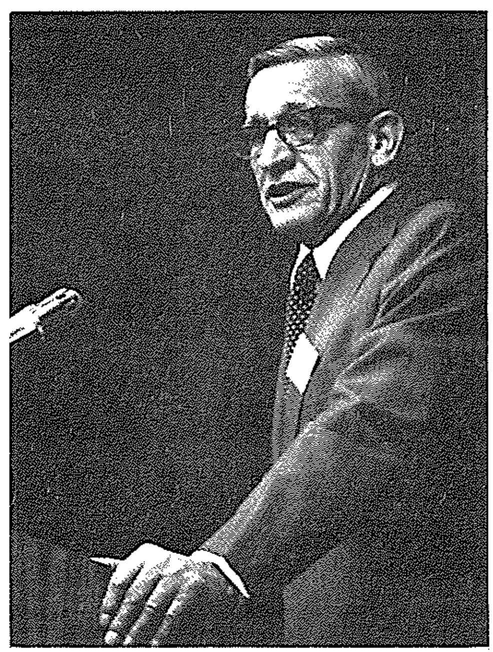
Session One: The Past 25 Years
Speakers



Ralph Stucky

Eldon Hanson

Robert Lansford



Steve Reynolds

WATER RESOURCES RESEARCH - THE EARLY YEARS

H. Ralph Stucky
Professor Emeritus
New Mexico State University

INTRODUCTION

I want to thank Tom Bahr for asking me to prepare this paper. It seems that Tom has asked a country boy, who grew up on a 240-acre irrigated farm in the Gallatin Valley of Montana, to review some of his life history, as well as review early water research. I appreciate the invitation.

From working on the home-irrigated farm in the 1910s and 1920s, and seeing some of the crops dry up, when our farm's 1881 water rights had to be shut off by the ditch rider, because those rights were junior to other rights on the ditch filed in the 1870s, I almost inherited an interest in water problems.

Then, as County Agent in two irrigated areas in Idaho, and later as County Agent and Extension Economist in Montana, a lot of work was required with irrigated farms and with several irrigation projects.

In May 1954, before coming to New Mexico as head of the Department of Agricultural Economics at New Mexico State University, I had just completed a thesis entitled Settlement and Repayment Policies on Irrigation Projects in the 17 Western States for my doctor's degree from the University of Minnesota.

The strongest impression I had from my first trip around New Mexico was the great lack of water for many uses, and the problems

New Mexicans were experiencing as a result of these shortages. Some of these water problems have been recognized for centuries and partial solutions have been developed.

The story of New Mexico's water resource problems and of water resources research is a story of people, many people. It is a story that began with the native people and the unfolding problems occurring with the settlement and development of the state and region.

Water is required by all life. It influences all factors of the environment. It is the lifeblood of New Mexico, and has been since the early records of man in this area.

The cisterns high up on the cliffs of the Acoma Pueblo, near Grants, supplied domestic water for the Indians living there. In the Chaco Canyon in northwestern New Mexico, at Pueblo Bonito, which dates from about 920 A.D., archeologists have found stone diversion dams that show considerable knowledge of irrigation on the part of the Indians of that time. The journal of Captain Juan Jaramillo, who traveled with Coronado on his expedition along the Rio Grande Valley in 1540-1542, refers to irrigation among the Pueblo Indians, noting that, "There is an irrigation stream, and the country is warm. They have corn, beans, and melons for food." Other evidence that irrigation was practiced by the early-day Indians has been found near Santa Rosa and Pecos, and among the Navajos.

Water, starting with a raindrop on a particular spot, moves very quickly to a small trickle, later to a stream, and on to the ocean. It also moves as surface water and groundwater.

New Mexico's distinctive tri-cultural history is apparent in its water laws. Indian, Spanish, and Mexican farmers of pre-Territorial New Mexico practiced the principle of prior appropriation, which was based on early Spanish and Mexican law. This principle, public ownership of surface water, with rights assigned by prior appropriation and beneficial use, was perpetuated in early treaties, land grants, the New Mexico Territorial Constitution, and the 1912 State Constitution. The same principles were applied to groundwater in 1931 by New Mexico law.

EARLY DISCUSSIONS

As some aspects of water were discussed with the Agricultural Economics staff and with others, it became evident that our staff and students needed more information on water and the numerous problems associated with water. As a result, a seminar on water was scheduled for the spring semester of 1956. When the public heard the seminars were being held and who the speakers were, several people called and asked how they might attend. We could not invite the public into the classroom, but we did agree to reschedule as many of the seminar speakers as possible for a public forum in the fall of 1956. The forum was held with an attendance of about 150 people from most parts of the state. Farmers, businessmen, university people, local, state and federal officials, and individuals with various interests came.

At the end of that meeting in Milton Hall on the university campus, it was agreed that this conference be designated the "First

Annual New Mexico Water Conference." The early conferences became a great force in the understanding of the water problems of the individuals, local, state and nation.

Some of those who prepared papers for the early conferences and participated in the discussions were: State Engineer Steve Reynolds (Steve has attended and participated in at least 23 of the 25 Annual Water Conferences; in addition, he has been a major speaker on a number of the annual programs); Roger B. Corbett, President of NMSU; Governor Edwin L. Mechem; Rogers Aston of Roswell; Lloyd Calhoun of Hobbs; Dean of Agriculture Robert H. Black; U.S. Senator Clinton P. Anderson; U.S. Congressman Thomas C. Morris of Tucumcari; Ross Malone of Roswell, at that time President of the American Bar Association; Justice Irwin Moise of the New Mexico State Supreme Court; Arthur S. Fiedler, U.S. Geological Survey, Washington, D.C.; William Hale, Groundwater Resources Division, USGS, Albuquerque; and Jack Campbell, Chairman of the Governor's Water Resources Committee, later Governor of New Mexico.

Water Resources Research Institute Established

The first eight Annual New Mexico Water Conferences, 1956 through 1963, with speakers such as the above and many others, might be considered forerunners of the Water Resources Research Institute. The Institute was established by the New Mexico State Board of Regents in February 1963, 17 months before Senate Bill S-2 (Water Resources Research Act of 1964) was signed by President Johnson on July 17, 1964. The participation of Senator Anderson and

Congressman Morris in the very early water conferences may have specifically directed their attention to the great need for water resources research and led them to be the first men to introduce the water research legislation in the Senate and House. These bills, with minor revisions, eventually became the Water Resources Research Act of 1964, establishing Water Resources Research Centers in each of the 50 states and Puerto Rico.

Senator Anderson, in presenting the legislation to the Senate, said he had patterned the water research bill after the Experiment Station Act of 1887, which established an Agricultural Experiment Station at the land grant colleges in each of the states. By coincidence, the Agricultural Experiment Station Act and the Water Resources Research Act were signed into law by the Presidents, one on July 17, 1887 and the other on July 17, 1964 -- 77 years to the day later.

Characteristics of Water

Water is as complex in its nature as in its uses. It does not recognize boundaries, whether private, county, state or even international. It is used and reused as it moves along. Therefore, all segments of our society -- government units, industry and individual citizens in all walks of life -- must share in the proper use of water and the control of pollution.

As stated by an unknown author, "Water is a 'must' for all forms of life on earth -- for drinking, growing food, keeping clean. Water is needed for work, for cooling, carrying, lifting and building. And water is needed for play -- for swimming, boating, fishing and camping."

The late John W. Clark, a civil engineer who became the second Director of the Water Resources Institute, stated during the First Annual Water Conference, "Remember, water is neither created or destroyed. Nor is it changed in form; it merely becomes dirty and all we have to do is wash it."

Some of those present here today will remember that John Clark emphasized that point by taking up a beaker of sewage water which had been "washed" in the laboratory and drank it. John did not get sick, but some of the audience felt like they might. He demonstrated what was a fact at that time, but is now a process being used by several cities to maintain their water supplies, by reclaiming their sewage waters for domestic use.

WATER RESOURCES RESEARCH INSTITUTE

The Board of Regents of New Mexico State University recognized the need for water research when it authorized the establishment of New Mexico State University Research Institute in February, 1963.

When the Water Research Act of 1964 was passed by Congress and signed by President Johnson in 1964, the Office of Water Resources Research was established in the Department of Interior. At that time Governor Jack Campbell recommended New Mexico State University as the institute center for New Mexico. In his letter of recommendation to the Department of Interior, Governor Campbell stated, "New Mexico State University had held nine water conferences and had conducted many studies in connection with its outstanding agricultural and scientific programs."

Objectives of the New Mexico Water Resources Research Institute:

1. To promote scientific endeavor in the area of water resources research.
2. To encourage and facilitate the entry of qualified scientists into water resources research through their particular disciplines.
3. To coordinate, integrate and facilitate the efforts of scientists and organizations conducting water resources research at New Mexico State University.
4. To interest, encourage and train young scientists through research, experiments, and investigations.
5. To disseminate the results of New Mexico's water resources research work in both broad and specific areas to the public and to organizations interested in such research.
6. To provide the means of contact between the scientists doing this research and organizations supporting such research.

Institute has Statewide Responsibility

The Institute, although located at New Mexico State University, has statewide responsibility to encourage and conduct water resources research at New Mexico State University and other institutions of higher learning in New Mexico. It also can, and does, cooperate with private, county, state, and federal organizations interested in water research.

Specific Characteristics

The New Mexico Institute has the following characteristics:

1. There has been a full-time Director of the Institute continuously since March 15, 1964.
2. The Institute operates as a unit administered directly from the New Mexico State University President's office.
3. The Institute has been housed since 1970 in a separate building, "Stucky Hall," built specifically for the exclusive use of the Water Resources Research Institute located on the University campus.
4. The Institute has signed agreements setting out its working relationships as follows:
   a. Memorandum of Agreement between the United States Office of Water Resources Research, New Mexico State University, and the New Mexico Water Resources Research Institute, signed March 12, 1965 by the Director of the New Mexico Water Resources Research Institute.
   b. Annual allotment project agreement, signed March 12, 1965.
   c. Policy statement issued January 6, 1967 by New Mexico State University President Roger B. Corbett.

d. Basic objectives and operating statement, issued January 6, 1967 by Richard Duncan, Vice President for Research.

e. Memorandum of Agreement between University of New Mexico, New Mexico Institute of Mining and Technology, and New Mexico State University, signed July 8, 1966.

f. Supplement to the July 8, 1966 agreement between University of New Mexico, New Mexico Institute of Mining and Technology, and New Mexico State University, signed June 23, 1970.

5. Because of the New Mexico Water Resources Research Institute's unique relationships established by legislation and by the above agreements, the Institute does not have a research staff of its own, but draws on the faculties and research assistants from the appropriate departments in one or more universities by soliciting either single faculty member proposals or by organizing multidisciplinary projects and again soliciting faculty member participation in the various phases of larger projects. This avoids building a staff which quickly gets "cast in concrete." When a project is completed the Institute is not obligated to support an in-house staff.

6. Some projects are single-discipline, one-man efforts, while others are multidisciplinary, multiuniversity projects with joint participation in the funding, the gathering of data,

and the research procedures and analysis. Participation by private, state, or federal agencies may become available for support of either type of project, depending on the subject being studied.

New Mexico Water Resources Research Institute the First in the Nation to Receive Approval Under S.2

Senator Clinton P. Anderson in his newsletter to his constituents, dated August 10, 1965, included the item: "Just 12 months ago Congress created the water resources research program. As a result, a state water resources research center has been established in each of the 50 states and Puerto Rico -- the first at New Mexico State University."

A Broad Program of Water Resources Research

The Water Resources Research Act of 1964 established a Water Resources Research Institute or Center in each of the 50 states and Puerto Rico. The institutes or centers were to add to, and not substitute for, the research being conducted by the Agricultural and Engineering Experiment Stations, the several federal and state agencies, such as the State Engineer Offices and the U.S. Bureau of Reclamation, or private business and individuals. As stated above, the objectives of the program are to: (1) encourage and facilitate the entry of qualified scientists into water resources research; (2) interest, encourage, and train young scientists through research, experiments, and investigations; and (3) provide the means of contact between scientists doing research and organizations supporting research.

Scientists, Students and Financing Attracted

The New Mexico Institute in its first 11 years of operation attracted research scientists from six institutions of higher learning, representing 31 different academic disciplines. Also, direct appropriations were made to the institute by the New Mexico State Legislature, and direct funding for professional personnel was made available to collect data. Also, direct funding was provided to the institute by 16 local, state, or federal agencies. A total of 816 students in five academic institutions of higher education in New Mexico and one in Texas were employed by the principal investigators working on research projects funded in whole or in part through the New Mexico Water Research Institute during its first 11 years of operation.

These students not only made possible the volume and quality of research accomplished, but they gained valuable education and training from this employment.

Water Resources Research - The Early Years

Water is intertwined in the lives of every person in the United States, the North American Continent and the World. Water is required in almost every activity -- whether family, business and industry, social and political, or in governments and between governments. It involves studies in single disciplines such as engineering, agriculture, hydrology, meteorology, economics, business and political science, to name a few. Water does not respect political and legal boundaries, and does not respect disciplinary boundaries. For this reason, a great amount of research in many disciplines, and in multidisciplines is needed to assist in the most beneficial use of our water resources.

To address the topic, "Water Resources Research - The Early Years" -- even though many research projects have been completed and even more investigations begun, much, much more will be required to guide the development and management of our vital water resources.

Water development and management is related to the sources of water, qualities of water at a particular location, river basins, population, population locations, and endless other factors.

It appears to me that we are still in the early years of water resources research. The New Mexico State Water Resources Research Institute can assist in this work in New Mexico, the region, and the nation. This research institute, together with the 50 other water research institutes and centers, through cooperation and through leadership, can contribute to the knowledge required to develop and manage the resources. Other established agencies must also contribute in their areas of authorization and expertise.

As Dr. Gerald W. Thomas, President of New Mexico State University and member for three years of the U.S. Board of International Food and Agricultural Development, recently wrote, "Water is a renewable resource, the supplies are limited. Over the long term, water will likely be the most limited factor in world food and fiber production, exceeding both land and energy in importance."

The National Water Resources Research Institutes program, with its increased emphasis in both the state and nation, is still in its teen years (1964-1980). With the large volume of national and state legislation, court decisions, and increasing populations, water research has just begun.

Yes, truly we are still in the early years of water resources research.

A HISTORICAL PERSPECTIVE OF WATER MANAGEMENT IN NEW MEXICO

Steve E. Reynolds
New Mexico State Engineer
Secretary, New Mexico Interstate Stream Commission

Last month Tom Bahr asked me to tell you what has happened to water management in New Mexico in the last 25 years. My first reaction was that this should be a piece of cake for a guy who has been State Engineer for most of that time.

After some hard thought I concluded that I should tell you the good news first: not much has happened to water management in New Mexico in the last 25 years. The bad news is that you will have to listen to my news analysis for about 30 minutes.

The principles of our laws controlling the management of water, as they were codified for surface water in 1907, affirmed by our Constitution in 1912 and applied to groundwater in 1931, remain substantially unchanged and enjoy the emulation or envy of most of the states.

A paper by Robert G. Dunbar, Professor of History at Montana State University, printed in the Pacific Historical Review in November of 1978, (Vol. XLVII, No. 4) says:

> New Mexicans...(have created) institutions for the management of groundwater which have influenced many other states. Of the 19 states lying west of the 98th Meridian, no less than 14 have followed New Mexico's example, by abrogating the applicability of the English rule to groundwater and replacing it with the appropriation doctrine. The New Mexican pattern of restricting drilling and water

> consumption...(in) designated groundwater basins critically short of this resource has been copied by all of the Rocky Mountain states as well as Oregon, Washington, Nebraska, Oklahoma, and Hawaii. Those states which have applied the appropriation doctrine to groundwater have also adopted, with some modifications, New Mexico's permit system, which in turn was modeled on Wyoming's surface water law. And in the more humid section of the United States at least 12 states have borrowed either consciously or accidentally some aspects of the system of groundwater control which...(New Mexicans) originated. Indeed, half of the states of the Union have benefited from New Mexico's institutional pioneering.

I am going to limit my savoring of the piece of cake Tom offered to accepting a small measure of the credit for little change in our water-management institutions. I want to take this opportunity to express the view that most of the people of New Mexico do not fully appreciate the importance of the role that our courts have played in establishing and preserving New Mexico's water-management institutions.

This is not to say, of course, that the public does not understand pretty well the controlling role that the legal profession plays in government. They know that profession is usually better represented in the legislature than any other occupation. The lawyer legislators and the lawyer lobbyists are often the controlling factor in the enactment of legislation. The executive department officer delegated the responsibility of administering the act has a lawyer who tells him what the law requires him to do. And then the lawyers in black robes tell the administrator what he did wrong.

I am sure you will recognize that these remarks are tongue-in-cheek -- an engineer baiting the lawyers as tradition requires. I must admit that to the extent I am sanguine about our water laws -- and I am -- much credit to the legal profession is implied.

Realizing the importance of water to the economy of the State and the welfare of its citizens, many logically conclude that the office of the State Engineer is vested with great power. As are many logical conclusions, that one is not well founded. Our statutes on water fill a volume about two inches thick and the case law -- our Supreme Court opinions in water cases -- stack up another 3.5 inches on 8.5 x 14 sheets. The statutory and case law rather effectively constrain the discretion of the State Engineer. Furthermore, the State Engineer's every "decision, act, or refusal to act" is subject to appeal to the district court; and this recourse is not infrequently sought.

The late Supreme Court Justice Carmody once told me, "You are the most litigious S.O.B. in the history of the State." Those of you who knew Judge Carmody will remember that he was a great judge and not given to euphemisms, but he would approve my constraint in speaking to young, impressionable students. The Judge's clerk had made a count and found my name in the style of more Supreme Court cases than the name of any other individual. There have been about 60 Supreme Court opinions involving the State Engineer in the last 25 years.

I recognize that in our system of government, judicial legislation is frowned on. But, an essential function of our courts is to ensure that the statutes are enacted and administered in accordance with the principles enunciated in our Constitution. This function is particularly difficult and essential in the interpretation of laws dealing with technical subjects such as water. The record shows that our Supreme Court has been studiously careful and has exhibited great wisdom in its opinions in water cases. With your indulgence I will cite just a few examples from the Supreme Court opinions of the last 25 years.

In considering the Court's opinions it is important to have in mind that our Constitution provides that the unappropriated waters of the natural streams of the state, perennial or torrential, belong to the public; that these waters are subject to appropriation in accordance with law; that beneficial use is the basis, the measure and the limit of a right to use of the public waters; and that priority of appropriation gives the better right. It is also important to have in mind that our Supreme Court held in State ex rel Bliss v. Dority (55 N.M. 12), 1950 opinion, that these constitutional provisions are applicable to the groundwaters as well as to the surface waters of the state. I would emphasize the importance of this decision by pointing out that in 1955 the State Engineer had asserted jurisdiction over the groundwater underlying 8 percent of the state's total area by the declaration of eleven underground water basins. At this time, there are 27 declared underground water basins encompassing about 60 percent (71,700 square miles) of the total area of the state.

In Templeton v. the Pecos Valley Artesian Conservancy District and the State Engineer (65 N.M. 59), a 1958 Supreme Court decision, the issue was whether a person having a right to divert the surface waters could drill a well to supplement his supply which had been diminished by junior appropriators drilling and operating wells which intercepted the natural discharge of an aquifer to the stream upon which the surface-water user depended.

Considerations of equity might seem to make the answer clear, but our statutes and rules and regulations gave ample ground for plausible, technical argument. The effect of the Court's opinion was that the prior appropriator of stream water has the right to follow the stream water to its underground source and the right to drill wells and take the underground water necessary to fill his prior stream right, regardless of detriment to other underground water appropriators whose rights were subsequent in time to the stream rights.

In City of Albuquerque v. the State Engineer (71 N.M. 428), a 1962 decision, the question was whether the State Engineer could impose as a condition on a permit to appropriate underground waters a requirement that surface water usage under valid water rights be reduced by an amount sufficient to offset the effects of the groundwater appropriation on the fully appropriated stream flows.

The Court held that the engineer had not only the power, but the duty to impose such conditions on new groundwater appropriations as are necessary to protect surface water rights in a situation where there is a significant hydrologic relationship between the groundwater source and the stream. It is interesting that in this decision the Court relied on and made clear its decision in the Templeton case.

In Templeton and Albuquerque the Court made it perfectly clear that the coordinated management of surface and groundwater is not only possible but is essential under New Mexico's Constitution. These decisions put New Mexico a quantum jump ahead of the other states in the management of groundwater appropriations. That the coordinated management of surface and groundwater is essential is now generally conceded and several states have emulated our law in this respect.

In Mathers v. Texico and the State Engineer (77 N.M. 239), a 1966 decision, the issue was groundwater mining in the Lea County Underground Water Basin. The term "mining" denotes withdrawals in excess of recharge. In that basin the amount of water in storage in the aquifer is very large compared to the annual recharge; and any practical pattern of withdrawals can have little effect on the discharge from the aquifer in New Mexico across the Texas state line. In discussing the facts the Court termed the aquifer "nonrechargeable."

The Court held that in a geohydrologic situation such as that obtaining in Lea County, mining of the groundwater is acceptable under the doctrine of prior appropriation. The Court concluded:

> The administration of a "non-rechargeable basin," if the waters therein are to be applied to beneficial use, requires giving to the stock or supply of water a time dimension, or, to state it otherwise, requires the fixing or a rate of withdrawal which will result in a determination of the economic life of the basin at a selected time.

In effect, the Court held that it was reasonable for the State Engineer to establish an "economic life" for the basin and to distribute the allowed withdrawals over the area of the basin to achieve an areally uniform time of depletion of the water supply, and thus establish a time of use for the rights granted at something less than perpetuity.

Had the court gone the other way the first appropriator in a nonrechargeable basin might be the last and much of our fresh underground water would have been locked in place.

State ex rel State Engineer v. Miranda (83 N.M. 443), a 1972 opinion of our Supreme Court, treated the question whether a water right had been created by the grazing and cutting of grasses on land that had been irrigated by the natural spreading of water in Abo Wash. While the court had not before addressed this specific question, it had in Harkey v. Smith (31 N.M. 521), a 1926 decision, enunciated the principles involved. In that case, the court held:

> It may be stated generally that, under the arid region doctrine, uncontrolled by statute, the appropriation of water is accomplished by taking or diversion of it from a natural stream or other sources of water supply, with intent to apply it to some beneficial use or purpose, and consummated within a reasonable time by the actual application of the water to the use designed or some other useful purpose.... Under this doctrine it is quite as necessary to make use of the water as it is to divert it; in fact no appropriation can be effected without such use. The intent, diversion, and use must coincide.

In its opinion in Miranda the Supreme Court pointed out that in the trial before the district court, the court, together with counsel for both parties, had agreed that the case would turn on one legal issue, "whether physical efforts of man resulting in visible diversion of water are necessary to the establishment of water rights in the State of New Mexico"; the Supreme Court then applied the principle of Harkey v. Smith saying:

> We hold that man-made diversion, together with intent to apply water to beneficial use and actual application of the water to beneficial use, is necessary to claim water rights by appropriation in New Mexico for agricultural purposes.

Miranda makes it clear that there can be no "instream" water right in New Mexico. The importance of this decision perhaps was not fully appreciated until it became clear that the several federal executive department task forces appointed to formulate a national water policy, pursuant to President Carter's June 1978 Water Policy Message, were undertaking to make the protection and enhancement of instream flows, rather than conservation as proposed by President Carter in 1977, the cornerstone of a national water policy.

The necessity of a man-made diversion to establish a water right is perhaps the principal factor distinguishing the appropriation doctrine from the riparian doctrine of water rights. Under the latter, the riparian, the owner of the banks of the stream, has a right to the continued natural flow of the stream through or along his property. The Colorado Supreme Court, in a 1965 decision, has stated the proposition this way:

> The right to the maintenance of the "flow" of a stream is a riparian right and is completely inconsistent with the doctrine of prior appropriation.

Most authorities that I am aware of agree that the adoption of the riparian doctrine would have virtually prohibited economic enterprise other than grazing in a semiarid state such as New Mexico.

I am aware that the question of instream rights is the subject of some difference of opinion among New Mexicans. I would offer some brief comments on the issue, not with the hope of resolving the differences, but with the hope of perhaps changing perspectives on both sides.

Those who argue that it would not be prudent to make it legally possible to establish instream flow rights in New Mexico do not contend that instream flows and the use of water for fish and wildlife, recreation, and esthetic purposes in the State are not beneficial. The State, as well as private enterprise, has appropriated water and developed reservoir and irrigation projects, in accordance with State law, to enhance the environment, fish and wildlife habitat, and recreation opportunity.

The stream flow required at various points in the State is governed by interstate compacts, international treaties, federal court decrees, water rights conferred by the State under the doctrine of prior appropriation, and legislation authorizing federal water-development projects. In many situations, an incidental effect of these institutional constraints is an instream flow having important value in terms of recreation, fish and wildlife habitat, and esthetics.

Furthermore, in many areas of the State the geography and public land ownership patterns adequately protect instream values. Mountain streams generally do not provide favorable sites for conservation storage.

The effects of a change in State or federal law that would allow the establishment of instream flow rights in New Mexico would be greatly mitigated by the fact that most of our stream flows are not fully appropriated, and it seems clear that those appropriation doctrine rights could not be taken for instream flows without compensation. However, in New Mexico a water right is a property right and the right to change the point of diversion, place and purpose of use of a water right, is an intrinsic part of that property right. The establishment of instream flow rights, at this time, could be detrimental to the interests of the State and its water-right owners by limiting flexibility in the diversion and use of the State's water. Instream rights could affect the value of existing irrigation water rights by precluding a change in point of diversion from below what might be claimed as an instream right to above the reach where the instream claim is made. Changes in the point of diversion of appropriation doctrine rights may be necessary to meet our growing municipal and industrial needs.

The decision in Miranda seems to have foreseen the state versus federal controversy over the protection and enhancement of instream flows, but we cannot be sure that it will resolve that controversy. A June 25, 1979 opinion of Leo Krulitz, then Solicitor for the Department of the Interior, contends that the federal government can establish instream flow rights on federal land under what has been termed the "non-reserved federal water right theory" without regard to state law; that is, specifically without regard to our Supreme Court's decision in Miranda. New Mexico, and most if not all of the other western states, have advised Secretary Andrus that the Krulitz theory is without legal foundation and the Secretary has deferred implementation of that theory, but we cannot yet be sure that the problem is resolved.

I have cited only six of about 160 Supreme Court decisions in water cases, but these seem to me to demonstrate the wisdom and sound common sense that the court has applied to our water law. I submit that we have reason to be profoundly grateful for the contribution that our judicial system has made to water management in New Mexico.

THE IMPORTANCE OF CROP PRODUCTION FUNCTIONS IN EVALUATING CONSUMPTIVE USE OF WATER

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INTRODUCTION

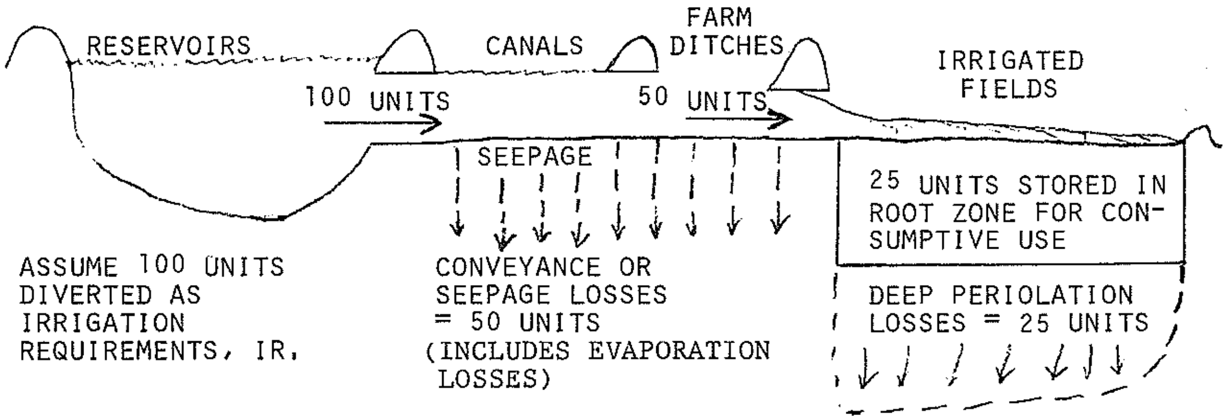
Consumptive use (evapotranspiration) information is required for many purposes, some of which are: (1) planning irrigation projects; (2) determining irrigation requirements for crops for designing irrigation systems; (3) determining equitable water rights; and (4) evaluating the life expectancy of the water supply in underground basins.

Consumptive use as used herein, is synonymous with evapotranspiration (ET) which is the quantity of water transpired by plants, retained in plant tissue, and evaporated from adjacent soil surfaces in a specified time period. It is usually expressed as a depth of water in centimeters, inches, or feet, etc.

Consumptive use is not a fixed value since it varies with crop yield. This variation is shown with crop-production functions which will be discussed later in this paper.

Normal consumptive use is the evapotranspiration that occurs when crops produce average yields. It may be determined by plotting the average yields on crop-production functions.

As an example to illustrate the importance of and the application of consumptive use as a base for computing irrigation requirements, Figure 1 is presented. In the figure and example, the following assumptions are made:



$$\text{IRRIGATION EFFICIENCY} = \frac{\text{25 UNITS STORED IN ROOT ZONE}}{\text{100 UNITS = IR (RESERVOIR DIVERSION)}} = 25\%$$

$$\text{CONVEYANCE EFFICIENCY} = \frac{\text{50 UNITS DELIVERED}}{\text{100 UNITS DIVERTED}} = 50\%$$

$$\text{FIELD APPLICATION EFFICIENCY, } E_a = \frac{\text{25 UNITS STORED}}{\text{50 UNITS APPLIED TO FIELDS}} = 50\%$$

$$\text{IRRIGATION EFFICIENCY} = (E_c = 50\%)\ (E_a = 50\%) = 25\%$$

IRRIGATION REQUIREMENTS, IR, MAY BE COMPUTED IF CONSUMPTIVE USE AND IRRIGATION EFFICIENCY ARE KNOWN THUS:

$$IR = \frac{\text{25 UNITS OF CONSUMPTIVE USE}}{\text{IRRIGATION EFFICIENCY = 25\%}} = \frac{25}{.25} = \text{100 UNITS}$$

Fig. 1. Profile of an irrigation system showing types of water losses and examples of computations of irrigation efficiencies and irrigation requirements.

1. 100 units of water are diverted from the reservoirs
2. 50 units are lost in conveyance by seepage and evaporation
3. 50 units are applied to irrigated fields of which half or 25 units are lost by deep percolation, thus leaving only 25 units as stored moisture in root zone for consumptive use.

The main objective of irrigation is to supply moisture in the root zone for plant growth. With only one-fourth of the diverted water, or only 25 units stored as soil moisture in the figure, the irrigation efficiency is 25%. The irrigation efficiency may also be computed by multiplying the conveyance efficiency, E_c, by the water applications efficiency, E_a, as shown in Figure 1.

Irrigation requirements may be computed with consumptive use as a base by working the example in reverse, if irrigation efficiency is also known thus:

$$\text{Irrigation Requirements} = \frac{\text{Consumptive Use} = 25 \text{ units}}{\text{Irrigation Efficiency} = 25\%} = \frac{25}{25} = 100 \text{ units}$$

Crop-production functions cited in this paper were obtained from research by Hanson and Sammis (10), Sammis et al. (12), and Horton, Wierenga, and Beese (11). The main objective of this research, which will be discussed in the remainder of this paper, was to determine evapotranspiration (ET) of selected crops throughout the growing season at Artesia, Clovis, Farmington, Las Cruces, and Los Lunas (Fig. 2) and to relate ET data to yield.

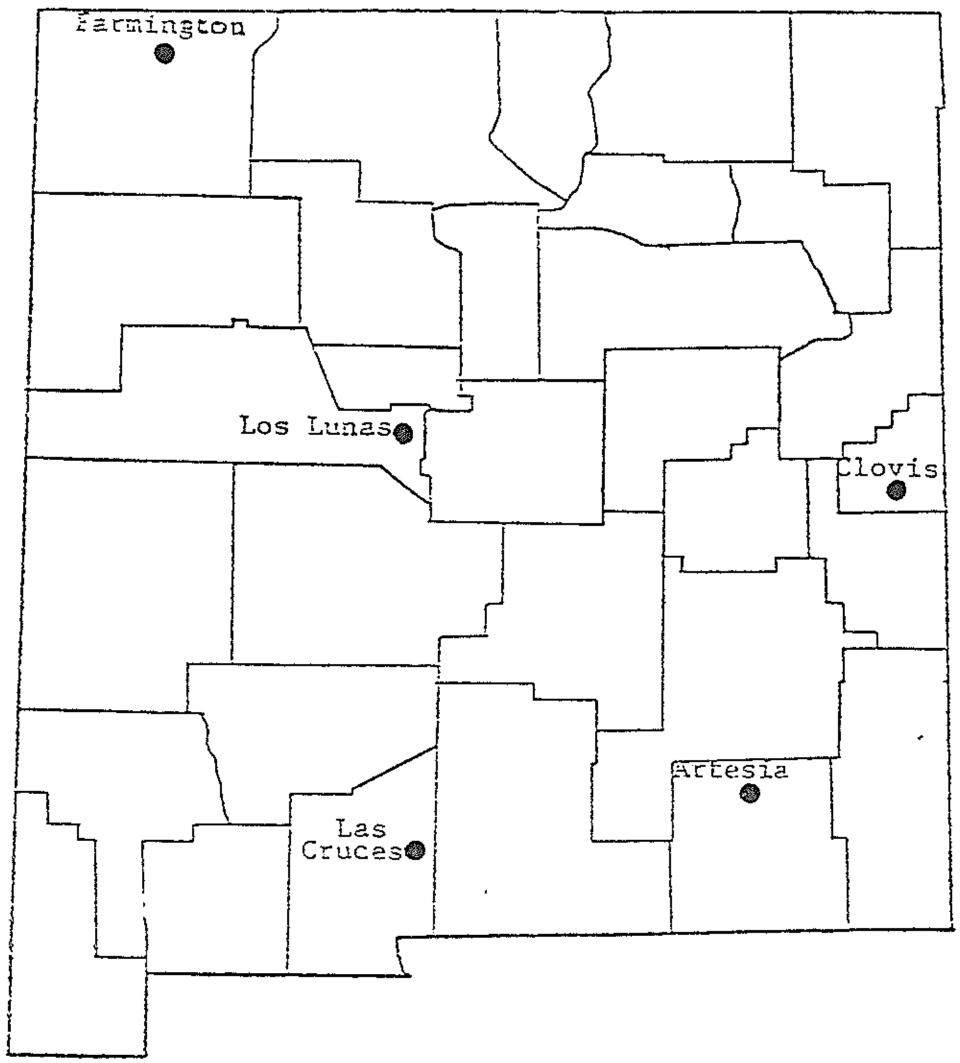


Fig. 2. Locations where evapotranspiration measurements are being conducted on selected crops in New Mexico.

MATERIALS AND METHODS

Figure 3 is a map of the 1976 and 1977 study sites and surrounding fields. Figure 4 is a map of the 1978 research site. Table 1 presents the various crops grown at the study sites throughout the state. For 1976 and 1977 research, the ET rate was measured for each crop with a non-weighing type lysimeter and a water-balance technique.

$$ET = I + R - D \pm \Delta SM \quad (1)$$

where I = Irrigation

R = Rainfall

D = Drainage

ΔSM = Change in soil moisture

Lysimeters 1.8 x 1.8 meters and 1.21 meters deep were installed in field plots for each crop. Lysimeter construction plans are presented in Figure 5. A hole was dug by hand with the soil moved from the hole and stored according to the order it was removed. The hole was then lined with plywood 1.9 cm thick (3/4 inch) and five layers of 4 mil black plastic. Suction candles and drainage pipe 1.27 cm in diameter (1/2 inch) were installed at the bottom. The lysimeters were filled with 15 cm of sand and then backfilled with the original soil in the order that it was removed. Neutron access tubes were installed in the lysimeters to measure weekly, with a neutron probe, the changes in soil moisture at every 15 cm of depth. The drainage water was pumped out with a vacuum pump during several days following irrigations.

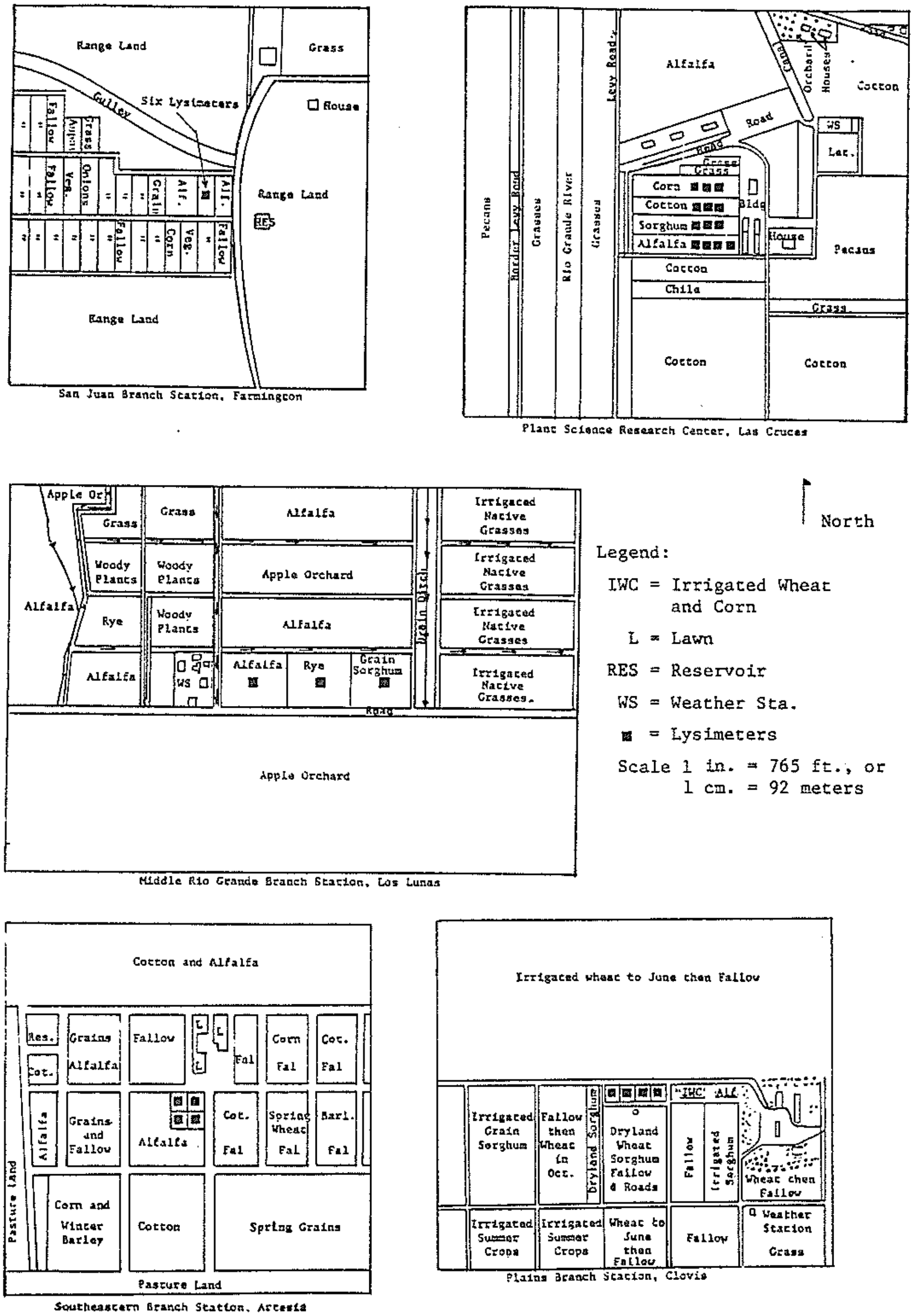


Fig. 3. Study sites and surrounding fields 1976 and 1977.

Table 1. CROPS GROWN AT STATIONS

Location	1976[a]	1977[a]	1978[b]
Las Cruces - Plant Science Research Center	Alfalfa, Mesilla Sorghum, RS671[c] Cotton, 1517V	Alfalfa, Mesilla Sorghum, RS671[c] Cotton, 1517V Barley Sudangrass	Alfalfa, Hairy Peruvian Cotton, 1517-75
Artesia - Southeastern Branch Station	Alfalfa, Mesilla Barley, Penasco Sorghum, RS671 Cotton, 1517V	Alfalfa, Mesilla Barley, Penasco Sorghum, RS671 Cotton, 1517V	
Los Lunas - Middle Rio Grande	Alfalfa, Mesilla Sorghum, RS671 Bluegrass, Newport	Alfalfa, Mesilla Sorghum, RS671 Bluegrass, Newport Rye, TP	
Clovis - Plains Branch Station	Alfalfa, Mesilla Sorghum, DeKalb E59+ Corn, Pfizer TXS-115A Wheat, Centurk	Alfalfa, Mesilla Sorghum, DeKalb E59+ Corn, Pfizer TXS-115A Wheat, Centurk	
Farmington - San Juan Branch Station	Alfalfa, Mesilla Sorghum, RS671 Barley, Steptoe Corn, PX610	Alfalfa, Mesilla Sorghum, RS671 Barley, Steptoe Corn, PX74	

a Crops grown in lysimeters with surface flooding.
b Crops grown in field plots with sprinkler irrigation.
c Crop yields were omitted due to damage by birds.

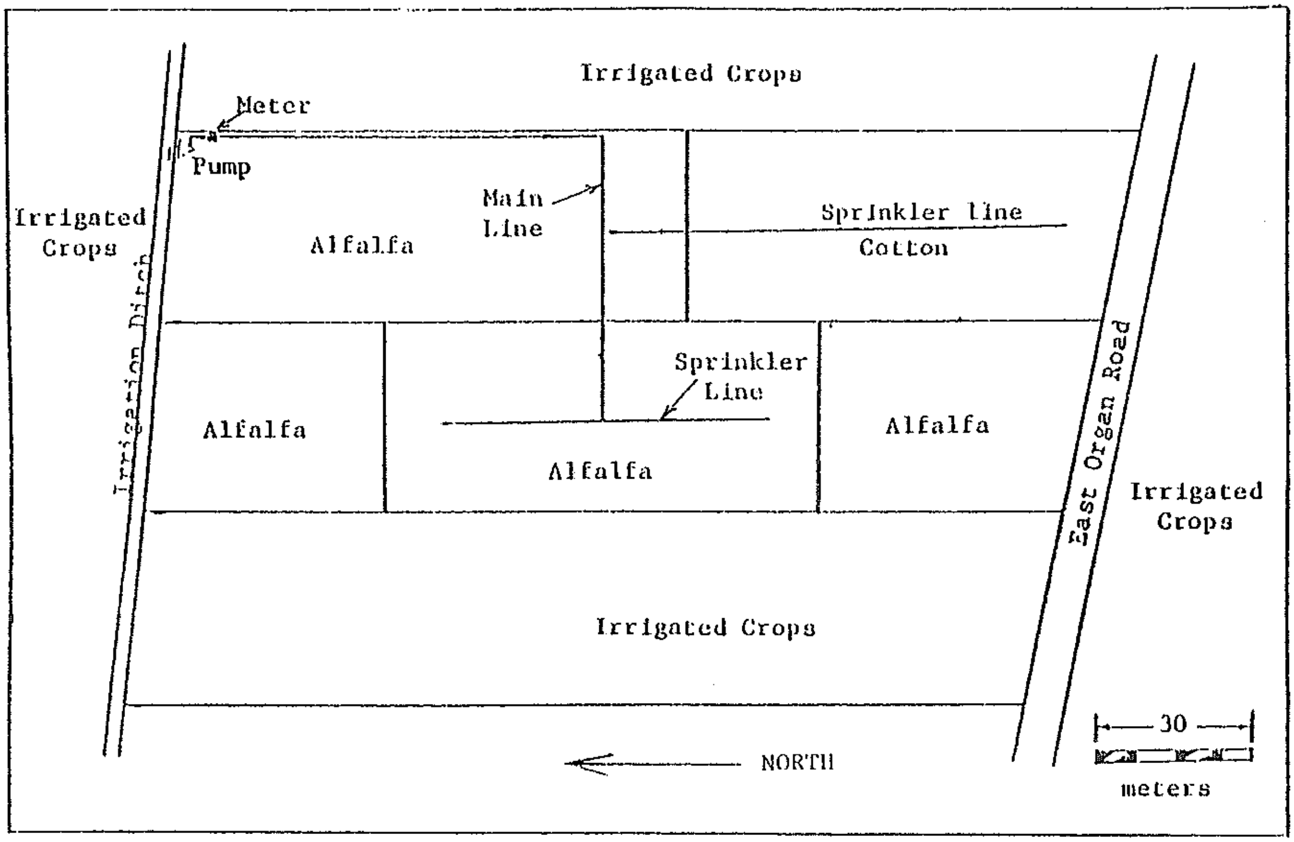


Fig. 4. Schematic diagram of the alfalfa and cotton plots irrigated by sprinklers. 1978.

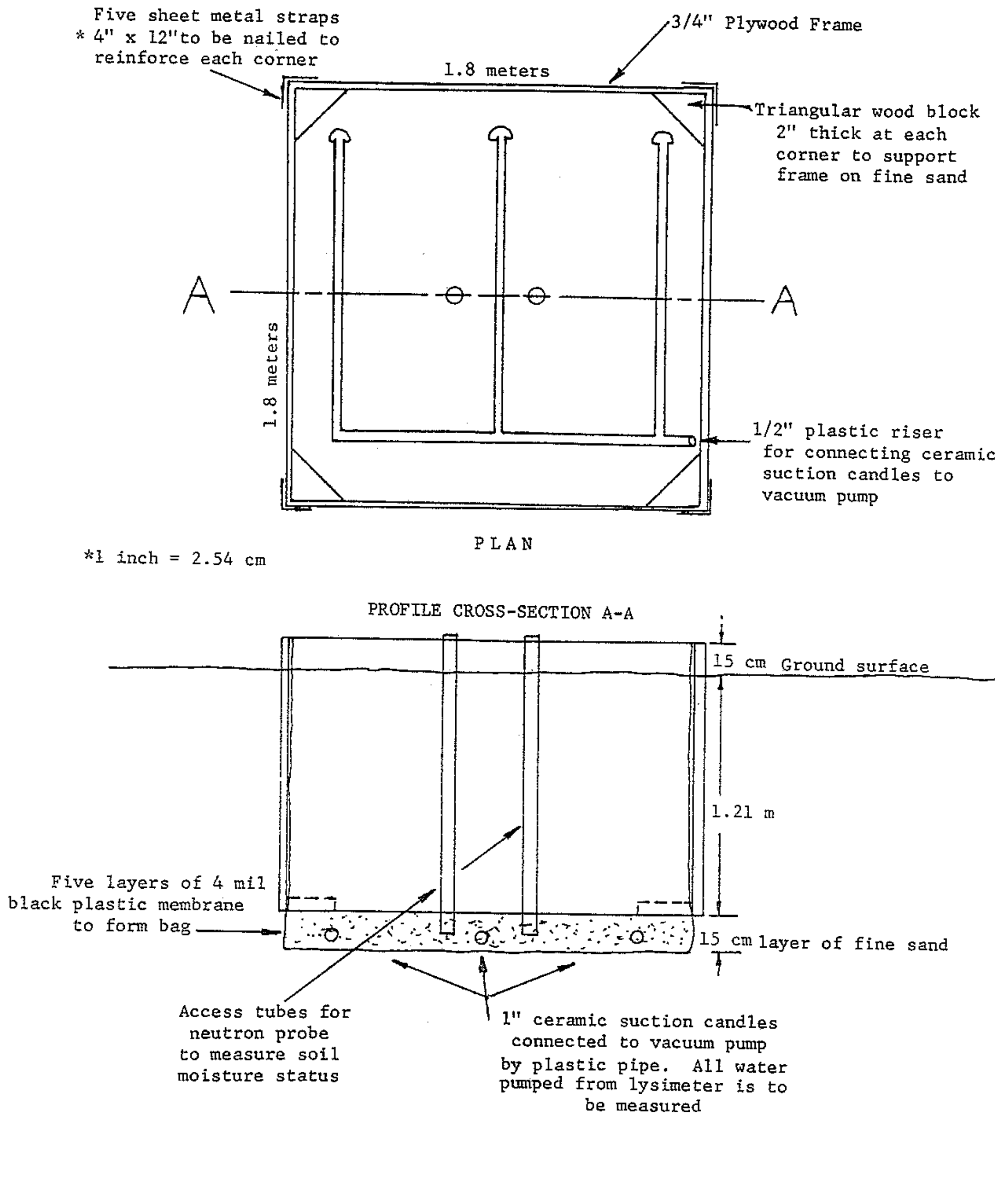


Fig. 5. Plan and profile of drainage-type lysimeters.

Irrigations were generally applied weekly during peak evapotranspiration months to assure that crop growth and yields would not be limited by inadequate water. Fertilizer was applied as necessary so that deficiencies would not limit growth and evapotranspiration rates.

Yield was measured from the lysimeters and adjacent field at harvest time.

The 1978 research site (Fig. 4) was located 5 kilometers east of the Plant Science Research Center near Las Cruces. Alfalfa and cotton were each grown in approximately 30- by 50-meter plots using a sprinkler-line source (8) without stressing the crop near the sprinkler-line throughout the growing season. A decreasing total water application was applied away from the line (Figs. 6 and 7). Water quality ranged from 0.43 to 1.61 mmhos per cm (EC x 10^{-3}).

Measurements of soil moisture were taken on the cotton and alfalfa plots at two-week intervals through the growing season. Water applied to the plots was measured with catchment cans spaced every meter away from the sprinkler-line source. The cans were raised in height as the plants grew so their level was the same as the canopy level.

RESULTS AND DISCUSSION

Crop-production functions

Evapotranspiration and yields from lysimeters in 1976 and 1977 have been plotted in Figures 8 through 11. Data from sprinkler plots in 1978 have been plotted in Figures 8 and 9. Also included

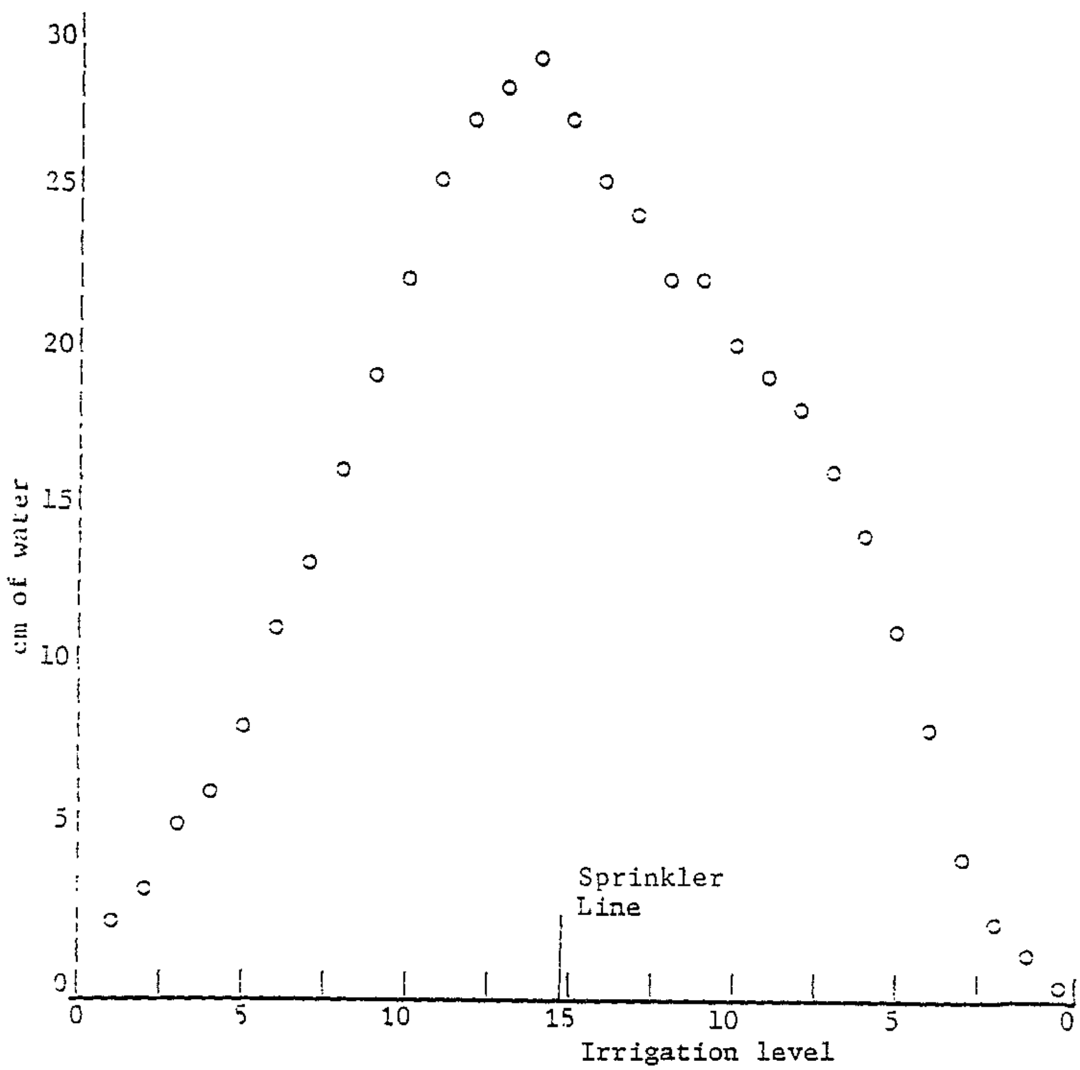


Fig. 6. Total seasonal applied water to the cotton plot (1978) using a sprinkler-line source excluding 16.9 cm (6.7 in.) of rainfall.

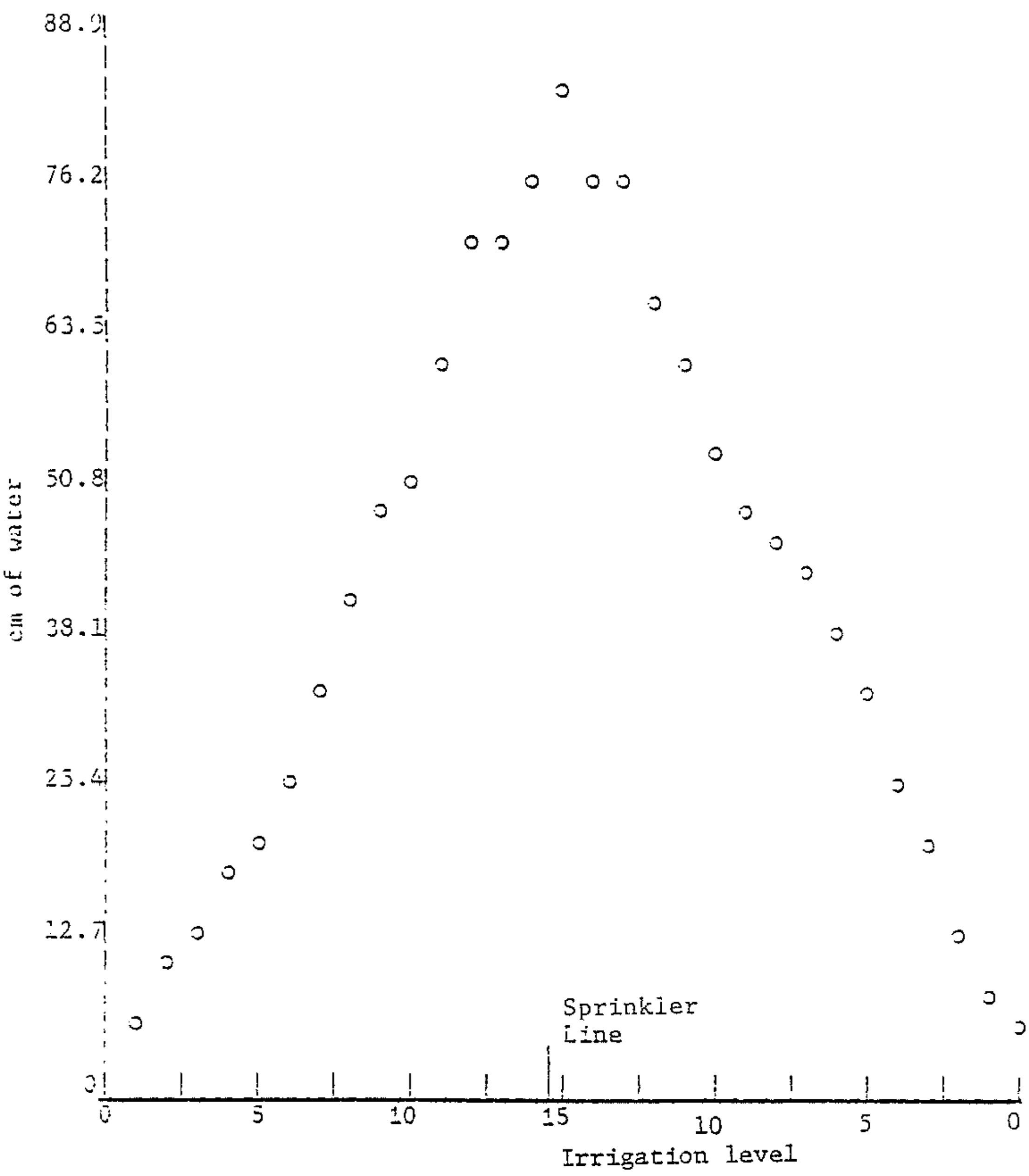


Fig. 7. Total seasonal applied water to the alfalfa plot (1978) using a sprinkler-line source excluding 18 cm (7 in.) of rainfall.

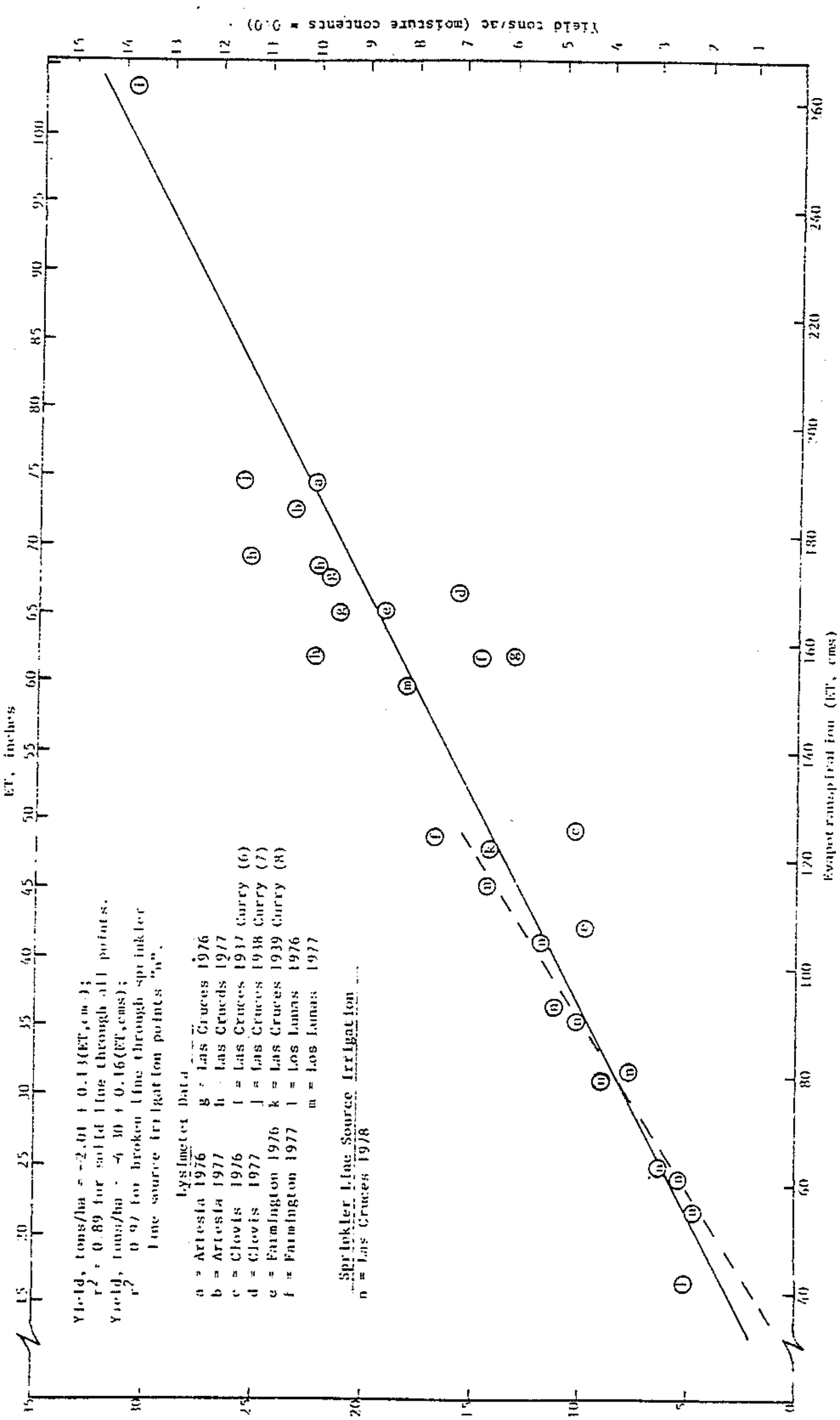


Fig. 8. Crop-production function for alfalfa.

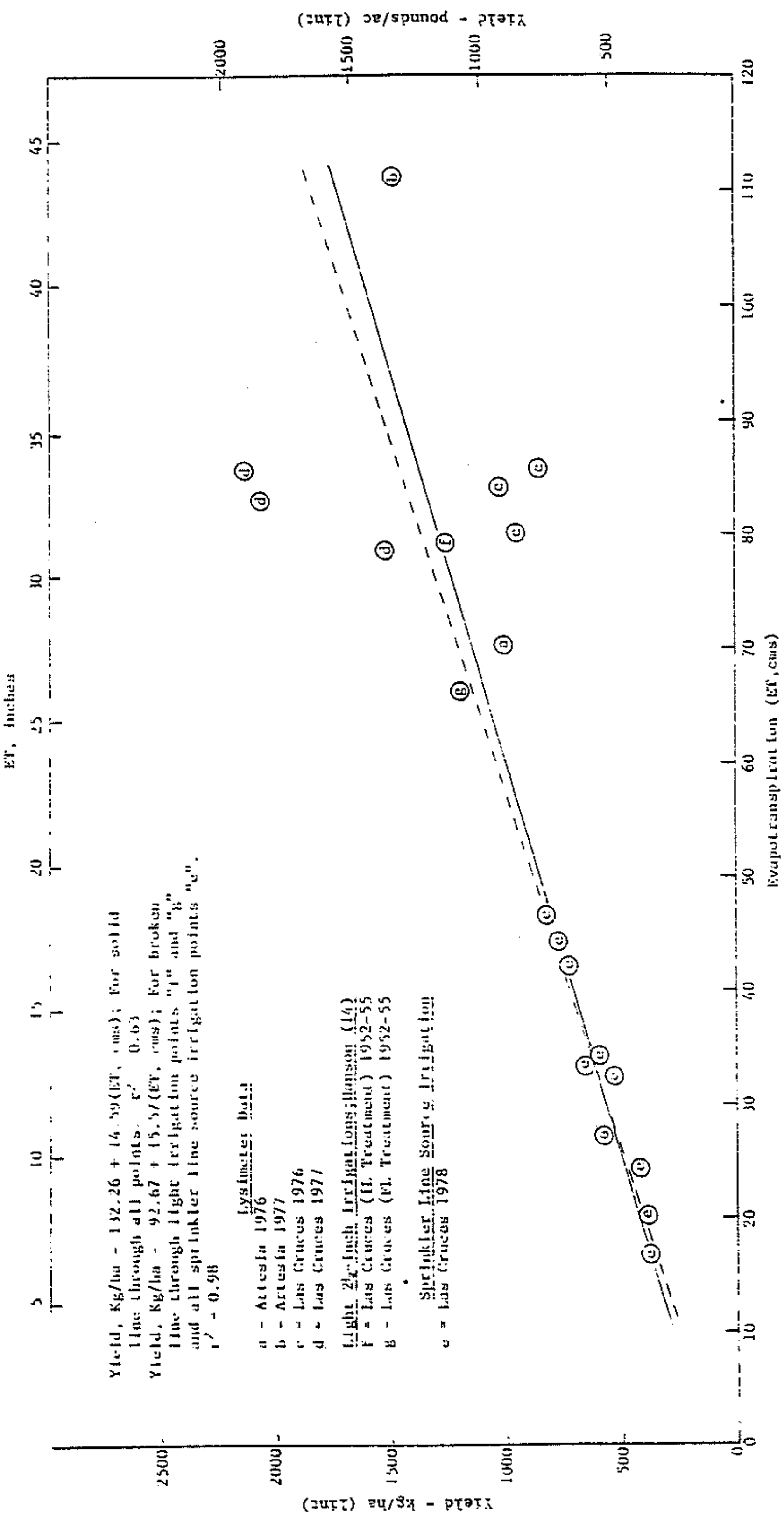


Fig. 9. Crop-production function for cotton.

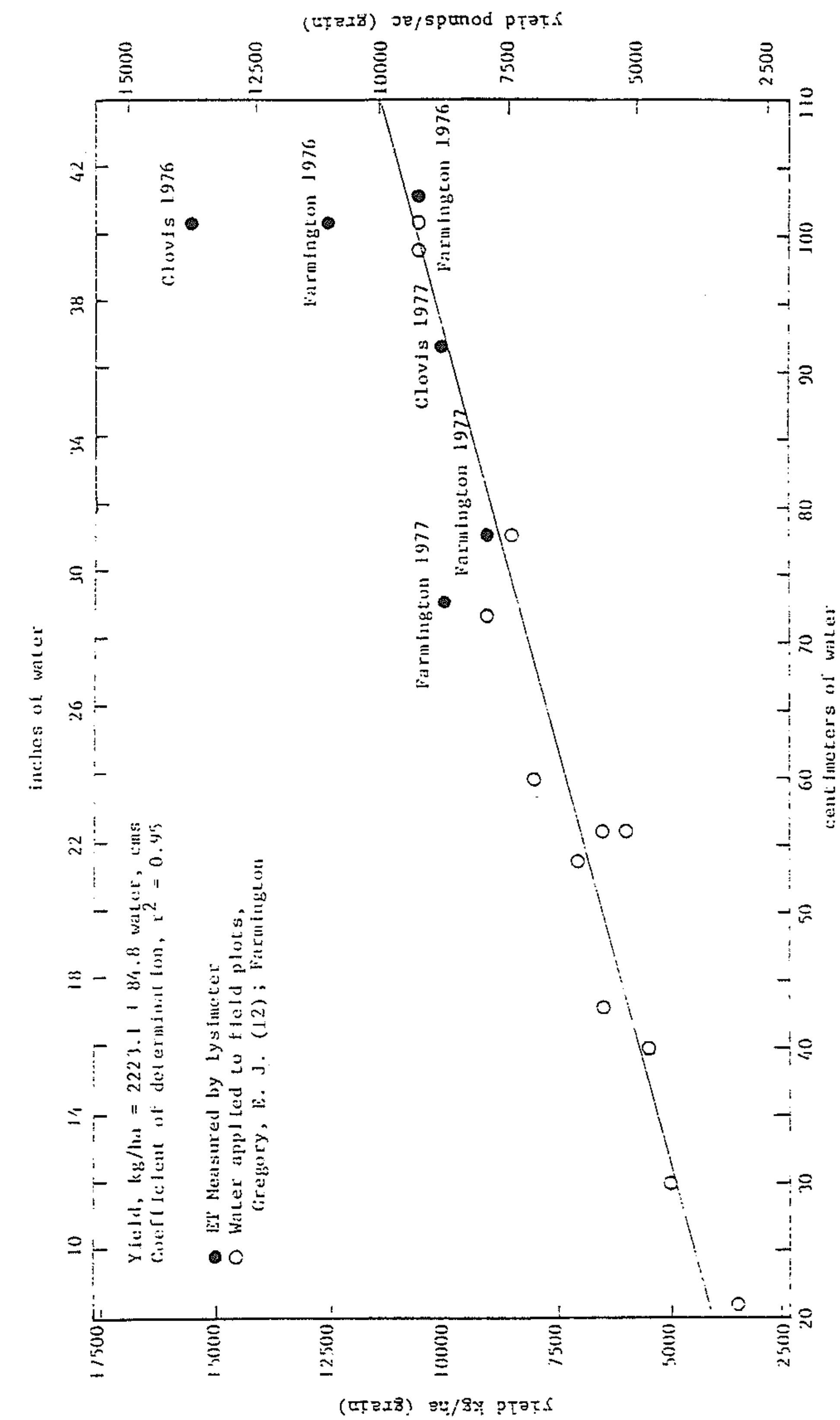


Fig. 10. Crop-production function for grain corn.

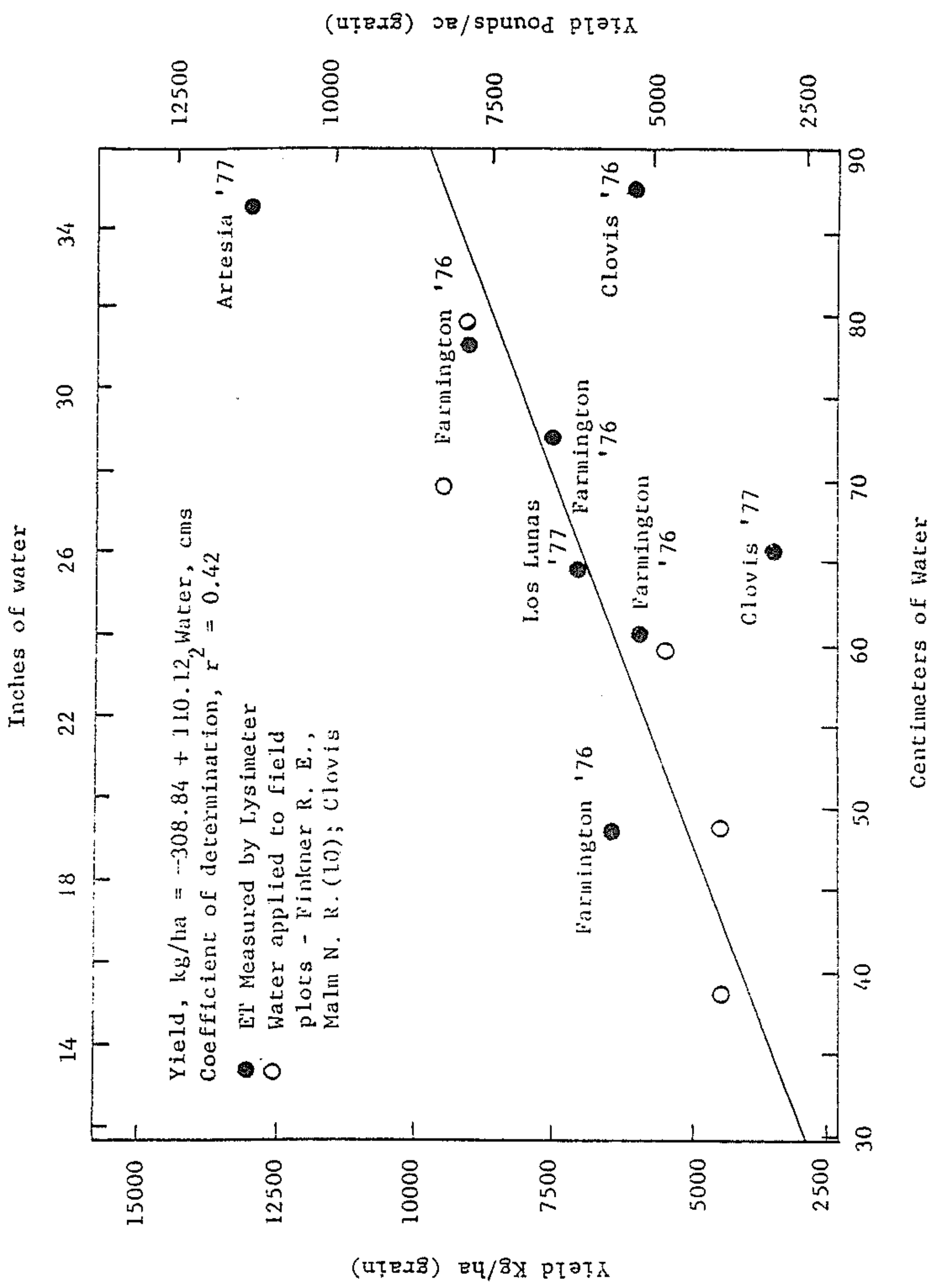


Fig. 11. Crop-production function for grain sorghum.

in Figures 9, 10, and 11 are additional data of water applied and yield from selected irrigation research projects in the state which were conducted earlier by Gregory (7), Finkner and Malm (6), and Hanson and Knisel (9). The crop-production functions are quite linear, as shown with coefficients of determination in Figures 8 through 11. Although the "water applied" measurements of earlier irrigation research projects may not be strictly ET, they are close estimates inasmuch as they represent irrigation treatments of reasonable light irrigations where deep drainage was minimal. The "centimeters of water" in the figures include rainfall.

Crop-production functions from other research by Horton, Wierenga, and Beese (11) with chile in 1977 to 1979 are shown in Figures 12 and 13. The data for each year almost fits a straight line with slopes varying somewhat from year to year. The average r^2 value for three years is 0.84 and 0.80 for green chile and red chile, respectively.

For alfalfa (Fig. 8) and cotton (Fig. 9), the sprinkler-line source data are combined with lysimeter data. The crop-production function for alfalfa, using only the sprinkler-line source data, has a coefficient of determination of 0.97 as a linear function. When the sprinkler-line source data are combined with the lysimeter data, the coefficient of determination is 0.89. In the range of normal production on farms, the results from both curves will not vary more than 6%. Using all of the points is considered to give the best results for alfalfa crop-production functions for the whole state.

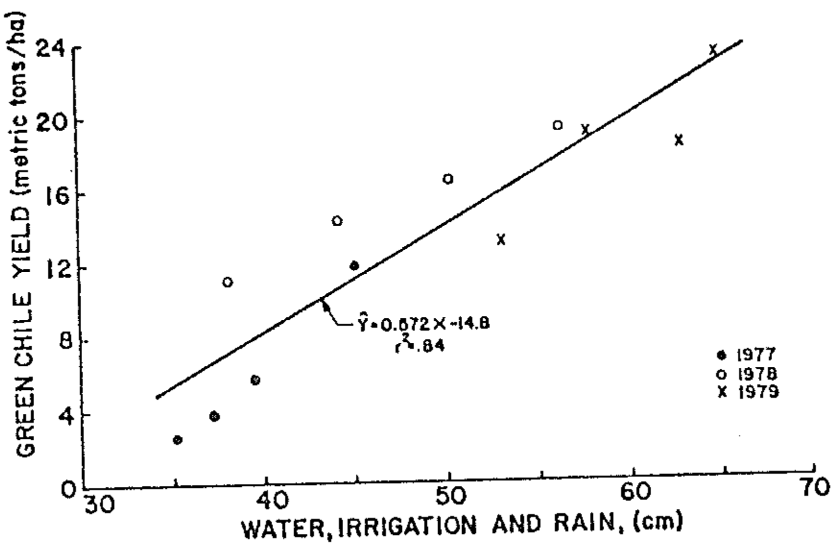


Fig. 12. Average green chile yields (metric tons/ha) by treatment for 1977, 1978 and 1979 versus total water, rain plus irrigation (cm). From Horton, Wierenga, and Beese (11).

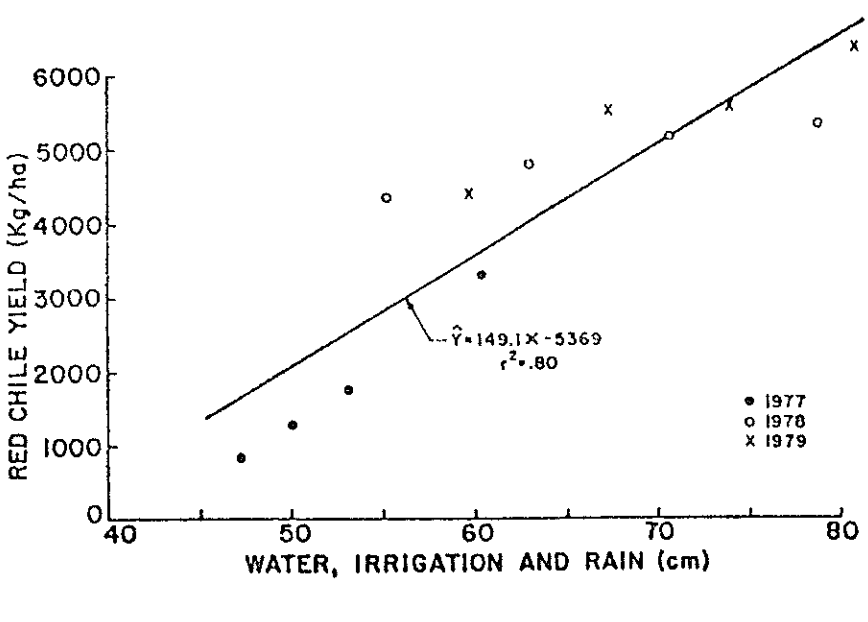


Fig. 13. Average red chile yields (kg/ha) by treatment for 1977, 1978 and 1979 versus total water, rain plus irrigation, (cm). From Horton, Wierenga, and Beese (11).

Sprinkler-line source data are on the low end of the crop-production functions and none of the water applied appears to have been lost by deep percolation. Even the highest sprinkler applications, which were measured near the line, are close to or above the production functions in Figures 8 and 9. If there had been appreciable deep percolation, the points for the higher sprinkler applications would have deviated to the right and to a position below the crop-production function.

The cotton data, using the sprinkler-line source, have a coefficient of determination of 0.98 as a linear function, but when included with lysimeter data, which have considerable scatter, the coefficient of determination drops to 0.63. Again, as with alfalfa, the slope of a curve through the sprinkler-line source data is very similar to the slope of a curve through all the combined points. Even though the cotton-production function for only the sprinkler-line source data has the highest coefficient of determination, the function for all points in the figure is considered to be most appropriate for use. In the range of normal production on farms, the results from both curves will not vary more than 4%.

For the crop-production function for corn in Figure 10, data from an applied water study by Gregory (7) was plotted with lysimeter data. The data are fairly close to the function except for one of the lysimeters in 1976 which is considerable higher in yield than predicted by the crop-production function.

Data in Figure 11 for sorghum has the lowest correlation and additional studies need to be made before any large amount of confidence can be put on the crop-production function in Figure 11. As linear crop-production functions for corn and sorghum, the coefficients of determination are 0.95 and 0.42, respectively.

Stewart et al. (13) report that the crop-production function is linear for grain corn and dry matter with r^2 ranging from 0.51 to 0.98.

It should be noted that the crop-production functions for alfalfa, cotton, grain sorghum, and corn represent studies at more than one location within the state. It appears that as an initial estimate, the crop-production function for alfalfa can be used in several areas of the state. For the other crops, additional studies need to be done in other areas to determine the reliability of transferring the crop-production functions around the state.

Any variable that causes a reduction in evapotranspiration may result in a corresponding reduction in yield. Evapotranspiration reductions may be due to limitations of water, solar radiation, temperature, management, insect infestations, or an increase in soil salinity. Salinity effects may be observed in Curry's data of 1937, 1938, and 1939 (3, 4, 5). These data, shown in Figure 8, were collected using lysimeters that were operated by Curry to maintain a water table at approximately 90 cm (36 inches) below the ground surface. An increase in salt in the soil profile from one year to the next is inevitable with this type of lysimeter. Although there were no measurements of the amount of salt increase, approximate computations indicate that soil salt could have increased as much as 0.4%. This could have caused the yields and evapotranspiration to decrease during 1938 and 1939.

Limitations in Estimating Consumptive Use by the Crop-Production Functions

It is much easier to farm small lysimeters and small experimental plots to obtain high yields than to farm large acreages. Higher yields and higher ET may occur in lysimeters where the soil has been excavated and replaced during the lysimeter construction. This, in effect, is "deep plowing" which will break up impermeable layers or plow pans which may exist in the fields and restrict root growth. The lysimeters used in this research had a 15 cm (6 inch) ridge projecting above the ground to keep out water during furrow or flood irrigations of adjacent fields. The ridge provided somewhat of a shelter and extra advective energy, thus causing some "hothouse" effects. The results of these effects were observed in some lysimeters where the plants within the lysimeters grew faster and larger and required more frequent irrigation to prevent wilting, as compared to crops on adjacent farmland resulting in higher ET.

With respect to crop-production functions, the advective energy and deep plowing effects probably do not distort the ET-yield relationship. Where these factors cause higher ET there also appears to be an overall corresponding increase in yield, thus keeping the slope of the functions quite constant.

In managing small alfalfa plots, for example, harvesting can be accomplished in one day and irrigation water applied the next day. With large-scale farm operations, it may require a week or 10 days to remove the harvested bales before the next irrigation water may be applied. Delaying the irrigation after alfalfa cuttings may restrict ET and alfalfa yield in many types of soils.

Research on experimental plots may show potentials which will be achieved if it is possible to overcome large-area management problems. Economics of large-scale farming place a limit on achieving potential yields with present equipment and costs.

There appears to be more direct and stable correlation between ET and yield of alfalfa than for grain crops. With alfalfa, the entire plant is harvested which gives a better measure of yield than a seed crop for relating yield to ET. With grain crops, there may be a low yield of grain due to weather conditions, cultural practices, or damage by birds or insects, even though the plants may be large and may require a relatively high ET. Consequently, using average county yields (1) of grain crops to compute average county ET using the crop-production function may be misleading. One approach would be to use the yields from fields having relatively high yields for that county. This would represent the ET for the crop under proper management conditions.

Caution must be taken when using the crop-production functions to make sure that the yield published in agricultural statistics represents the total yield. Where some of the alfalfa may have been grazed by animals, the yield published in statistics will be low.

The use of crop-production functions having high coefficients of determination appears to be one of the better methods of estimating ET in an area, provided reasonable estimates of yields can be determined for that area.

The results of this research show that more work is needed with these and other crops, especially with seed crops, to have data with adequate coefficients of determination.

In the past, ET has been estimated with equations based on limited meteorological data, such as the Blaney-Criddle method (2). Results of the Blaney-Criddle method for alfalfa are shown in Figure 14. Using county yields (1) with the crop-production functions results in ET estimates slightly lower than the Blaney-Criddle method. The high ET, shown in the figure for lysimeters, is representative of the high yields measured for alfalfa in the lysimeters (Fig. 8).

In Figure 14, where the average county yield of 5 tons per acre is plotted with the crop-production function, the normal consumptive use is approximately 91 cms or 36 inches. Where reliable crop-production estimates are available for an area, the use of the crop-production function appears to be the best method for determining normal consumptive use.

SUMMARY AND CONCLUSIONS

Alfalfa, grain corn, cotton, chile, and grain sorghum were grown at selected locations throughout the state of New Mexico, including Las Cruces, Artesia, Los Lunas, Clovis, and Farmington.

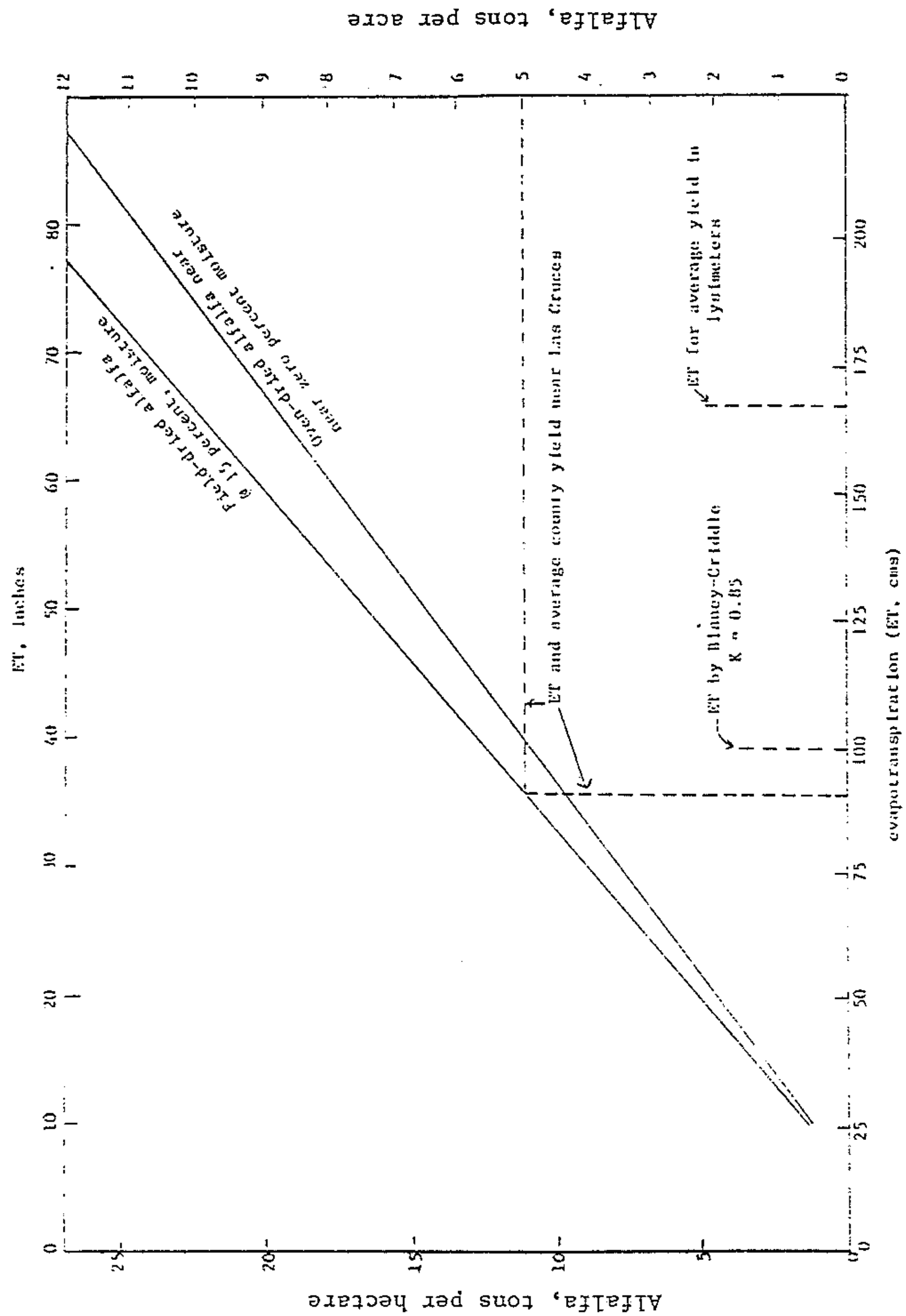


Fig. 14. Crop-production function for alfalfa showing the average evapotranspiration measured in lysimeters at Las Cruces as compared to that of the average county yield and the Blaney-Criddle method.

Lysimeters were installed in the center of the fields, and yields with monthly and yearly evapotranspiration rates were measured in 1976 and 1977. In 1978, a sprinkler-line source was used to irrigate alfalfa and cotton in field plots for the measurement of yields and evapotranspiration. These data and data from other irrigation projects were used to derive crop-production functions for alfalfa, grain corn, cotton, and grain sorghum. Additional data are needed to establish or refine the crop-production functions for most of the crops. The coefficient of determination, r^2, ranged from 0.97 for alfalfa to 0.42 for grain sorghum.

An example of using a crop-production function with average county yield to determine normal consumptive use is presented. Caution must be taken in using county average yields with the crop-production function of grain crops, due to the high variability in county yields. Also, in areas where alfalfa is grazed, part of the yield will not be included in agricultural statistics for use with the crop-production function.

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WATER RESOURCES OF THE RIO GRANDE - AN INTERDISCIPLINARY APPROACH

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Professor of Agricultural Economics
New Mexico State University

The New Mexico Water Resources Research Institute has fostered interdisciplinary as well as interuniversity research from its inception. Multidisciplinary-interuniversity research has been made possible through the various agreements entered into by the Institute with federal agencies and with the University of New Mexico, the New Mexico Institute of Mining and Technology, and New Mexico State University. These types of research projects are extremely useful for two major reasons. First, a mix of highly qualified research personnel can be drawn to the project from these three New Mexico institutions of higher learning, and second, several aspects of a large and complex problem can be studied at one time with exchange of information and coordination of effort between the various investigators.

Examples of interdisciplinary-interuniversity projects are given here to indicate the range of subjects and the variety of disciplines involved. The primary purpose of the interdisciplinary-interuniversity research projects were:

1. To apply the newly developed techniques of several research disciplines in a coordinated and unified interuniversity project to the present and future management and allocation of water in New Mexico.

2. To establish a set of alternative goals and to develop and analyze alternative designs which may be used to achieve these alternative goals.

3. To determine the water use pattern which would evolve as a result of the selection of alternative goals.

Shortly after the Institute officially started in 1966, the Water Resources Research Institute sponsored a "brainstorming" session to discuss the possibilities of a Pecos Basin project. It was expected that possibly 40 interested persons might wish to attend. There were 71 participants from the three university units, together with private individuals and state and federal agency personnel. There was a brisk, sincere discussion which resulted in a project proposal entitled "A Comprehensive Water Resources Analysis of a Typical Overdrawn Basin in an Irrigated Semi-Arid Area: Pecos River Basin, New Mexico." Investigators, representing seven departments from the three universities, were as follows: Willis Ellis, Law, and Ralph D'Arge and Nathaniel Wollman, Economics, University of New Mexico; C. E. Jacob, Hydrology, and W. K. Summers, Geology, New Mexico Institute of Mining and Technology; and from New Mexico State University, John W. Hernandez, Civil Engineering; Harold Dregne, Agronomy; Robert Lansford, Agricultural Economics; and H. R. Stucky, Institute Director and Coordinator of the entire project.

The result of this "brainstorming" session was the organization of the first interdisciplinary-interuniversity project, Project

3109-102, a comprehensive study of the entire Pecos River Basin in New Mexico.

Following the completion of the Pecos River Basin Study, a group of potential investigators got together to discuss the possibility of an interdisciplinary-interuniversity study of the Rio Grande in New Mexico. The outgrowth of these meetings was the funding of a matching grant from OWRT entitled, "An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico." The investigators represented seven disciplines: civil engineering, industrial engineering, hydrology, architecture, law, sociology, and economics; and three universities were represented: University of New Mexico, New Mexico State University, and New Mexico Institute of Mining and Technology.

The primary objective of this study was to develop methodology and criteria which might make a major contribution to the efficient allocation, management, and consumptive use of the water supply of the Rio Grande in New Mexico and to similar arid areas of the United States and the world.

Because of the interest in and results from the above study OWRT funded one of the first regional matching grants in the nation for an interdisciplinary, comprehensive water resources analysis of the Rio Grande from Elephant Butte to Fort Quittman, Texas. The Universities involved were Texas A&M University, the University of New Mexico, and New Mexico State University.

Because of the interest generated by Los Alamos Scientific Laboratory personnel at a previous Water Conference a large group of university faculty members from the University of New Mexico, New Mexico Tech, and New Mexico State University prepared and submitted a proposal to the Board of Educational Finance through the Water Resources Research Institute to study the feasibility for the establishment of an energy-water complex in the Tularosa Basin. This study was among the first funded from the enactment of monies for research from severance tax revenues on energy resources in New Mexico.

The primary objective of this study was to prepare a preliminary evaluation of the economic feasibility for a proposed nuclear desalting complex in the Tularosa Basin of New Mexico producing 2,000 megawatts of electricity and desalting a half-million acre-feet of saline groundwater.

A more recent study funded by the Environmental Protection Agency through the Water Institute was entitled, "Demonstration of Irrigation Return Flow Salinity Control in the Upper Rio Grande." Its primary objective was to show the feasibility of alternative water management practices on the quality of drainage return flow and soil salinity in the Upper Rio Grande Basin and to test a hydro-salinity model.

This interdisciplinary study involved the use of monitoring an actual farm that many of you visited during the Water Conference a couple of years ago.

What made these large interdisciplinary studies successful? I feel two things were very important in making them successful. The first was that most of the projects described above had an advisory committee composed of state and federal agencies who met with the research staff on various technical and policy questions. The assistance from the advisory committee was very helpful. In addition, communication developed between researchers at the universities and the state and federal agencies. Appreciation and respect developed for each other's problems and possible solutions.

The second factor contributing to their success was research meetings with colleagues from other universities and disciplines which started a dialogue. It is very difficult sometimes to carry on a discussion because of the specialized jargon used by each discipline and different meanings associated with technical terms. I feel that through these interdisciplinary research projects barriers were broken and meaningful research has been carried out.

MEET THE SPEAKERS
SESSION II

GEORGE O'CONNOR is Associate Professor of Agronomy at New Mexico State University, specializing in soils. He has been involved in numerous research projects for WRRI, and is currently involved in a greenhouse study designed to evaluate the potential for using saline water to grow common crops in soils of agricultural importance in New Mexico. O'Connor is a graduate of the University of Massachusetts, and obtained his Doctoral Degree from Colorado State University.

KENNETH R. REHFELDT is presently Research Associate in Hydrology at New Mexico Institute of Mining and Technology. The work presented at the Water Conference was sponsored by WRRI and is part of the research done to obtain his Master's Degree in Hydrology, awarded in May, 1980. He received a Bachelor's Degree in Geological Sciences at the University of Wisconsin-Milwaukee in 1978. His research interests are numerical modeling of groundwater flow systems, and stochastic methods in hydrology, especially kriging.

BILL MELTON and MARVIN WILSON are Agronomy Professors at New Mexico State University. The research agronomists have been working for two years on the problem of improving alfalfa production under less-than-optimum moisture conditions. Melton is a graduate of New Mexico State University and the University of Illinois; Wilson is a graduate of Oklahoma State University and Oregon State University. Wilson is the former Head of the Department of Agronomy and former Associate Director of New Mexico State University's Agricultural Experiment Station.

JAMES F. DANIEL is the U. S. Geological Survey's top water-resources official in New Mexico. He directs the Survey's $4.28 million annual water-investigation and data-collection program in the state. Jim has served in California, Indiana, Missouri, Alabama, and most recently was Regional Ground-Water Specialist for the Southeastern Region, until coming to New Mexico in the fall of 1979. Daniel has been with the USGS for 21 years, having joined the Survey in Merced, California in 1958. He received a Bachelor's Degree in Civil Engineering in 1965 from California State University at Sacramento.

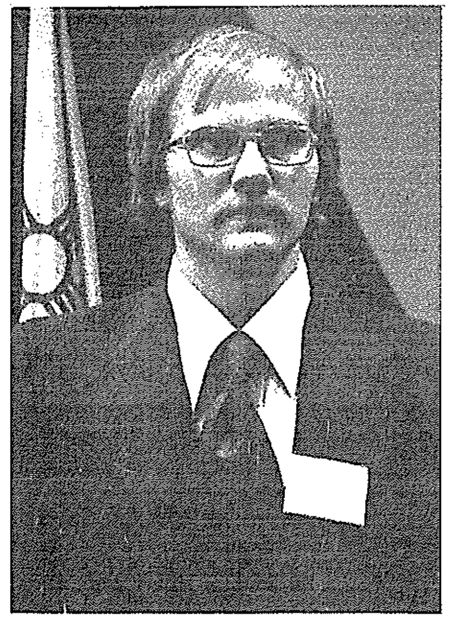
WARREN WEBER is the New Mexico Representative of the Water and Power Resources Service. He has just completed 40 years with the agency (formerly the Bureau of Reclamation), having served in the states of Washington, Montana, North Dakota, and New Mexico. Weber's major responsibility is to supervise a variety of water-resource planning activities sponsored by the federal government.

JOE B. HARRIS is a Resource Economist in the Water Resources Division of Camp Dresser & McKee Inc. An agricultural economist with almost 30 years professional experience in resource planning and management, Harris joined CDM/WRD in 1979 following extensive experience in Texas State government. Since joining CDM, Harris has applied his experience in resource economics and planning to a variety of projects, with principal attention to the Six-State High Plains-Ogallala Aquifer Regional economic development study.

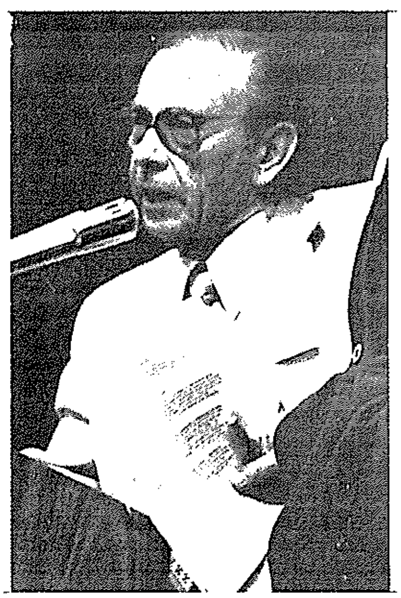
FRANK A. DUBOIS is an Agricultural Programs Specialist with the New Mexico Department of Agriculture. He was formerly an assistant to U. S. Senator Pete V. Domenici of Las Cruces, New Mexico, from 1974 to 1979. His degree is from New Mexico State University in Agricultural and Extension Education.

Session Two: Current Activities
Speakers

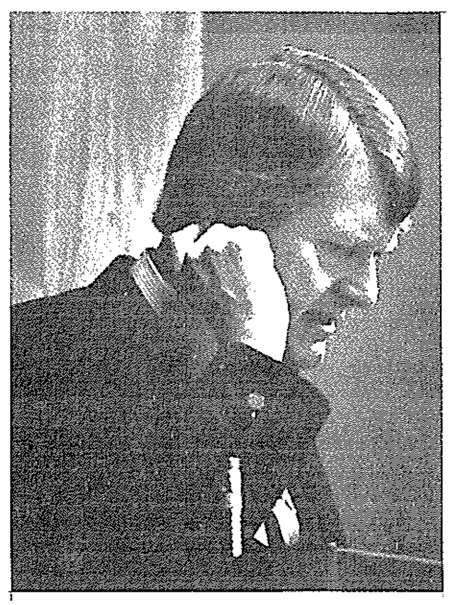
George O'Connor



Ken Rehfeldt

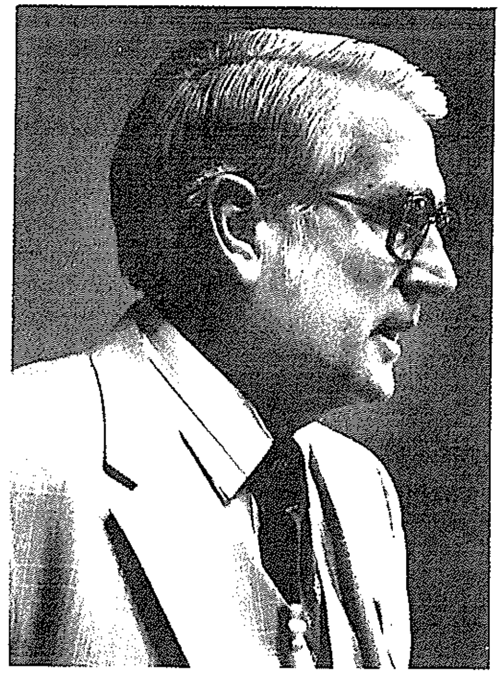


Marvin Wilson



Jim Daniel

Warren Weber



Joe Harris

Frank DuBois

SALINE WATER UTILIZATION - AN INTERNATIONAL PERSPECTIVE

George O'Connor
Associate Professor of Agronomy
New Mexico State University

In 1977, I attended an International Workshop on Biosaline Research, cosponsored by the National Science Foundation and the Kuwait Institute for Scientific Research. The biosaline concept espoused there (San Pietro 1978) envisions the "harmonious interplay of high solar radiation, high temperature, and saline water availability as the foundation of a unique, renewable resources program for desert lands focused on biogrowth in a saline environment." The organizers challenged the participants to put aside traditional ideas of irrigated agriculture, and to concentrate instead on new ways to use the world's immense resources of saline environments.

Potential approaches included: 1) expanded utilization of plant species native to arid and saline environments; 2) breeding for increased salinity tolerance; 3) harvesting of marine flora (macro-algae) for food; and 4) modification of the environment through controlled-environment agricultural technology. The latter technique allows a broad range of conventional and unconventional crops to be grown with limited supplies of fresh or saline water in greenhouses.

Potential users of the biosaline concept include virtually every country in the world, but for differing reasons. The less-industrialized countries could profit tremendously through increased food production and greatly improve their peoples' quality of life. The highly industrialized countries could make better use of underutilized land, and divert fresh water supplies to alternate uses -- domestic or industrial.

Over the last few months, I have had the opportunity: 1) to discuss examples of biosaline research with several representatives of the less-industrialized countries; 2) to witness experiments in the USSR and Israel; and 3) to conduct my own work here in New Mexico. My purpose here today is to share some of my experiences with you.

Saline Water Resources and their Classification

At first glance, the scientific literature and practical experience would lead one to believe that there is nothing new that needs to be learned about utilizing "saline" waters. Farmers, for example, have apparently used "saline," "salty," or "brackish" waters for years. The critical element, however, is in the definition of saline; the level of total dissolved solids (TDS).

The state of New Mexico (U.S. Department of the Interior 1976) classifies water according to the values given in Table 1. Examples of each salinity class are given for reference.

Most (>95%) of the water used for irrigation in the USA has TDS <1,500 mg/l, and much of the published research has been with this quality water. However, there are numerous recent reports of saline-water research utilizing waters with 2,500-5,000 mg/l TDS (Jury et al. 1978; Miller 1979; Moore and Murphy 1978). Epstein and Norlyn (1977) used Pacific Ocean water while Boyke (1967) describes research with Caspian Sea and Mediterranean Sea water. Our work

Table 1. Saline Water Classification* and Examples

Class	TDS (mg/l)	Example
Fresh	< 1,000	Most irrig. waters (USA)
Slightly Saline	1,000-3,000	Shallow wells (Mesilla Valley), Irrig. return flow
Moderately Saline	3,000-10,000	Caspian Sea, Groundwaters (New Mexico)
Very Saline	10,000-35,000	Pacific Ocean, Groundwaters
Brines	> 35,000	E. Mediterranean Sea, Hot Springs

*After U.S.D.I. 1976 New Mexico Water Resources: Assessment for Planning.

(O'Connor 1979) at New Mexico State University utilized waters from 1,250-15,000 mg/l TDS and simulated groundwater resources in the state. Quality-wise, many natural waters with TDS >1,500 mg/l have NaCl as the dominant salt. This abundance of Na has been a major concern because of problems in maintaining soil physical properties and has likely discouraged exploitation of saline-water resources.

Saline waters are abundant worldwide and are often in close proximity to semiarid and arid regions ideally suited to the biosaline concept. Saline groundwaters in New Mexico are estimated at 15 billion acre-feet. Add to this the estimated 1,060 trillion acre-feet of ocean waters and the millions of acres of arid lands, and the potential impact of biosaline concept starts to come into focus. The potential is truly immense. What efforts have been made to utilize this almost boundless resource?

Some of the earliest and most extensive research in saline-water utilization was conducted by Israeli scientists. Boyko (1967) described experiments started in 1929 that utilized very saline groundwaters to grow nonhalophytic trees and conventional agronomic crops, such as sugar beets and barley.

Although Israel is usually considered the forerunner in salinity research, several other countries have experimental programs and extensive histories of saline-water utilization (Table 2).

In New Mexico, Stewart (1967) grew selected range shrubs and grasses with Tularosa Basin groundwater containing up to 16,000 mg/l TDS. More recently, Epstein and Norlyn (1977) were able to grow

Table 2. Countries Using Saline Waters to Grow Indicated Crops

Country	Water Quality	Crops
India	Seawater (various concentrations)	Wheat,tobacco, alfalfa
Italy	Groundwater (Up to 9000 mg/l)	Tomatoes, sorghum, cabbage
Spain	Seawater (33,000 mg/l)	Maize, potatoes pepper
Sweden	Seawater (6000 mg/l)	Pasture and meadow species
USA (NM)	Groundwater (Up to 16,000 mg/l)	Range shrubs and grasses
USA (Calif.)	Pacific Ocean water	Barley, tomatoes

barley and tomatoes on sand dunes with Pacific Ocean water. The list could be expanded, but I want instead to emphasize the research approaches currently being used to test the prospects of saline-water utilization.

Representative Current Research Approaches

1. Utilize naturally occurring halophytic (salt-tolerant) species to supplement traditional crops. Gary Cunningham (Biology Department, NMSU) is experimenting with saltgrass as a potential forage. Jim Fowler (Agronomy, NMSU) and Jim Hageman (Chemistry, NMSU) have evaluated Russian thistle as a forage. Both species occur naturally in saline or water-limiting environments and may represent good alternatives to traditional forages, if saline water is the only available source of irrigation water.
2. Breed or select for salt tolerance. Many of our conventional agricultural crops have been shown to possess sufficient genetic diversity to allow selection for greatly increased salt tolerance. This was the basis of Epstein's highly publicized research in California. Whether this increased salt tolerance will allow sufficient economic return, however, is open to question with some crops. Certain species of tomato, for example, tolerate salt very well; but the fruit is small, hard, and lacks other characteristics American consumers demand.

3. Supplement saline-water supplies with fresh water. Several experiments with "saline water" have proven successful when saline water was supplemented with fresh water irrigations or with natural rainfall. Many crops are most sensitive to salt damage early in their growth cycle. If fresh waters are available for early season irrigations, saline water can often be used to complete the irrigation season with minimal reduction in yield. In Mediterranean climates (for example, Israel), winter rains (150-200 mm) have been found effective to leach surface accumulations of salt. This leaching is often sufficient to create a desalinized environment in which crops may germinate and grow normally. We are currently investigating the extent to which saline waters can substitute for fresh water irrigations with sorghum.

Management Techniques

1. Successful utilization of saline irrigation water often requires different management than when only fresh waters are used. Perhaps the best-known technique in this regard is high frequency irrigation to reduce water stress between irrigations. Water stress and salinity stress are essentially additive effects. Minimizing water stress by high frequency trickle irrigation allows using more saline waters without reducing yields.

2. Saline waters often have high sodicity hazards as indicated by their high sodium absorption ratio values. Fortunately, the high salinity of these waters usually suppresses the effect of adsorbed sodium on soil structure and little effect on soil permeability is observed. But during rainstorms or fresh water irrigations, salts can be washed out allowing considerable soil dispersion and greatly reduced soil permeability. Some soils possess the ability to release additional salt quickly enough to maintain the critical salt level needed to suppress dispersion. Other soils, however, require the addition of amendments, usually gypsum, to supply the critical salt level. The Israelis are currently very active in determining which soils need gypsum and in what amounts.

3. There are several other techniques available that I will not describe in detail. These include: a) increased leaching; b) irrigating at night; c) switching to more salt-tolerant crops, etc. In general, utilization of saline water will require increased management. Thus, saline-water utilization may not be reasonable or economic in all agricultural settings.

Some words of caution are necessary for anyone planning to use saline water. Literature data and field data can be misleading as to the success of an operation.

Misleading Data

1. Most soils are much less saline now than they will be under saline-water irrigation. Soils are tremendous buffers, however, and may not exhibit the increased salinity over short periods. Even one- or two-year studies are often insufficient to show the steady-state effects that will develop with long-term use. Long-term studies of 3 to 5 years or more are needed before saline-water utilization can be safely recommended.
2. The second most common example of misleading data is from studies where natural precipitation is significant. When soil dispersion is controlled, winter rains or pre-season irrigations with good quality water often allow plants to grow with saline water without serious yield reductions. If rain is insignificant or falls during the cropping season, this good quality water may be of limited usefulness. Salinity problems may develop in the latter case where none are observed in the previous case.
3. A third factor, among several others, is the quality of saline water used. As discussed previously, saline means different things to different people. The water you use should be right for your crop and soil.

Saline-water utilization has tremendous potential in New Mexico and throughout the world. Although much research has been completed, more is needed for the specific waters, soils, and crops of a particular area. I hope that our research will supply some of that information in the coming years to farmers of New Mexico.

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RESULTS OF COMPUTER MODELING OF GROUNDWATER FLOW - THE CALCIUM CARBONATE AQUIFER OF THE CENTRAL ROSWELL BASIN

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INTRODUCTION AND PURPOSE

The flow of groundwater in the Roswell Artesian Basin has been studied since the early 1900s with varied ideas proposed to explain different aspects of the groundwater flow system. The purpose of the present study is to help delineate the distribution and source, or sources, of recharge to the Roswell Basin by using a computer model to simulate groundwater flow in the carbonate aquifer beneath and west of Roswell and in the Glorieta Sandstone and Yeso Formation west of the carbonate aquifer. The use of the computer model offers the unique opportunity to evaluate different theories by simply changing various model parameters such as transmissivity, storage coefficient, interaquifer leakage and recharge.

The results obtained are approximate, but represent the best estimate of the distribution of recharge in the Central Roswell Basin to date. The compatibility of the model results with previously proposed ideas will lend credence to some and refute others. The model results should generate some new ideas, hopefully provoke further research, and serve as a stepping stone to future modeling attempts of the Roswell Basin.

The material in this paper is based on work done by the author for his Master of Science Degree in Hydrology at New Mexico Institute of Mining and Technology in Socorro. Many points that are only mentioned in this paper are explained more fully in the author's thesis.

DESCRIPTION OF THE STUDY AREA

The study area is an east-west strip in the central part of the Roswell Artesian Basin in Chaves and Lincoln Counties, New Mexico, and includes much of the Rio Hondo Drainage Basin (Figures 1, 2). The study area was chosen because of the relative abundance of data in the Hondo valley region as compared to other parts of the Roswell Basin.

HYDROGEOLOGY

This report is concerned mainly with the flow of groundwater in the carbonate aquifer which is composed of the San Andres Limestone and the Grayburg Formation. Groundwater in the carbonate aquifer is affected by groundwater in the underlying formations, the Yeso and Glorieta, and by the overlying formations, the Queen and the Alluvium. A good discussion of the stratigraphy is given by Kelley (1971).

Water is unconfined in the carbonate aquifer west of about Range 24 East and confined in and east of Range 24 East. The western boundary of the carbonate aquifer occurs where the water table intersects the Glorieta-San Andres contact, and the eastern boundary is approximately the Pecos River. The northern and southern boundaries are estimated to be near Arroyo Del Macho and South Seven Rivers, respectively. The boundaries are shown in Figure 3.

Moving from west to east in the Roswell Basin, progressively younger formations are encountered, because the beds dip to the

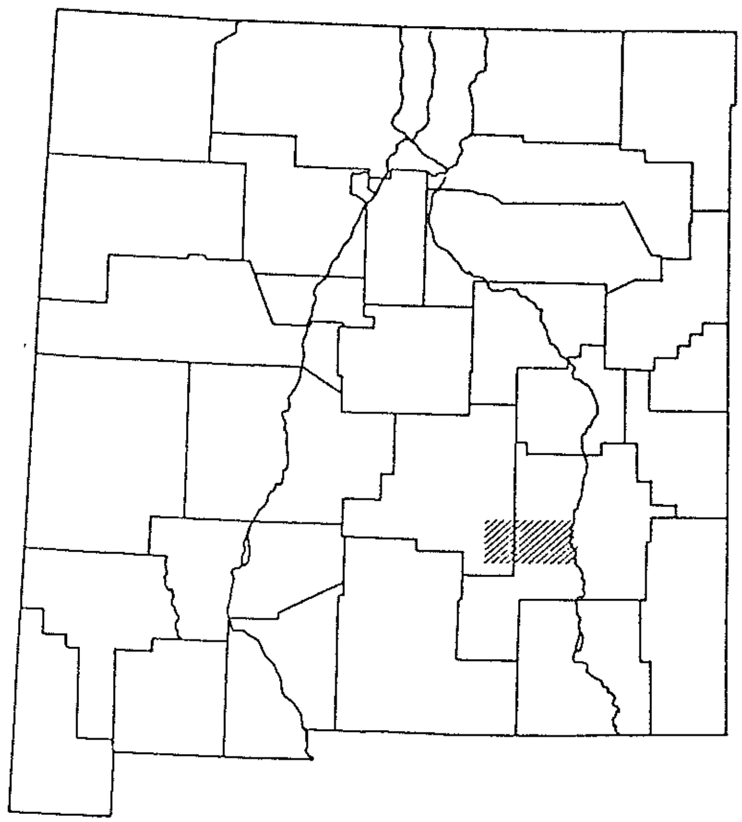


Fig. 1. Location of the study area.

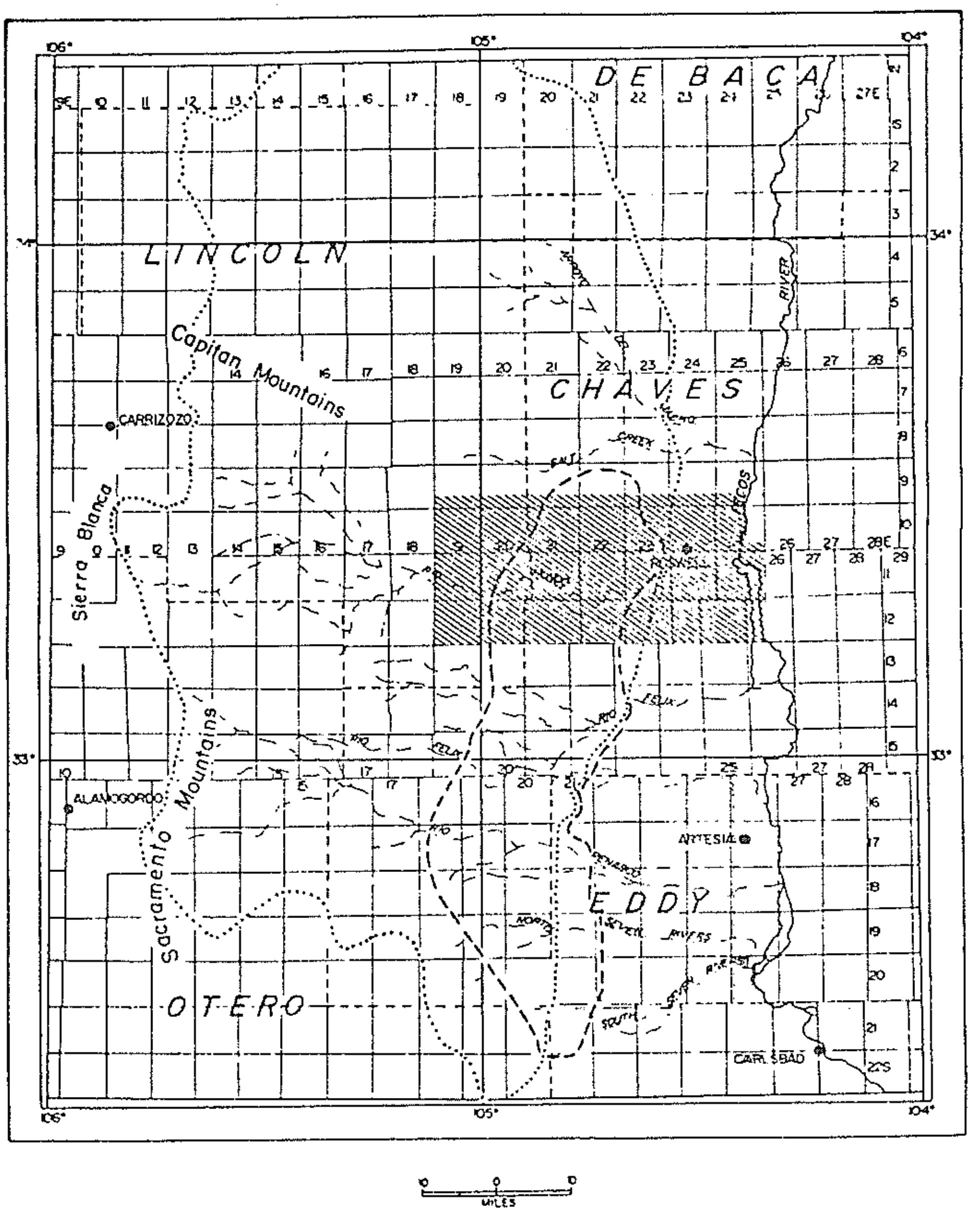


Fig. 2. Location of the study area in relation to hydrologic boundaries.

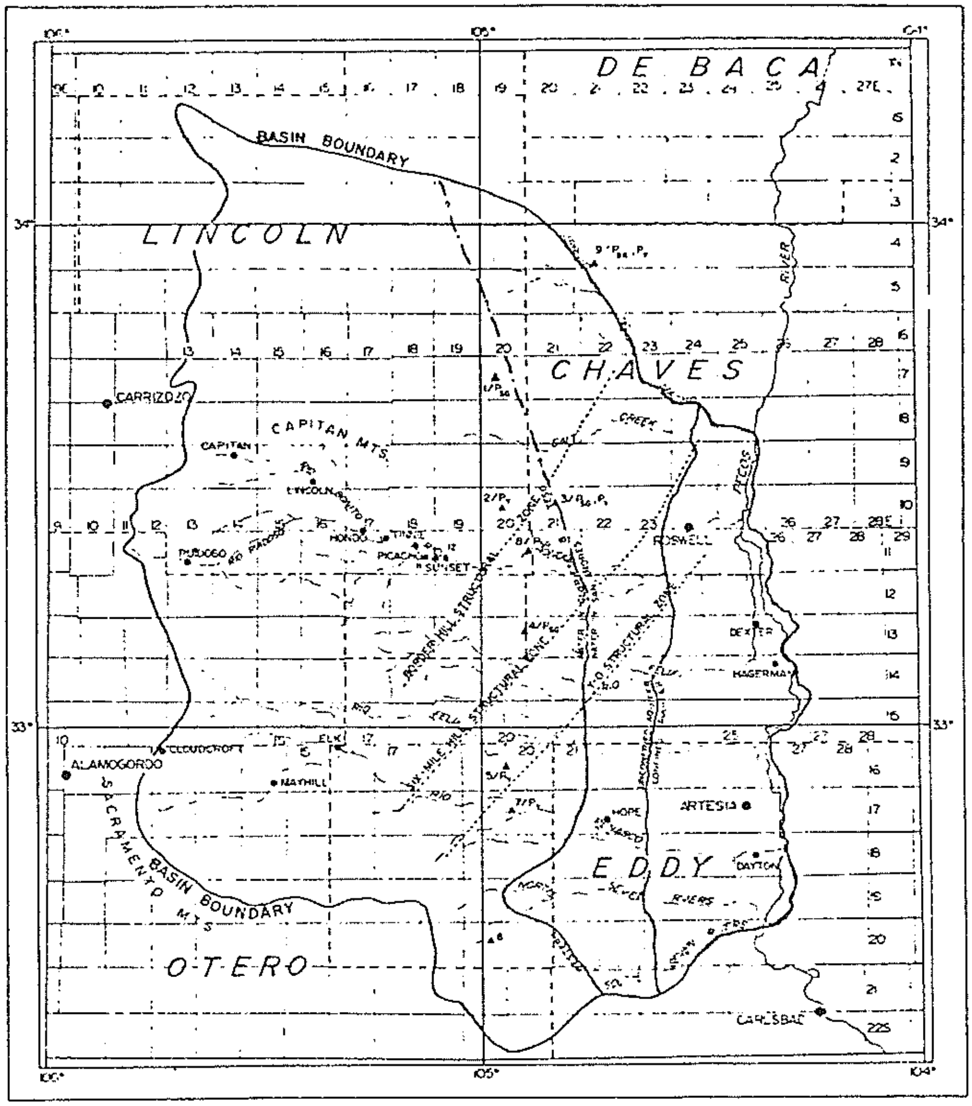


Fig. 3. Outline of the Roswell Basin with the hydrologic boundaries.

east-southeast at a greater angle than the topography. The slope of the water table in the western (unconfined) part of the main aquifer is less than the dip of the strata, and consequently the water table intersects progressively younger formations from west to east.

Interaquifer leakage occurs between the carbonate aquifer and the alluvial aquifer through the Queen aquitard in a band about 20 miles wide adjacent to the Pecos River. Leakage is generally greatest in the vicinity of Roswell and decreases to the south and southwest. Prior to the development of irrigation wells, water leaked vertically upward from the carbonate aquifer to the alluvial aquifer. Recently, the large drawdown of the potentiometric surface of the carbonate aquifer during the summer irrigation season reverses the direction of vertical leakage, and the net yearly leakage may be nearly zero. A good summary of the hydrogeology is given by Gross, Hoy and Duffy (1976).

COMPUTER MODEL

The computer model chosen is a two-dimensional finite-difference model written by Trescott, Pinder and Larson (1976), herein called the Trescott model, or the model. The model was chosen because it is easy to obtain, extremely well documented, and easy to use. The application of a computer model to an aquifer is a three-step process of calibration, verification, and prediction.

Calibration is the trial and error process of adjusting the aquifer parameters in a model in order to match the computed head distribution to the observed head distribution for some historic period of time. If the computed head map does not match the observed head map, the parameters are adjusted and another computed head map is generated. For this study, the parameters of interest are transmissivity, storage coefficient, hydraulic conductivity of the aquitard, and recharge.

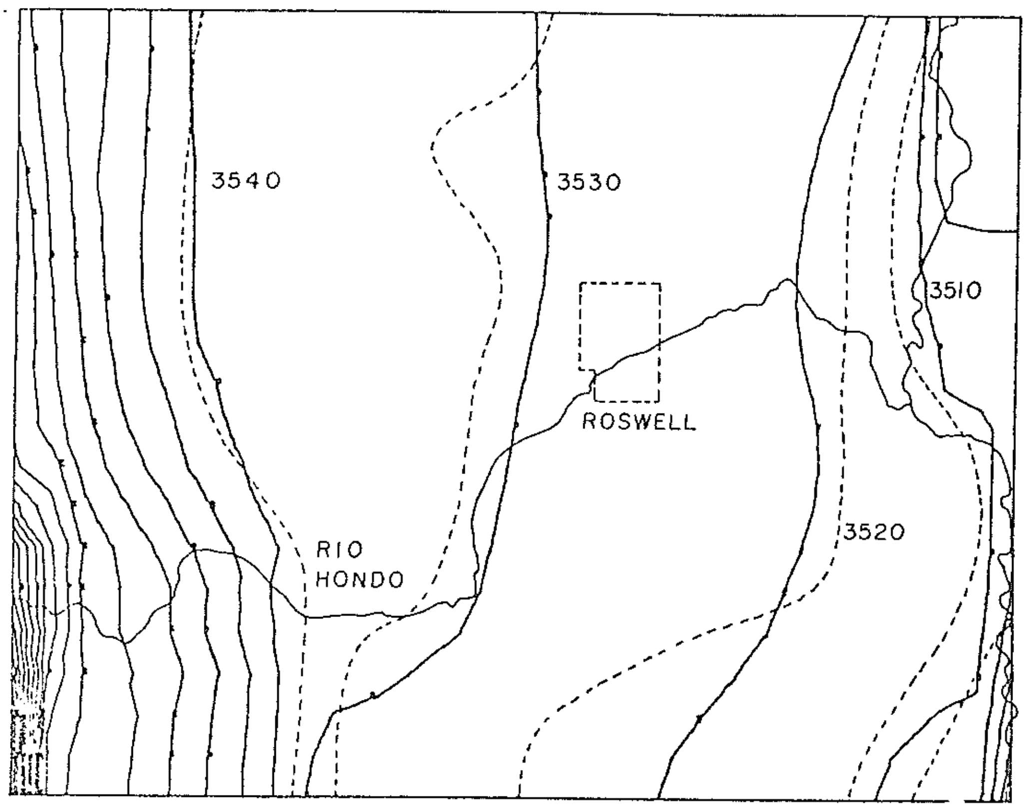
Following the calibration, the calibrated parameters are verified against another historic period of time. The purpose of the verification is to provide a check on the calibration. For example, if the observed water levels used for the calibration were the result of some anomalous condition, the verification would produce a poor match between the computed and observed heads at the end of the verification period. On the other hand, if the verification produces a good match, we can be reasonably sure the calibrated parameters are correct.

The final step in the modeling process is prediction. The model is used to predict future water levels given expected pumpage and recharge.

For the present study, the calibration period is January 1967 to January 1968, and the verificaton period is January 1967 to January 1975. Predictions using the model have not yet been performed.

RESULTS

Figure 4 contains both the computed and observed hydraulic head map for January 1968 for the eastern two-thirds of the study area. For the most part, the computed and observed heads differ by less than 3 feet. An exact match would be unwarranted because of inaccuracies in the water level data used to draw the observed water level contours.

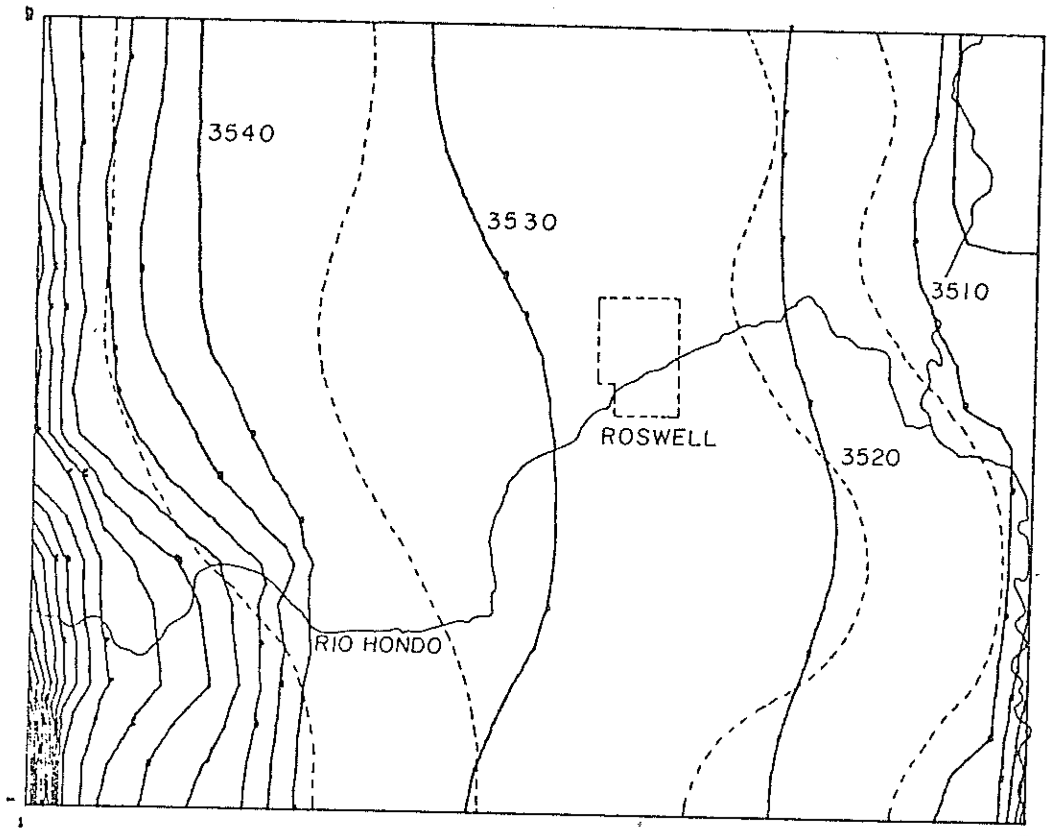


HYDRAULIC HEAD 1968

Fig. 4. Computed (solid lines) and observed (dashed lines).

The next step in the modeling process is the verification of the calibrated parameters. Figure 5 contains the computed and observed head map for January 1975. East of Roswell the match is as good as for January 1968. However, northwest of Roswell, the computed and observed heads deviate. The reasons for the lack of fit are not clear. Obviously, the calibrated parameters are in error. The question is which ones. Sensitivity studies have shown that the most sensitive parameter is the observed water level. In the area where the fit is poor, water level data are sparse to nonexistent. Therefore, the contours drawn from observed data may be significantly in error in the area northwest of Roswell. Until such time as water level data are improved in that area, the calibrated parameters cannot be improved. All in all, the match of heads for January, 1975, is acceptable.

Figure 6 contains the yearly average sources and discharges to the flow system calculated from the verificaton simulation. Some of the terms in Figure 6 require an explanation. The recharge includes the amount distributed over the area and the amount contributed by the Rio Hondo. The western flow source is largely flow across the western boundary and represents the amount of water entering the carbonate aquifer by flow along the regional water table. However, this is not to say that the total contribution to the carbonate aquifer from the Glorieta and Yeso is only 1,100 acre-feet per year. In fact, a significant amount of water in the carbonate aquifer is derived from upward leakage of water from the underlying



HYDRAULIC HEAD 1975

Fig. 5. Computed (solid lines) and observed (dashed lines).

MASS FLUX

SOURCES	ACRE-FEET/YEAR
Recharge	124,403
Western Flow	1,117
Leakage	36,032
DISCHARGES	
Eastern Flow	2,012
Pumpage	105,866
Leakage	48,225
NET LEAKAGE (UPWARD)	12,194

Fig. 6. Yearly average sources and discharges.

Glorieta and Yeso, as will be shown later. The eastern flow is the amount of water flowing out of the model area to the east beneath the Pecos River. The leakage is the amount of water entering and leaving the confined portion of the carbonate aquifer through the overlying aquitard. The fluxes obtained appear to be reasonable when compared to similar estimates by Fiedler and Nye (1933), Hantush (1957), and Saleem and Jacob (1971).

RECHARGE

The calibrated distribution of recharge is presented in Figure 7. The other calibrated parameters, transmissivity, storage coefficient, and aquitard hydraulic conductivity will not be presented here. The other parameters are entirely consistent with published data from the basin. The calibrated recharge is therefore determined using the model with parameters that are consistent with the published values. One can then assume that the calibrated recharge is a reasonable approximation to the true recharge distribution.

The amount of recharge, as calculated by the model, varies over the basin. In the western region where the flow occurs largely in the Yeso, the calculated recharge was about 0.1 inches per year. This is the amount that actually recharges the deep, or regional, water table as opposed to perched systems. Undoubtedly, more water actually infiltrates into the overlying carbonate because of the presence of many springs which issue from perched systems along the Yeso-Glorieta (San Andres) contact (Davis, Wilcox and Gross 1979).

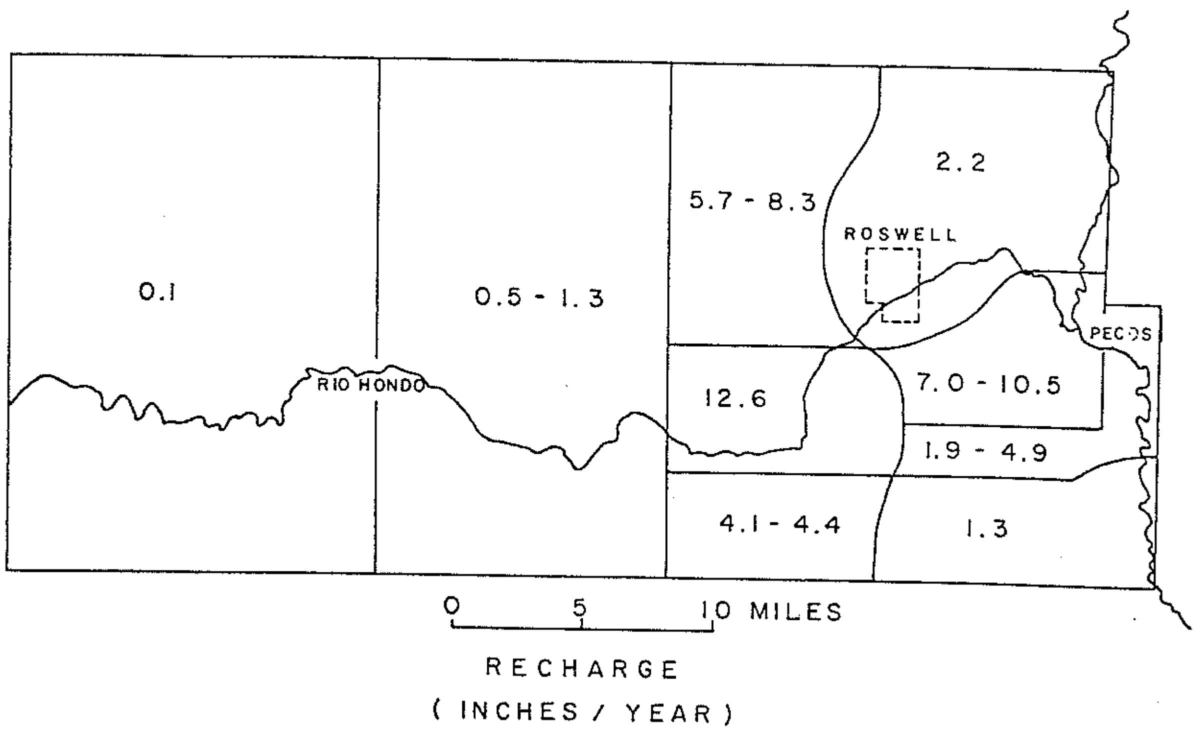


Fig. 7. Calibrated recharge.

Progressing eastward, a zone of about 0.5 inches per year occurs at about the location where the water table lies in the Glorieta Sandstone. The Glorieta, being more permeable than the Yeso allows more water to infiltrate and may, in fact, absorb water that is flowing eastward along the Glorieta-Yeso contact.

East of the line where the water table intersects the San Andres (Fig. 3), the amount of recharge again increases to the range of 0.8 to 1.3 inches per year. The increase may be due to a lessening of the land surface gradient which allows more water to infiltrate. East of the above region and west of the line where the San Andres becomes confined, something unusual occurs. The amount of recharge jumps from the range 5.7 to 8.3 inches per year above Township 11 to almost 13 inches per year in the region east of the Hondo Reservoir.

In the confined zone "recharge" was needed over and above leakage. Large amounts of this "recharge" were added to Township 11, Ranges 24 and 25, which is an area of heavy pumping. Possibly the value of transmissivity could have been increased to a point where recharge in the PIA would reach the pumping centers. That would have been inconsistent with pumping test values obtained by Hantush (1957, 1961), which are at worst an overestimate of the actual transmissivity (Neuman and Witherspoon 1969). Therefore, the "recharge" is probably a real phenomenon, and not a failure to calibrate the model properly. The source of the "recharge" in the confined zone is obviously not precipitation, and is probably not leakage from the overlying aquitard, because leakage is calculated separately in the model.

The amount of yearly recharge in the Principal Intake Area jumps from a maximum of 1.3 inches west of Range 23 East to a minimum of 4 inches in Range 23 East. Much of Range 23 East has a recharge of greater than 6 inches and a maximum of 12.6 inches occurs in the lower two-thirds of Township 11 South. The question arises as to how 6 to 12 inches of recharge can occur in an area where the average annual precipitation is about 13 inches (Mourant, 1963, the average of Roswell and Picacho).

Two possible explanations can be proposed: (1) precipitation infiltrates rapidly through solution features, cracks, and along stream channels, and (2) water in the Glorieta and Yeso is leaking vertically upward into the carbonate aquifer. Evidence for either explanation is available, as it appears that the answer is probably a combination of both.

In support of the first explanation, Motts and Cushman's (1964) Northern Evaporite Area corresponds closely to the area of high recharge in the model. They describe the Northern Evaporite Area as having good to excellent recharge capacity, numerous sinkholes, and that the seepage loss per mile of stream channel is probably greater than in other parts of the intake area. Precipitation will infiltrate rapidly and reach the water table sooner than in other parts of the intake area, because the water table is closer to the land surface (Fiedler and Nye 1933). Also, water from the west will enter the area in the stream channels and will be lost through leakage. Therefore, the potential for large amounts of infiltration exists along the eastern edge of the Principal Intake Area.

Rabinowitz and Gross (1972) also described the above area as one of rapid recharge as opposed to slower recharge to the west. However, Gross, Hoy and Duffy (1976), have shown that Rabinowitz and Gross's interpretation of the data may be questionable, and are the most recent proponents of the idea of upward leakage from the Glorieta and Yeso.

Fiedler and Nye (1933) were the first to propose a possible deep flow component from the Yeso and Glorieta. They said water in the Yeso and Glorieta had a greater artesian head than the main aquifer, and that water may be forced upward along joints and fractures, but the amount was assumed small, although never measured. Hantush (1957) and Saleem and Jacob (1971) also said that some recharge may be leakage from the Yeso and Glorieta. Bunte (1960) showed that the Glorieta is a major conduit of recharge north of the study area. Havenor (1968) presents some data which indicate the presence of upward vertical flow. The combined water level in the City of Roswell Test Well No. 2 (11.22.04) was 5 feet higher with both the San Andres and Glorieta producing than the water level of the San Andres alone. Many authors have said that the Glorieta and Yeso are not permeable enough to produce much water. Over an area as large as the Roswell Basin significant amounts of water can be produced from leakage through very tight formations. The overlying aquitard for example, allows about 40,000 acre-feet per year to leak through in either direction. The strongest evidence for a deep flow comes from tritium data (Gross, Hoy and Duffy 1976; Gross and Hoy 1979).

Briefly, tritium is a naturally-produced radioactive isotope of hydrogen that decays with a half-life of 12.3 years. Prior to 1953, only small amounts of tritium were present in precipitation and groundwater. With the onset of atmospheric testing of thermonuclear devices in 1953, the amount of tritium in precipitation increased nearly 3 orders of magnitude to a peak in 1963 (Rabinowitz and Gross 1972). Since the Test Ban Treaty in 1963, atmospheric tritium levels have dropped, but are still above the pre-testing level. Consequently, the tritium activity in groundwater has increased as the high tritium precipitation recharges the groundwater.

In the area of rapid, high recharge, one would expect the tritium activity of the groundwater to be very near that of the precipitation. This, unfortunately, is not the case. Gross, Hoy and Duffy (1976) found the tritium activity of water from the Principal Intake Area to be well below expected values.

Based on the published tritium measurements of Gross and Hoy (1979), the average tritium activity in precipitation at Roswell for the period of 1972 to 1978 was 56.8 TU (1 TU = tritium unit = 1 tritium atom per 10^{18} hydrogen atoms), while the average tritium activity for 14 wells in the intake area for 1968 to 1978 was 13.2 TU. The average tritium activity in six wells in the area of high recharge (Range 23) for 1972 to 1978 was 15.2 TU. The tritium activity of wells just east of the intake area was only 9.3 TU. The difference between the tritium activity of groundwater and precipitation is significant when viewed in terms of the 12.3 year half-life of tritium, because it would take about 24 years for a set volume of water of tritium activity 56 TU to reach 14 TU by the natural decay of tritium. One might argue that the groundwater tritium activity is lower because of mixing of recharge with the ambient groundwater.

This is not the case in the carbonate aquifer. If we assume the aquifer is 200 feet thick with a porosity of 0.03 we have 6 feet of water per unit area in storage. With half a foot of recharge per year, the water in the aquifer should be replaced every 12 years. In the 12 years or so prior to the 1968 to 1978 period used above, the tritium activity of precipitation was much greater (Gross, Hoy and Duffy 1976, p. 54). Therefore, the ambient groundwater activity in 1968 should have been quite high, perhaps even higher than the precipitation in 1968. The low tritium activity of water in the Principal Intake Area cannot be explained simply as the mixing of recharge and ambient groundwater.

A deep recharge component appears to be the best way to explain the low tritium levels in the Principal Intake Area and the needed "recharge" in the confined zone. A rough calculation to determine the percentage of recharge from precipitation and from the deep flow can be done with the tritium data. If the measured average tritium of the groundwater in the PIA is assumed to be a mixture of deep water and precipitation, we can use a simple mixing model.

The model (Fig. 8) simply says that part of the groundwater is derived from precipitation of average tritium activity of 56.8 TU and the remaining groundwater is derived from a deep flow. The tritium activity of the deep flow can be estimated from the tritium activity of the PVACD observation wells located at the western edge of the PIA. Four of the wells, numbers 1, 2, 3, and 4, are located in the study area and monitor water levels in the Glorieta and Yeso. For the period of 1974 to 1976, the average tritium activity of the four wells was 5.08 TU. The percentage of each recharge component is calculated by

$$T_{aq} = xT_p + (1-x)\, T_d$$

where

T_{aq} = average tritium activity of the PIA

T_p = average tritium activity of precipitation

T_d = average tritium activity of deep flow

x = percentage of recharge from precipitation

$1-x$ = percentage of recharge from deep flow

T_{aq} = 13.2 TU, T_p = 56.8 TU, T_d = 5.1 TU.

The percentage of recharge from precipitation is only 16%. Deep flow accounts for over 80% of the recharge. If the calculation is done using the aquifer tritium activity of 15.2 TU from only the wells in the high recharge zone, the percentage of recharge from precipitation increases to only 20%.

Assuming that 20% is approximately correct, one would not expect normal fluctuations in precipitation to cause a significant fluctuation in water levels. Although a strong correlation appears

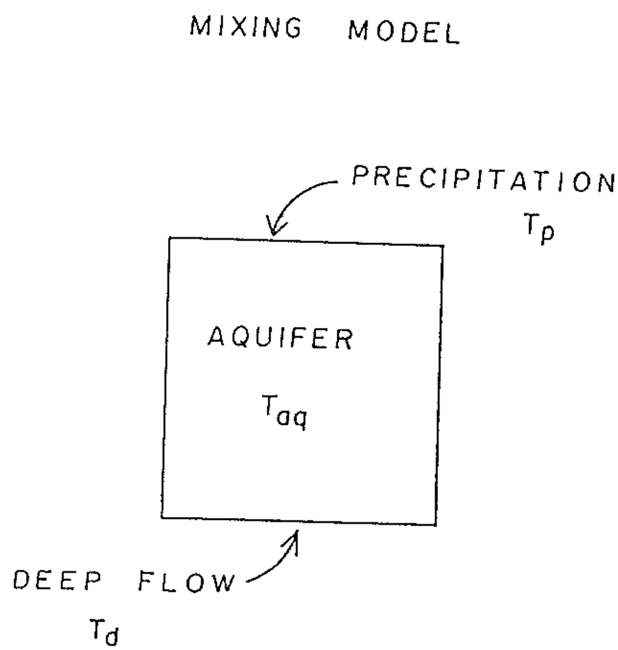


Fig. 8. T_{aq} = tritium activity of the aquifer
T_p = tritium activity of the precipitation
T_d = tritium activity of the deep flow

to exist between precipitation events and water level rises, Hantush (1957) and Mourant (1963) have stated that the water level rise is caused mainly by the reduction in pumping associated with the precipitation. Mourant (1963, p. 22) presents the hydrograph of a well located in the region of high recharge (11.23.03.342). The water level in the well rose in June and July because the local rainfall caused a decrease in pumpage. In October, when pumping was small, a heavy rainfall produced no noticeable response in water level. Therefore, it appears that local fluctuations in precipitation have little effect on the water level in the main aquifer. Duffy, Gelhar and Gross (1978, p. 20) present some evidence to suggest that long-term trends in precipitation affect the water level in the PVACD observation wells located just west of the Principal Intake Area. That being the case, long-term trends in precipitation will affect the deep recharge component, and will have a considerable effect on water levels in the carbonate aquifer. More work needs to be done, however, before any definite conclusions can be made.

HYDROGRAPH

As stated in the introduction, the computer model can be easily changed to incorporate new theories. In the calibration, the recharge was unevenly distributed throughout the year in the same manner as precipitation. As the model results were analyzed, the effect of precipitation was shown to be small and deep flow appears to be the major component of recharge. The deep flow is relatively unaffected by yearly variation in precipitation and should be essentially constant. Therefore, two more computer simulations were performed; one of one year and one of eight years corresponding to the calibration and verification simulations, respectively. In each, the recharge was held constant throughout the year. In addition, during the eight-year simulations, only the stream recharge and pumpage were changed from year to year, while the areal recharge remained constant. The resulting hydraulic head maps are very similar to the results obtained with recharge variable throughout the year. In general, the water levels in the high recharge area increased slightly, and the net upward leakage through the aquitard was decreased by almost 4,000 acre-feet per year. The decrease in net upward leakage is the result of increased drawdown in the confined zone during the pumping season caused by the redistribution of recharge.

The hydrograph of the Berrendo-Smith recorder well (10.24.21.212, Hudson, 1978) is compared to the hydrograph of the corresponding node in the model in Figure 9. The predicted hydrograph using constant recharge is a much closer approximation to the observed hydrograph than the predicted one with variable recharge. This also supports the theory that a substantial portion of the recharge to the carbonate aquifer is derived from the underlying formations.

The biggest argument against a deep flow hypothesis is that the deep water is of poor quality. Mourant (1963) has shown that the

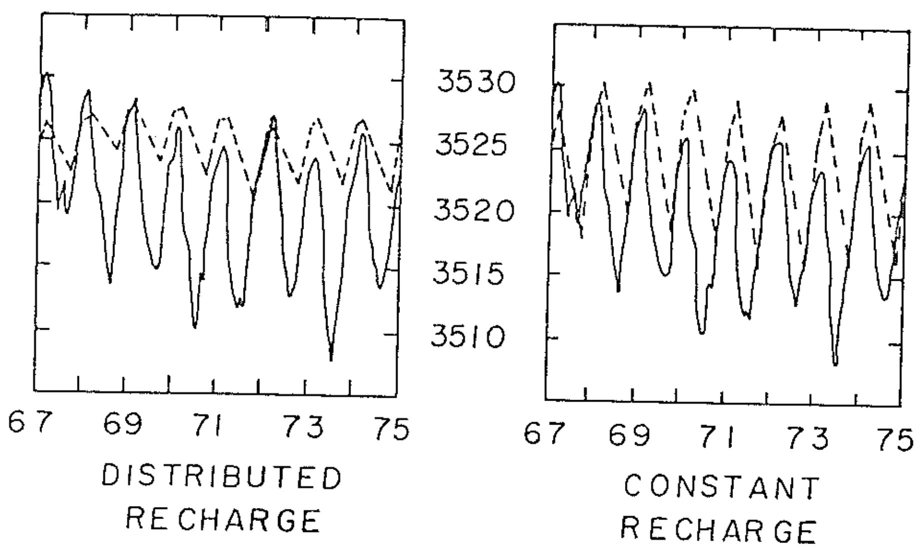


Fig. 9. Hydrographs of the Berrendo-Smith recorder well (solid lines) and the corresponding node in the model (dashed lines) for distributed and constant recharge.

Yeso contains potable water in the area west of the PIA. However, the water is of poorer quality than the carbonate aquifer in the PIA. It would appear then, that the Yeso probably does not contribute significantly to the deep flow. On the other hand, the Glorieta water is of better quality than that of the carbonate aquifer. Therefore, the Glorieta is the likely source of the deep flow.

CONCLUSIONS

1) Most of the recharge to the carbonate aquifer occurs in and east of Fiedler and Nye's Principal Intake Area.
2) Only 20% of the recharge to the PIA is from precipitation.
3) About 80% is deep flow, most of which is probably from the Glorieta Sandstone.

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WATER CONSERVATION THROUGH PLANT BREEDING - ALFALFA

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Most plant breeders have directed their efforts toward maximizing production under intensive management systems. This philosophy has encouraged the development of varieties capable of utilizing large quantities of environmental resources, including water. Pumping costs, restrictions on amounts of water that can be pumped, and inconsistent supplies of surface water have forced a re-evaluation of "stress" level production.

Many research papers have been published on specific plant measurements in response to moisture stress. Most of these techniques are very time-consuming and expensive and not adapted to use in a plant breeding program. Essentially no work has been published in which an effort has been made to transmit these characteristics across generations and result in a variety with increased performance under stress conditions.

Alfalfa normally requires large amounts of water for optimum production. However, many studies have commented on its drought resistance. This points out the apparent flexibility in alfalfa. This variation in behavior illustrates the possibilities of genetic manipulation to develop varieties which will perform better than existing varieties under some level of moisture stress. The possibilities of such an accomplishment in terms of future world food needs and water conservation certainly warrants investigation.

The objectives of this study are as follows:

1. To determine production levels that can be expected under limited moisture conditions;
2. To determine if genetic variability exists for performance under limited moisture conditions;
3. To establish techniques that would be useful in screening large plant populations for improved performance under limited moisture conditions; and
4. To evaluate selected plants for their ability to transmit these traits to their progeny.

Twenty-four alfalfa varieties are being evaluated under 16, 48 and 80-acre-inch per year irrigation regimes. Significant differences were obtained among varieties, among irrigation regimes and for the variety x irrigation regime interaction.

Forage yields relative to the optimum irrigation treatment (80 acre inches) were 44 percent for the low irrigation regime (16 acre inches) and 106 percent for the intermediate regime (48 acre inches). In 1979, one of the 80 acre inch plots was killed by Phytophthora, a disease associated with excess soil moisture. This may have biased the results, but illustrates that problems exist with excess as well as minimal moisture.

Varieties performed differently when averaged among irrigation regimes or when compared across regimes. Some varieties performed well under all moisture regimes; others performed well under low moisture regimes; some performed well only under high moisture, and some performed poorly regardless of irrigation treatments. These results are encouraging to the plant breeder because they suggest that by genetic manipulation, it may be possible to develop varieties which will perform better than existing varieties under limited moisture conditions.

Further evidence of useful plant variation was obtained by comparing plants selected from the various screening procedures with unselected populations. Selection intensity was five percent. In one test (field capacity - 1979), the average forage production of the selected plants within the low moisture regime exceeded the average of all plants in this regime by 247 percent; exceeded the average of the intermediate regime by 141 percent, and exceeded the average of the optimum regime by 113 percent. Similar increases have been obtained from other selection procedures.

Analysis of amounts of phenotypic variation (coefficient of variation) among varieties indicated that some varieties were more variable than others. The ideal plant breeding situation would be to identify a germplasm source with high average performance with high amounts of variability. Several varieties appeared to meet these requirements. Zia was prominent in this regard in most tests.

These results definitely show the existence of phenotypic variability for performance under less than optimum moisture conditions. The critical point is -- how much of this apparent gain will be transmitted to the next generation? Both field and greenhouse tests have been established in 1979-80 to evaluate this potential. If progress can be demonstrated, it will be only a matter of time until varieties can be produced specifically for moisture stress environments. Procedures and techniques derived from this project could also be applied to other crop species.

U.S. GEOLOGICAL SURVEY: UPDATE ON CURRENT ACTIVITIES

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It is a pleasant task to recount for this gathering an overview of the water-resources activities of the U.S. Geological Survey in New Mexico. In addition, it provides a useful opportunity to interact with so many people with major water-related roles.

In such a short period of time, one can only skim the highlights of our programs. This is an attempt to portray a sense of the breadth of the program and to call especial attention to just a few activities which are relatively new, or with which others might be unfamiliar.

The Survey, as most know, is somewhat unique among federal agencies in that a large part of the work is funded on a 50/50 matching basis with state and local entities. During fiscal year 1975, about two-thirds of the Survey's water-resources program efforts in New Mexico were funded in this manner; the remaining one-third were funded by other federal agencies and Survey funds appropriated by Congress. As seen in Figure 1, the ratio of jointly-funded activities during fiscal year 1980 is now about 43 percent of program activities. This reflects a rapid increase in funding from the other areas; the jointly funded work has increased, but not as quickly.

Projects and funding emphasis within the three major categories are shown in Figure 2 for joint funding; in Figure 3 for other

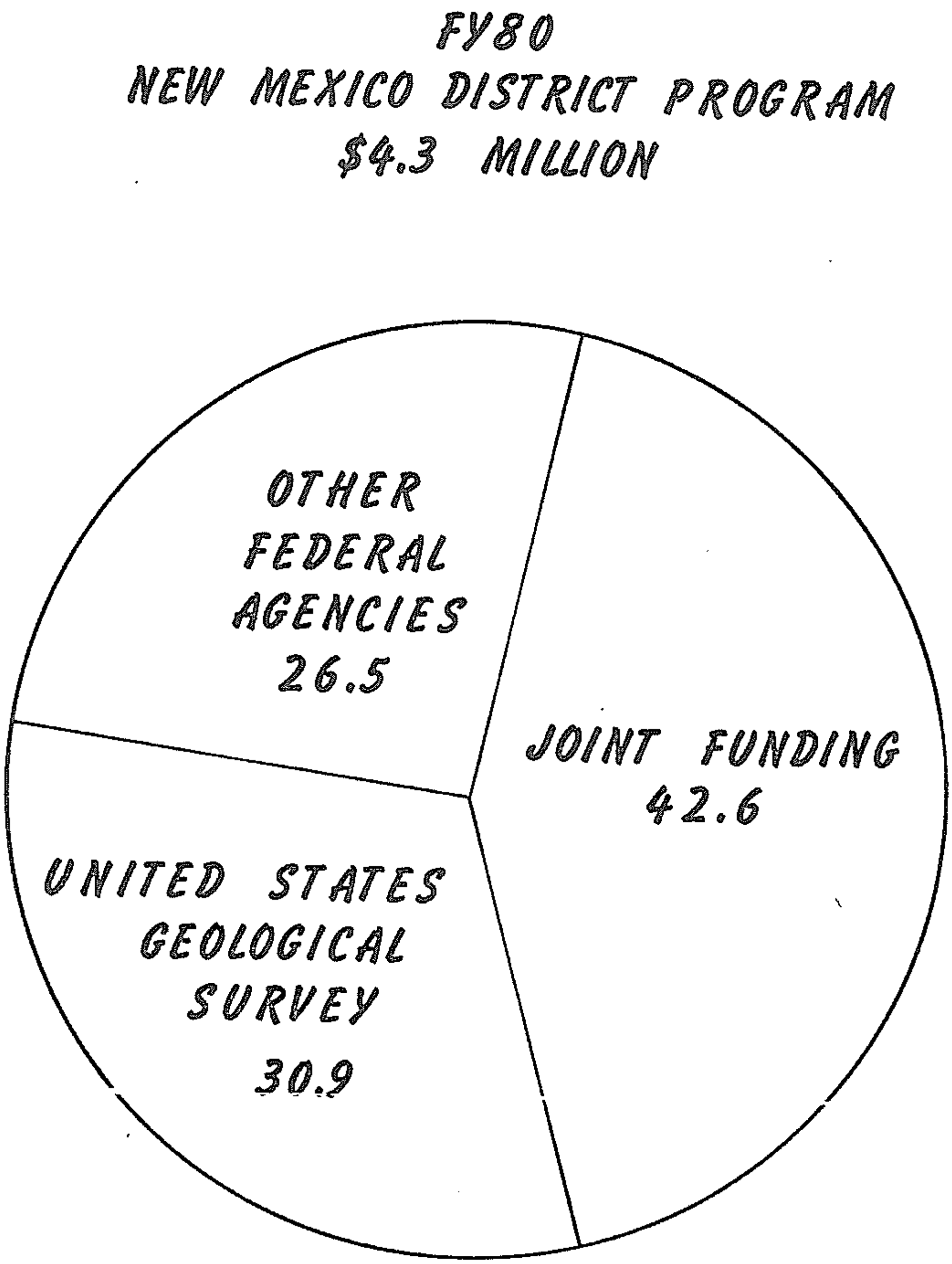


Fig. 1. Funding by source and percent.

FY80 NEW MEXICO DISTRICT COOPERATIVE PROGRAM $1.8 MILLION

PROJECTS

NM 00-001	SURFACE WATER STATIONS
NM 00-002	GROUND WATER STATIONS
NM 00-003	QUALITY OF WATER STATIONS
NM 00-004	SEDIMENT STATIONS
NM 78-007	WATER USE
NM 48-100	RIO GRANDE COMMISSION
NM 60-101	STATE ENGINEER, MISC.
NM 63-103	ROSWELL BASIN, QUANTITATIVE
NM 71-105	NEW MEXICO DATA BANK
NM 70-106	MISCELLANEOUS, PECOS RIVER
NM 67-203	FLOOD ANALYSIS
NM 72-214	WATER RESOURCES MIMBRES BASIN
NM 72-215	WATER RESOURCES SANTA FE
NM 73-219	URBAN AREAS RECONNAISSANCE
NM 75-221	EFFECTS OF DEVELOPMENT IN NW NEW MEXICO
NM 76-224	URBAN FLOOD HYDROLOGY, ALBUQUERQUE
NM 78-225	ZUNI WATER RESOURCES
NM 79-226	SAN AUGUSTIN PLAINS GROUND WATER
NM 79-227	MODEL STUDY OF ROSWELL BASIN, NM
NM 80-228	MIMBRES BASIN MODEL
NM 80-229	HIGH PLAINS STUDY, LEA COUNTY

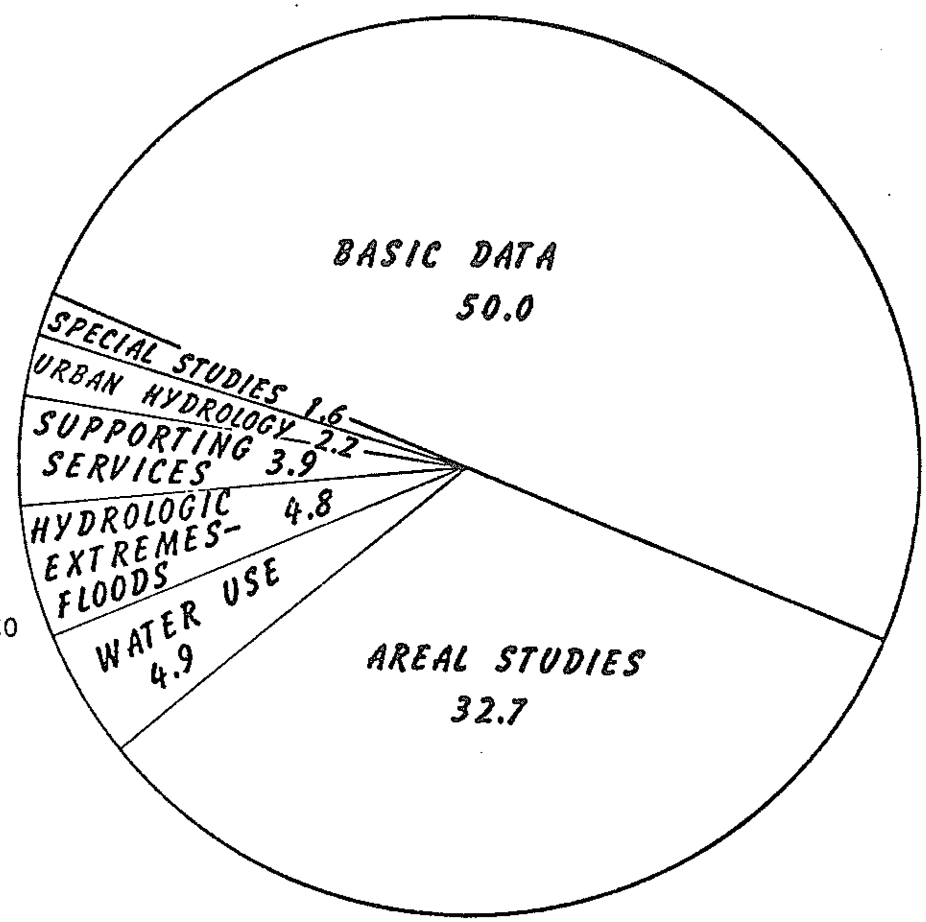
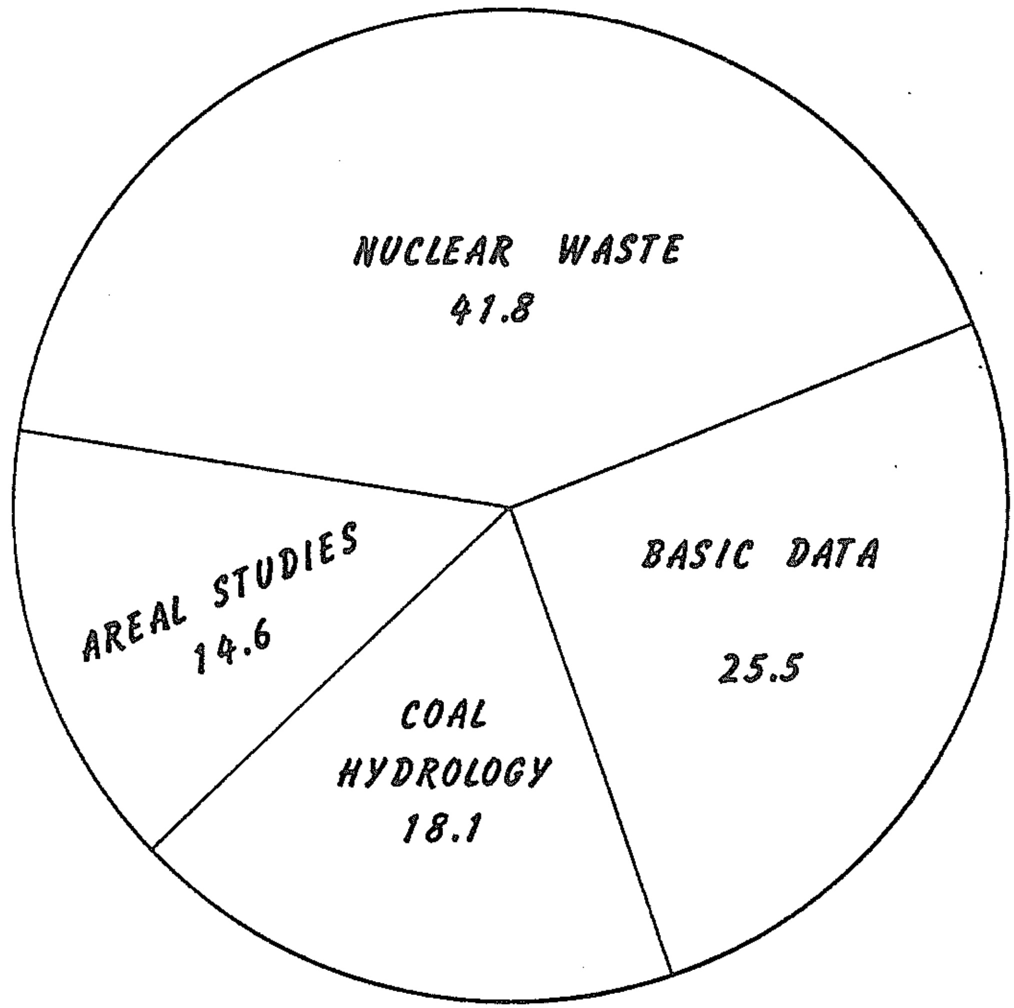


Fig. 2. Expenditure of joint funds by category and percent.

FY80 NEW MEXICO DISTRICT OTHER FEDERAL AGENCIES PROGRAM $1.2 MILLION

PROJECTS

NM 00-001	SURFACE WATER STATIONS
NM 00-002	GROUND WATER STATIONS
NM 00-003	QUALITY OF WATER STAIONS
NM 00-004	SEDIMENT STATIONS
NM 61-109	WSMR WATER LEVELS
NM 75-321	COAL LEASE AREAS, NW NEW MEXICO
NM 75-324	RADIOACTIVE BY-PRODUCTS IN SALT
NM 76-325	QW MONITORING IN CHACO RIVER BASIN
NM 78-329	WATER RESOURCES, LAGUNA PUEBLO
NM 78-330	WATER RESOURCES, ACOMA PUEBLO
NM 79-333	RF/RO MODELING IN COAL-LEASE AREAS



federal agencies; and in Figure 4 for the Survey's appropriated federal program. Of the projects listed in Figure 2, the largest number are joint undertakings with the New Mexico State Engineer's Office. For example, others are financed in cooperation with the New Mexico Bureau of Mines and Mineral Resources, New Mexico State Highway Department, City of Albuquerque, and Albuquerque Metropolitan Arroyo and Flood Control Authority (AMAFCA), and Zuni Pueblo. Many other agencies participate from time-to-time, so that the list changes periodically. Apologies are extended if omissions have been made. Elephant Butte Irrigation District and the City of Las Cruces are two entities with whom financial cooperation has taken place previously and for whom some results are presently being finalized.

Approximately one-half of this joint effort is directed toward acquiring hydrologic data for current management or future needs. Of the remainder, areal studies are primarily groundwater oriented and would include Roswell Basin, Mimbres Basin, and Lea County; supporting services include the data bank and State Engineer miscellaneous projects. There is an approximately equal amount of interpretive studies and data collection.

Other federal agency programs are summarized in Figure 3. Again, there is a mixture of interpretive studies and data collection. One item of note in this category is the magnitude of energy-related studies. That emphasis did not exist in 1975. Now, however, almost two-thirds of the other federal agency program is

FY 80 NEW MEXICO DISTRICT FEDERAL PROGRAM $1.3 MILLION

PROJECTS

NM 00-001	SURFACE WATER STATIONS
NM 00-002	GROUND WATER STATIONS
NM 00-003	QUALITY OF WATER STATIONS
NM 00-004	SEDIMENT STATIONS
NM 75-321	COAL LEASE AREAS, NW NEW MEXICO
NM 77-406	EXPANDED MONITORING IN COAL-LEASE AREAS
NM 78-407	HIGH PLAINS AQUIFER STUDY
NM 79-408	SOUTHWEST ALLUVIAL VALLEY -EAST
NM 79-409	LIAISON USGS-BLM
NM 79-410	MINICOMPUTER EVALUATION
NM 80-411	INDIVIDUAL COAL MINE EFFECTS

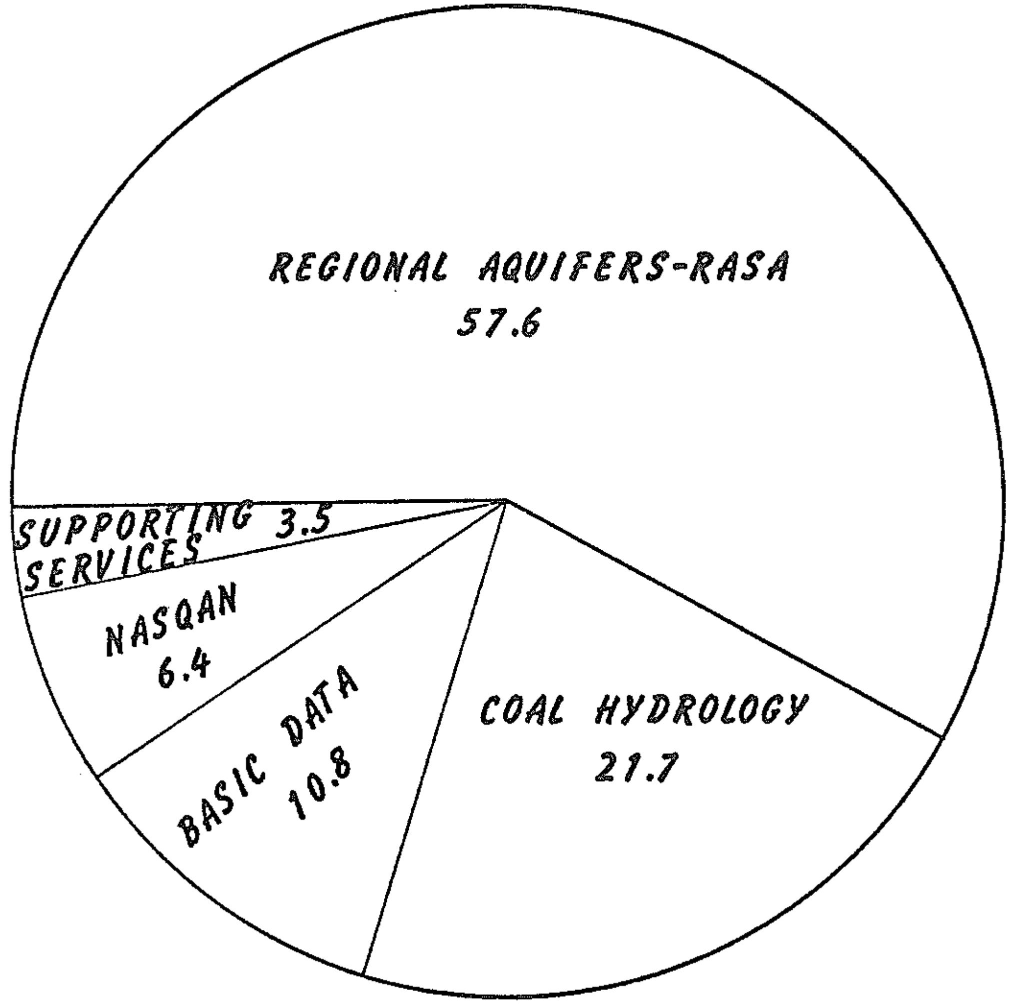


Fig. 4. Expenditure of U.S. Geological Survey appropriated funds by category and percent.

energy related -- when appropriate data collection is considered -- either in assessing or predicting impacts of energy development or energy waste disposal. Agencies supporting these projects include the U.S. Army (Corps of Engineers, White Sands Missile Range), U.S. Water and Power Resources Service, U.S. Department of Energy, U.S. Environmental Protection Agency, and the U.S. Bureau of Land Management, among others.

The Survey's appropriated federal program is summarized in Figure 4. Today this aspect of the total program accounts for about one-third, while in 1975 it was only about one-tenth. Again, energy-related coal efforts are significant, but the Regional Aquifer System Analyses also are significant. New Mexico has two on-going Regional Aquifer System Analyses that account for 58 percent of the funding. One is a part of the High Plains analysis; the other is the Southwest Alluvial Basins analysis that includes a large part of New Mexico, plus smaller parts of Colorado and Texas.

When all studies are considered, one reaches the conclusion that the Survey's program is very much dependent upon joint funding of projects and other agency needs. Because of this, we feel the program stays responsive to local needs and problems. If it were not responsive, those sources of funding would undoubtedly dry up.

It seems fitting that energy-related projects are so prominent in the program. The national interests are reflected in both other federal agency and survey funding. However, New Mexico is an energy resource-rich state and many of the jointly funded efforts are designed to obtain hydrologic information to assess development effects on water resources. With this information, state and local officials can better manage and allocate the water resources of the area.

By way of summary, the program deals with a broad range of water-information needs with a mixture of data collection and interpretive projects. That breadth is reinforced by the myriad of agencies -- federal, state, and local -- with whom we cooperate and collaborate. We're proud of our program, but we recognize there are many problems unsolved and unaddressed. It will take all the hydrologic talent available (not just that in the Survey) to stay abreast of today's and tomorrow's needs.

WATER AND POWER RESOURCES SERVICE:
UPDATE ON CURRENT AND PROPOSED ACTIVITIES

Warren Weber
Water and Power Resources Service
Albuquerque, New Mexico

As most of you know by now, the Bureau of Reclamation has changed its name to the Water and Power Resources Service. This was accomplished in November, 1979, by order of the Secretary of Interior to more accurately reflect the continuing functions of the agency. In other words, our emphasis has now shifted from "reclamation" of the arid desert lands of the west through irrigation to water resource programs more oriented towards water supplies for a variety of purposes and related power developments. Since the formation of the Reclamation Service as an offshoot of the U.S. Geological Survey in 1902 through the change to Bureau of Reclamation we have been experts in the area of irrigation. However, with the advent of 1979 we will change our primary mission to technical service in the fields of water supply and power.

This change does not mean that we will seriously alter our organizational make-up or the technical capability of our staff. We will continue to be experts in all facets of water resource planning and construction in the 17 western states. In addition to water supply and power we will study related aspects such as flood control, recreation development, fish and wildlife enhancement, water quality and, if appropriate, irrigation development or improvements. I expect much of our irrigation work to be concentrated in Indian projects. I also believe many of our future studies will be of a research nature, dealing perhaps with precipitation management, desalting, or alternative sources of power.

Now, for our current construction activities in New Mexico, I would like to refer to four projects. First is the Navajo Indian Irrigation Project which we are building as agents of the Bureau of Indian Affairs. We are trying to schedule development of one 10,000-acre block each year, requiring $15 to $30 million each year. The construction of Navajo Power Plant has been held up pending resolution of certain environmental concerns, and studies on those conditions are in progress now.

Construction of Brantly Dam on the Pecos River (and I include it in construction programs because it is authorized) is temporarily held up for a reauthorization process which involves raising the cost ceiling to about $180 million at today's prices. We also continue to perform rehabilitation and betterment work for improvement of facilities at the Carlsbad Irrigation District.

I include also in construction status Hooker Dam on the Gila River, or an alternative. The feasibility studies are being conducted by our Phoenix Office, but I report it to you because the work is in New Mexico. Hooker Dam was authorized as part of the Central Arizona Project, but only recently were studies started on Hooker Dam. I would guess that they will take at least three more years.

Now for our planning programs in New Mexico. First in importance is the Gallup-Navajo Indian Water Supply Project, a $200 million development of pipelines and pumping plants to bring water from the San Juan River to Gallup and perhaps 15 to 20 Navajo communities in New Mexico, Arizona, and Utah. Our current schedule calls for completion of all studies by this coming fall. In the meantime the Navajo Tribe has developed its own plan, which is a modification of ours. In an effort to resolve the differences, Senator Domenici has established a special task force to examine the issues and make a concensus recommendation to him. The task force hopes to complete its deliberations by May or June of this year.

We have already completed our water supply studies for the City of Raton and have recommended two alternative plans to them. In the meantime, Raton has hired its own consultant, Gordon Herkenhoff, to advise them on our plans and other related matters before they make a decision on how to proceed.

The Tularosa Basin Water Study was begun this year and is scheduled for three more years. It will not be oriented towards any specific projects or recommendations. Instead, the studies will inventory and identify the water resources of Tularosa Basin and suggest the various uses to which it can be put.

I will include here two Indian Projects which we are studying at the present time. One is on the Jicarilla-Apache Reservation, designed to develop uses for 26,000 acre-feet of water annually by diversion from the San Juan River. This concept has been agreed to between the State of New Mexico and the Secretary of Interior. The other is a proposal to irrigate about 2,500 acres on the San Juan Pueblo by pumping water from either the Rio Grande or the Rio Chama.

With the support of the New Mexico State Engineer and the Santa Cruz Irrigation District, we are conducting a study of raising and rehabilitating Santa Cruz Dam. The objectives are not only to make the structure safe, but also to provide a larger irrigation supply. Several alternatives have been suggested for study. This investigation may take three more years, depending upon the level of funding provided.

At the request of Senator Domenici we are providing technical assistance to the State of New Mexico by making studies for rehabilitation of eight diversion dams and acequias on the Rio Grande below Velarde. These facilities are presently in a deteriorated condition and much study is needed to determine what should be done with them.

The last planning study I want to mention is our Llano Estacado Playa Lake Study. As many of you know, the Ogallala aquifer is the principal water resource of the Llano Estacado area of eastern New Mexico and western Texas. The aquifer is slowly declining in yield and water of the area. The Playa Lake Study is an investigation to determine if the water resources in those lakes could be used to augment or extend the water supply in the Ogallala formation.

Before I talk about future programs of the Water and Power Resources Service, I would like to read to you some definitions or priorities for water resource projects that we intend to follow:

1. Studies with emphasis on energy development at existing facilities with apparent favorable outcome and minimal environmental impact. Water and energy conservation measures and solar energy potentials, Indian water and resources, studies partially funded by states, nonstructural alternative studies, and municipal and industrial needs are included.
2. Similar to priority number 1, but includes studies at new facilities with same objectives as above and, in addition, emphasis on groundwater over-draft, waste water reuse, and water quality improvement.
3. Investigations with high potential for development, considerable support and minimal environmental impact. Investigations with any purpose mentioned in 5-year goals (refers to Service program goals).

Now it is not possible for me to be specific about future programs and projects in New Mexico because none of them have been administratively approved or authorized by Congress. However, a number of possibilities can be envisaged such as:

1. Small wind energy conversion systems wherever feasible throughout the state with energy production integrated with other sources of power.
2. Low-head hydro-energy generation wherever sufficient water supply is available and possibly using existing low-head structures.

3. Pump-back hydro-energy generation for peaking power at existing structures such as Heron, El Vado, and Elephant Butte Dams.

4. Conservation of water and improved management by all uses and users throughout the State.

5. Control and managements of salinity problems, particularly in the Canadian and Pecos River Basins.

In closing I want you to know that the Water and Power Resources Service is still a group of dedicated and competent scientific people here to serve you and to help solve water resource problems. Together, I think we can do it all.

THE SIX-STATE HIGH PLAINS-OGALLALA AQUIFER AREA STUDY*: 1979-1982

Joe B. Harris
Resource Economist
High Plains Associates

We appreciate the opportunity to participate in your 25th Annual New Mexico Water Conference and to bring you up-to-date on a project of vital importance to your state. The Six-State High Plains-Ogallala Aquifer Regional Study, which encompasses parts of New Mexico, Texas, Oklahoma, Colorado, Kansas, and Nebraska, is nearing midpoint of a 42-month study period, to culminate in July, 1982 with a report to Congress and the U.S. Department of Commerce on available means for maintaining the economic vitality of the vast irrigated agricultural economy of the High Plains area in the face of declining reserves of groundwater and energy resources.

I would like to first bring you greetings from our firm's President, Mr. Harvey O. Banks, and Vice President, Mrs. Jean Williams, whom many of you know and have worked with in the past. Harvey serves as Project Director and Jean as Project Manager for the High Plains Study.

I brought along a few figures to review with you the basic purpose, objectives, organization, and content of our study. The

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* The High Plains Study is being conducted for the U.S. Department of Commerce, Economic Development Administration in accordance with Public Law 94-587 (90 Stat. 2943). A general contracting team made up of Camp Dresser & McKee Inc., as prime contractor, Arthur D. Little, Inc. and Black & Veatch, acting as the High Plains Associates, has lead responsibility for the study under the policy guidance of the High Plains Study Council, composed of representatives of the six participating states.

study was authorized by Congress in 1976 by P.L. 94-587 (Figure 1). The enabling legislation authorizes a total of $6 million for a three and one-half years study. Study objectives identified by Congress are shown in Figure 2. The Congressional intent and its implementation by the U.S. Department of Commerce Economic Development Administration, the designated administering federal agency, has been for a strong state participation and policy guidance role in the High Plains Study from its outset. In response to that intent, a High Plains Study Council composed of the Governors of the six study states, citizen representatives appointed by the Governors, and a representative of EDA, has been established. Additional policy guidance for the conduct of the High Plains Study from the High Plains Study Council is also shown in Figure 2.

The basic organization for the High Plains Study is illustrated in Figure 3. This is a very large and complex study, involving many interests and participants. A total of more than 200 direct study participants are represented by the organizations shown in Figure 3.

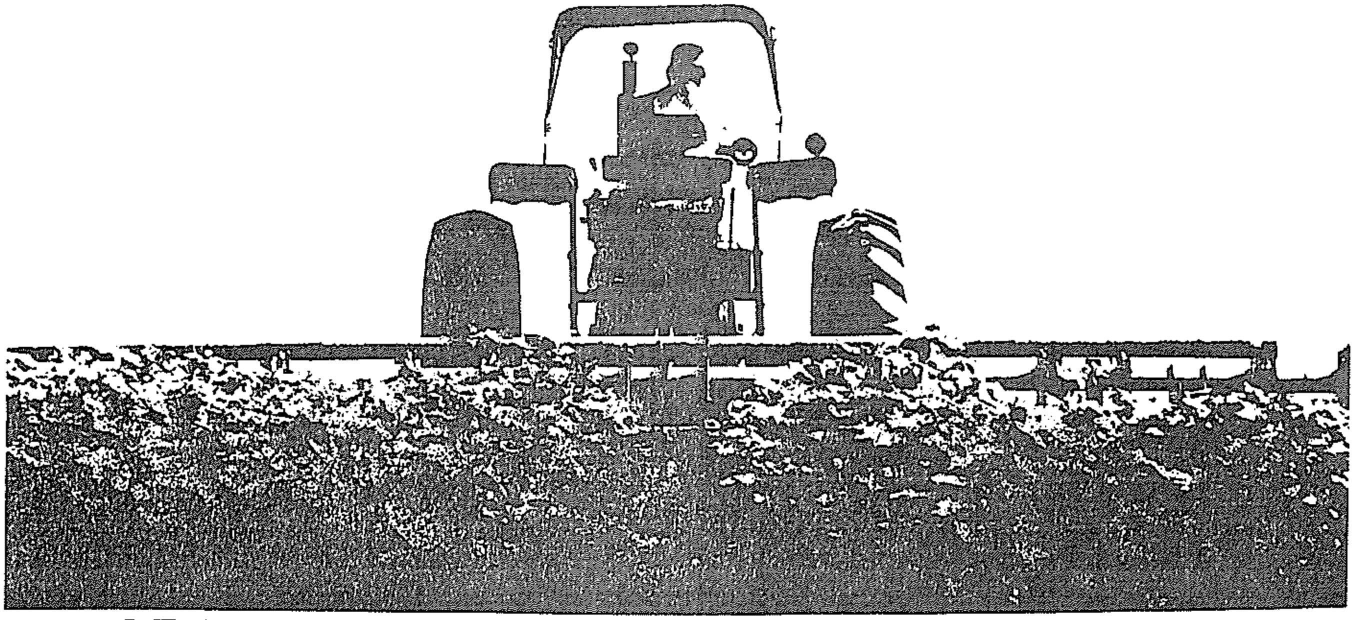
The study is further organized into eleven major regional study elements, being conducted by members of the general contractor team, and three broad state research elements being carried out in each of the six study states. These research activities are illustrated in Figures 4 and 5. Another major component of the study specifically required by the enabling legislation is the consideration of possible water supply augmentation to the High Plains area through

Figure 1

PUBLIC LAW 94-587--October 22, 1976 (90 STAT. 2943)

Sec. 193. In order to assure an adequate supply of food to the Nation and to promote the economic vitality of the High Plains Region, the Secretary of Commerce (hereinafter referred to in this section as the "Secretary"), acting through the Economic Development Administration in cooperation with the Secretary of the Army, acting through the Chief of Engineers, and appropriate Federal, State, and local agencies, and the private sector, is authorized and directed to study the depletion of the natural resources of those regions of the States of Colorado, Kansas, New Mexico, Oklahoma, Texas, and Nebraska presently utilizing the declining water resources of the Ogallala aquifer, and to develop plans to increase water supplies in the area and report thereon to Congress, together with any recommendations for further congressional action. In formulating these plans, the Secretary is directed to consider all past and ongoing studies, plans, and work on depleted water resources in the region, and to examine the feasibility of various alternatives to provide adequate water supplies in the area including, but not limited to, the transfer of water from adjacent areas, such portion to be conducted by the Chief of Engineers to assure the continued economic growth and vitality of the region. The Secretary shall report on the costs of reasonably available options, the benefits of various options, and the costs of inaction. If water transfer is found to be a part of a reasonable solution, the Secretary, as part of his study, shall include a recommended plan for allocating water in an equitable fashion, taking into account existing water rights and the needs for future growth of all affected areas. An interim report, with recommendations, shall be transmitted to the Congress no later than October 1, 1978, and a final report, with recommendations, shall be transmitted to Congress not later than July 1, 1980. A sum of $6,000,000 is authorized to be appropriated for the purposes of carrying out this section.

Figure 2



OBJECTIVES

PL 94-587

- ASSURE ADEQUATE WATER SUPPLIES TO THE AREA
- ASSURE AN ADEQUATE SUPPLY OF FOOD TO THE NATION
- PROMOTE ECONOMIC VITALITY OF THE HIGH PLAINS REGION
- DEVELOP PLANS TO INCREASE WATER SUPPLIES IN THE AREA
- ASSURE CONTINUED GROWTH AND VITALITY OF THE REGION

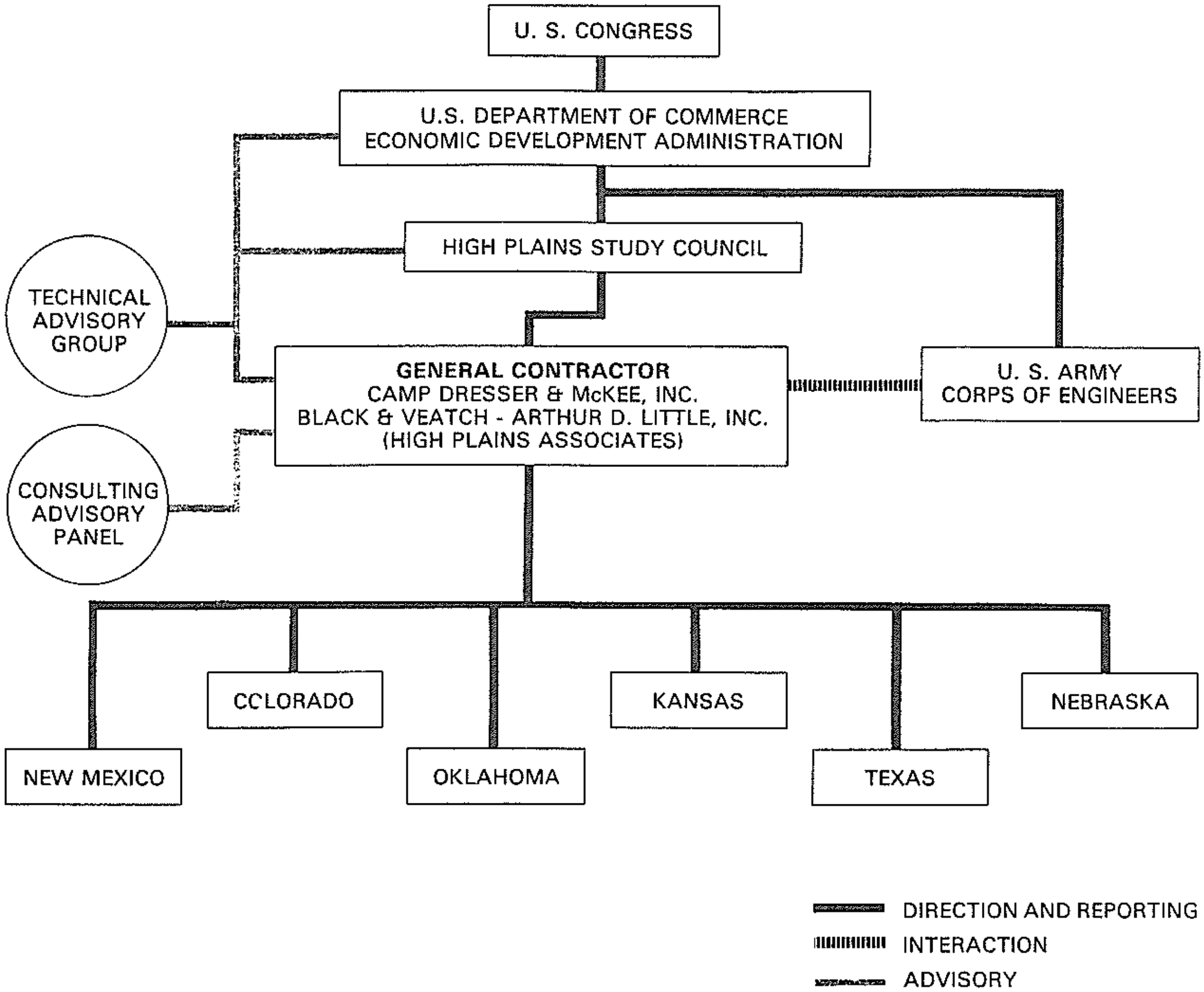
HIGH PLAINS STUDY COUNCIL

- DETERMINE POTENTIAL DEVELOPMENT ALTERNATIVES FOR HIGH PLAINS REGION
- IDENTIFY AND DESCRIBE THE POLICIES AND ACTIONS REQUIRED TO CARRY OUT PROMISING DEVELOPMENT STRATEGIES
- EVALUATE THE LOCAL, STATE AND NATIONAL IMPLICATIONS OF THESE ALTERNATIVE DEVELOPMENT STRATEGIES OR THE ABSENCE OF THESE STRATEGIES.

Figure 3

HIGH PLAINS-OGALLALA AQUIFER REGIONAL STUDY

STUDY ORGANIZATION



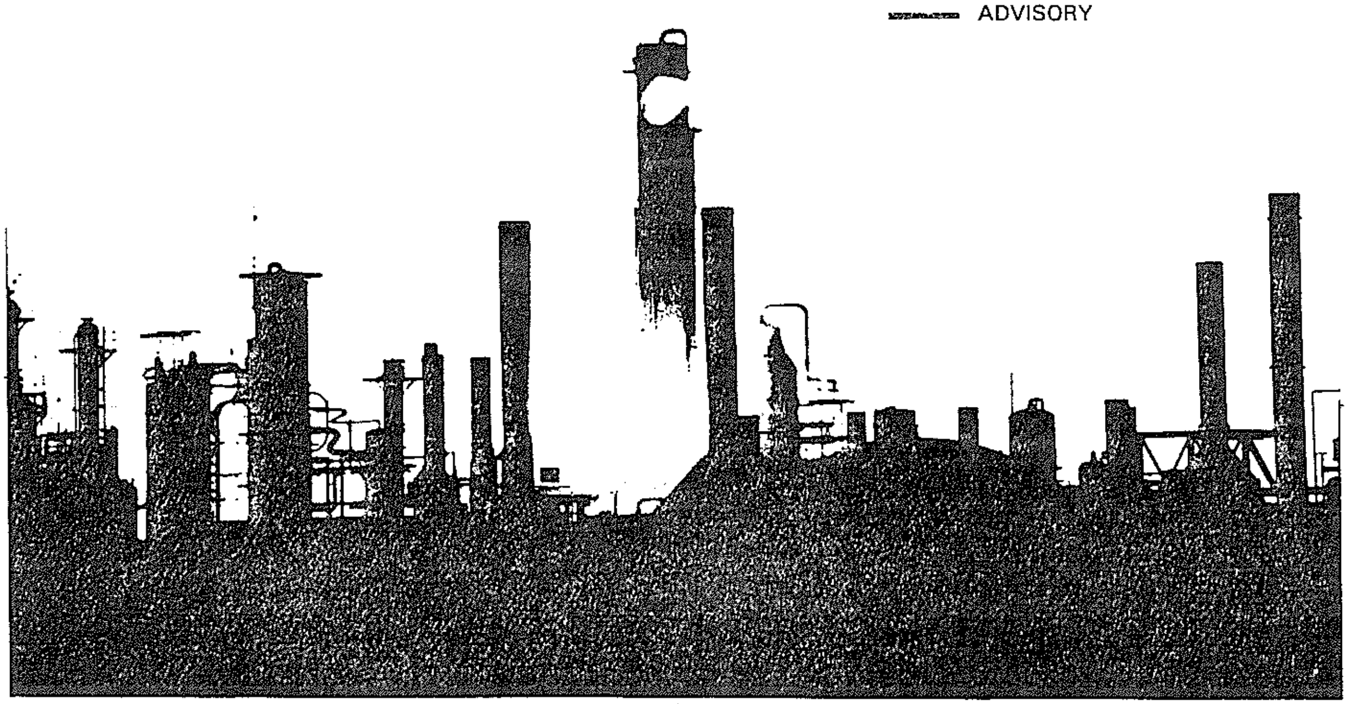
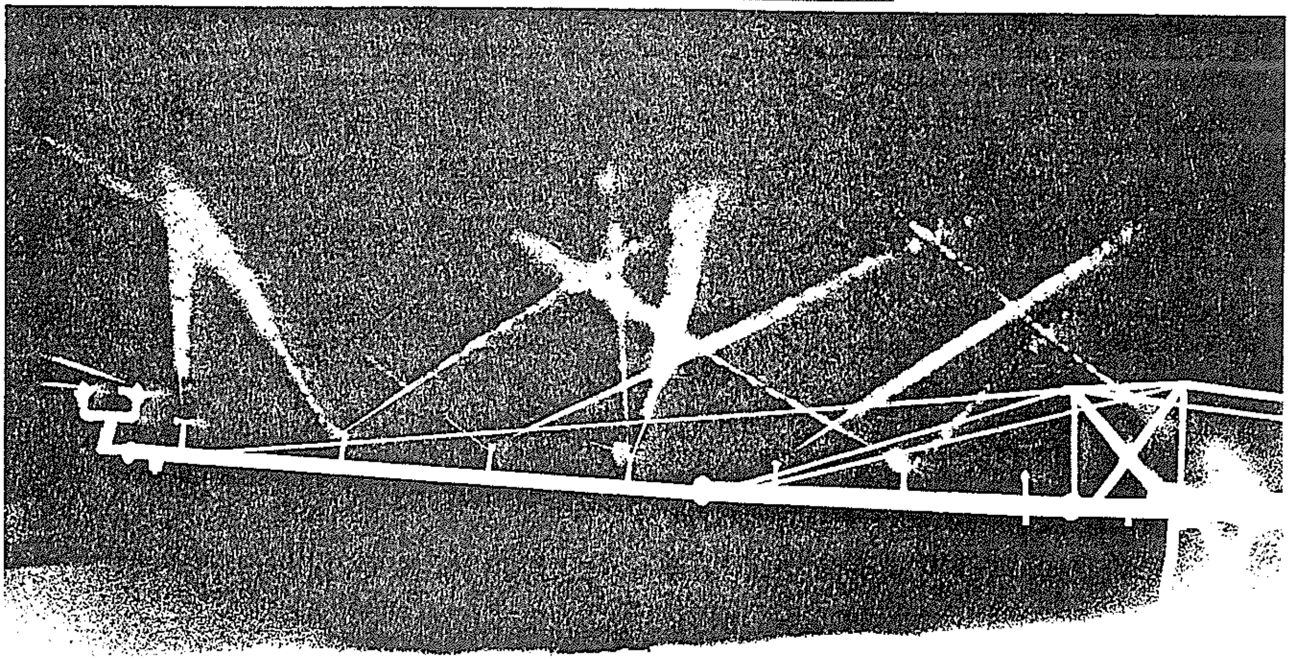


Figure 4

HIGH PLAINS-OGALLALA AQUIFER REGIONAL STUDY



RESEARCH TO BE CONDUCTED BY GENERAL CONTRACTOR

To be coordinated with Federal, State and local plans and programs.

THE REGIONAL RESEARCH WILL ASSESS AND EVALUATE:

B-1 INTERBASIN TRANSFERS - IN COOPERATION WITH CORPS OF ENGINEERS

B-2 NATIONAL AND REGIONAL CHANGES IN COMMODITY PRICES, SHIFTS IN AGRICULTURAL PRODUCTION, CHANGES IN CONSUMER PRICES AND SHIFTS IN CONSUMER EXPENDITURES

B-3 EFFECTS AND COSTS OF APPLYING ADVANCED AGRICULTURAL AND WATER MANAGEMENT TECHNOLOGIES TO ACHIEVE MORE EFFICIENT USE OF WATER

B-4 ENVIRONMENTAL IMPACTS

B-5 TECHNOLOGIES FOR AUGMENTING LOCALLY AVAILABLE WATER SUPPLIES AND COSTS

B-6 LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING ALTERNATIVE DEVELOPMENT STRATEGIES

B-7 CROP PRICE PROJECTIONS, ANALYSES OF TOTAL REVENUE AND COSTS FOR WIDE RANGE OF COMMODITY AND LIVESTOCK ENTERPRISE SITUATIONS

B-8 ENERGY PRICE AND TECHNOLOGY

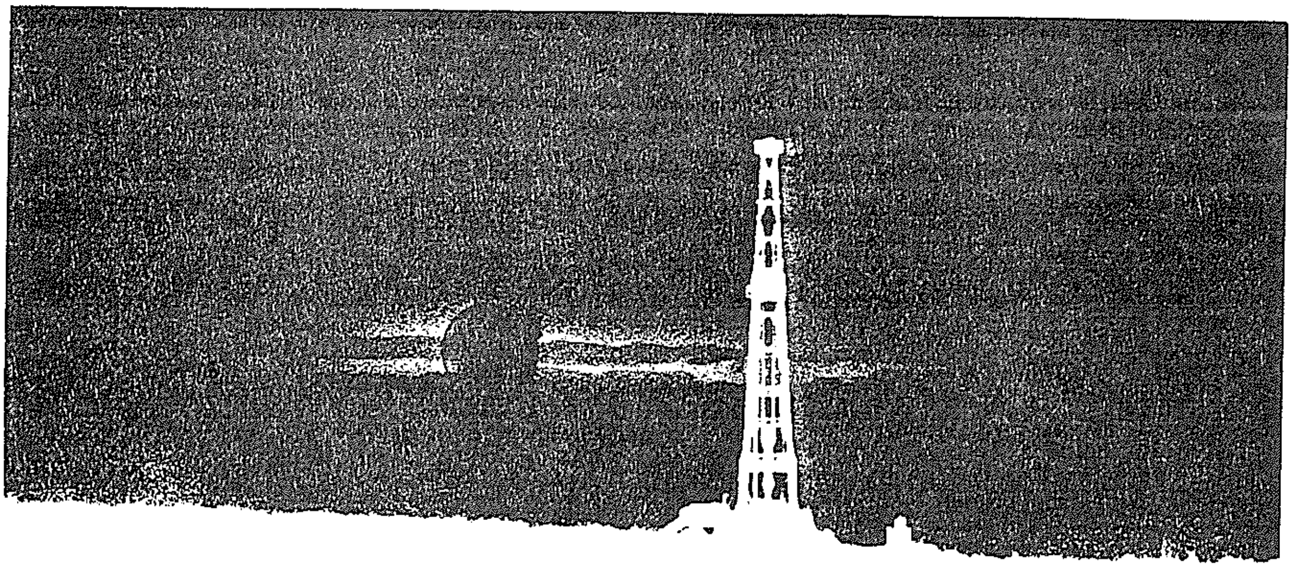
B-9 IMPACTS OF TRANSITION TO DRYLAND FARMING

B-10 REGIONAL POTENTIAL FOR NON-AGRICULTURAL DEVELOPMENT

B-11 ALTERNATIVE DEVELOPMENT STRATEGIES

Evaluations of alternative development strategies will be reported to High Plains Study Council for consideration and recommendations to Secretary of Commerce.

Figure 5



RESEARCH TO BE CONDUCTED BY THE STATES

A-1 STATE AGRICULTURE AND FARM LEVEL RESEARCH

Project cropping patterns; agricultural output and output value; inputs and input costs; agricultural employment and income.

A-2 ENERGY INDUSTRY IMPACTS

Project energy production; energy requirements for irrigation; employment; royalties and other income from energy industry; and water requirements.

A-3 STATE WATER RESOURCES EVALUATION AND IMPACTS RESEARCH

A-3.a Evaluate intrastate water resource situation; project intrastate water supplies and demands under alternative development strategies.

A-3.b Project economic adjustments and socioeconomic and environmental impacts at the subregional and State level resulting from changes in land use and changes in supply and uses of water, energy and other sources under each alternative development strategy.

Results of the State research will be used by the General Contractor in the regional and national analyses.

interbasin water transfers. Some of the possible sources, routes and designations of water transfer potentials being investigated by the Corps of Engineers are illustrated in Figure 6.

The culmination of all state, regional and Corps studies will be the assessment of a set of alternative development strategies for the High Plains region, as adopted by the High Plains Study Council, and the projected effects of their implementation over the 40-year study period (to 2020). The development alternatives to be assessed are shown in Figure 7.

The end result of the High Plains Study is to be a final report by the states and the general contractors to the High Plains Study Council. On the basis of that report, the Council will make recommendations for needed actions to the Secretary of Commerce and to Congress. The study final products are illustrated in Figure 8.

The High Plains Study is proceeding on schedule, with strong leadership from the states and effective research direction by such qualified practitioners as your own Bob Lansford. We have enjoyed a very good working relationship with the states, and that can be attributed in large degree to people like Steve Reynolds who represent New Mexico on the High Plains State Liaison Committee.

Thank you again for the opportunity to participate in your 25th Annual Water Conference.

Figure 6

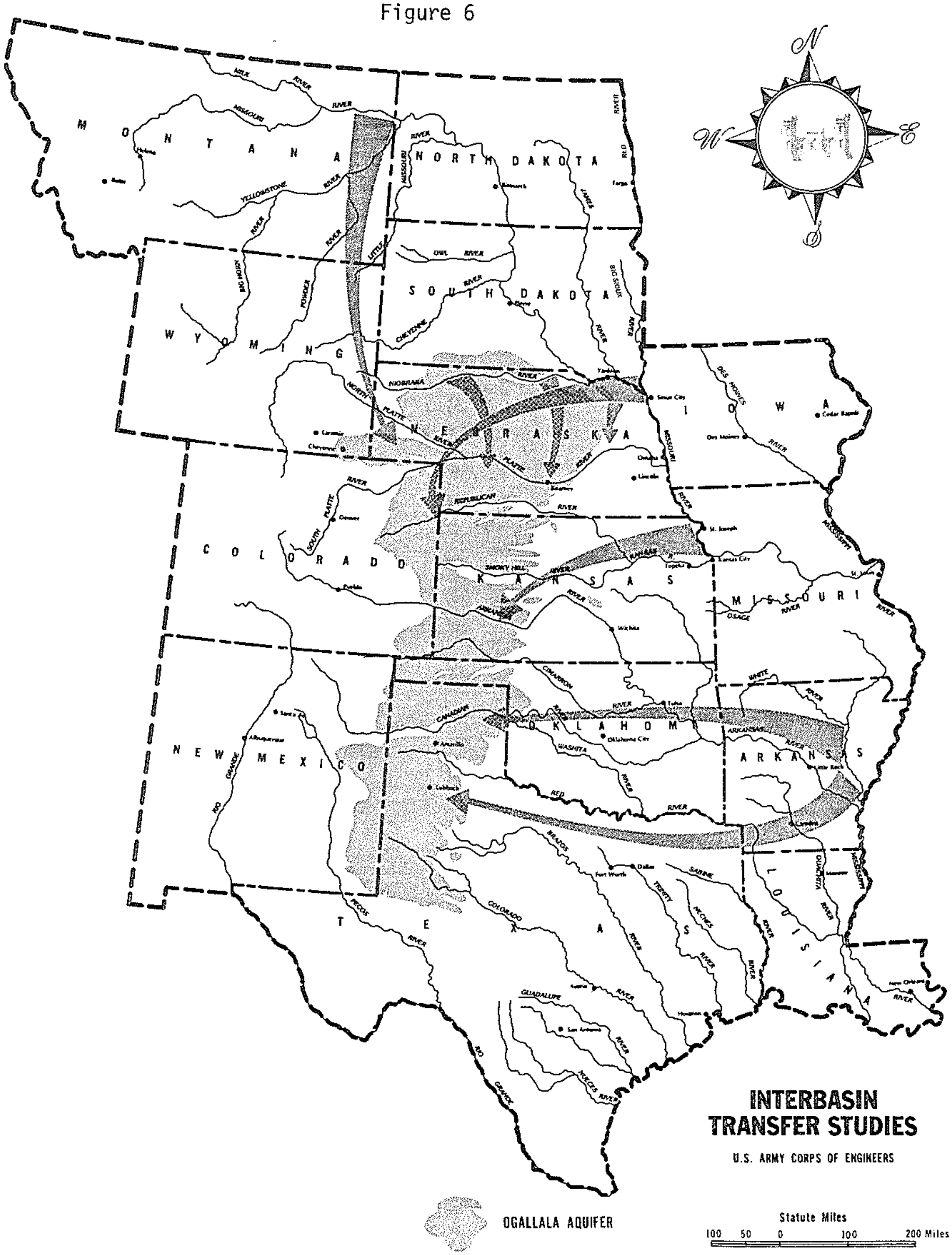

INTERBASIN
TRANSFER STUDIES
U.S. ARMY CORPS OF ENGINEERS
OGALLALA AQUIFER
Statute Miles
100 50 0 100 200 Miles
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA

Figure 7

HIGH PLAINS—OGALLALA AQUIFER REGIONAL STUDY

ALTERNATIVE DEVELOPMENT STRATEGIES

These alternatives are not mutually exclusive. For a particular subregion, or combination of subregions, a mix of alternatives may be found to be the best solution to meet objectives.

BASELINE

— CONTINUATION OF CURRENT LOCAL, STATE, FEDERAL POLICIES AND TRENDS; NO NEW STATE OR FEDERAL PROGRAMS

WATER RESOURCES ALTERNATIVES

Alternatives are listed in order of increasing cost and increasing availability.

1. WATER DEMAND MANAGEMENT: Encourage users to practice conservation through application of proven technology; provide incentives for the farmer to conserve.

2. WATER DEMAND MANAGEMENT: Apply all advanced water and agricultural management technology on a broad scale, identifying any necessary constraints.

3. LOCAL WATER SUPPLY MANAGEMENT: Augment water supplies at local level with techniques such as artificial recharge, weather modification, land management, snow pack management, vegetation management, desalting, evaporation management, and others.

4. SUBREGIONAL INTRASTATE IMPORTATION SUPPLY MANAGEMENT: Augment local water supplies with interbasin transfers of surface water as available.

5. REGIONAL INTERSTATE IMPORTATION SUPPLY MANAGEMENT: Augment local water supplies with major interbasin transfers of water, possibly providing for expansion of irrigated acreages.

NON-AGRICULTURAL DEVELOPMENT ALTERNATIVES

6. NON-AGRICULTURAL ALTERNATIVES: Development and use of available resources for purposes other than agricultural production.

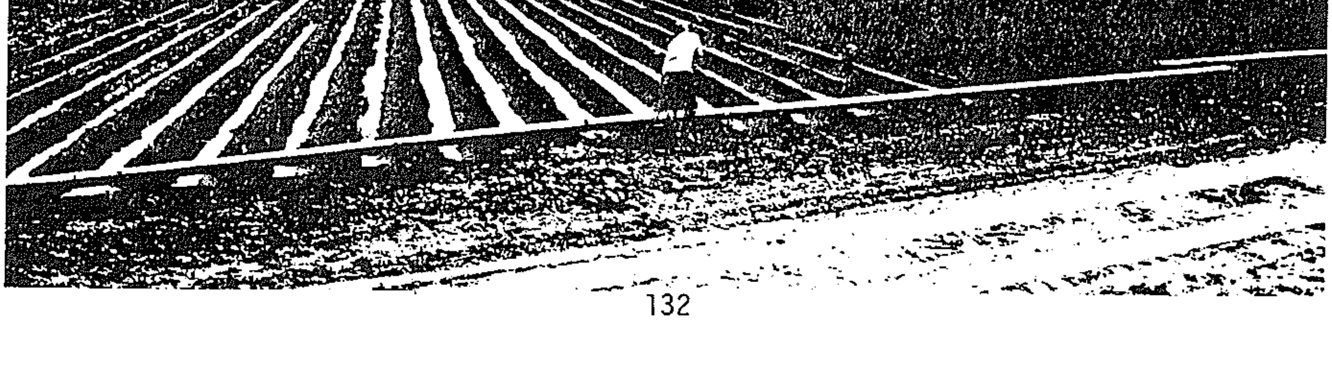


Figure 8

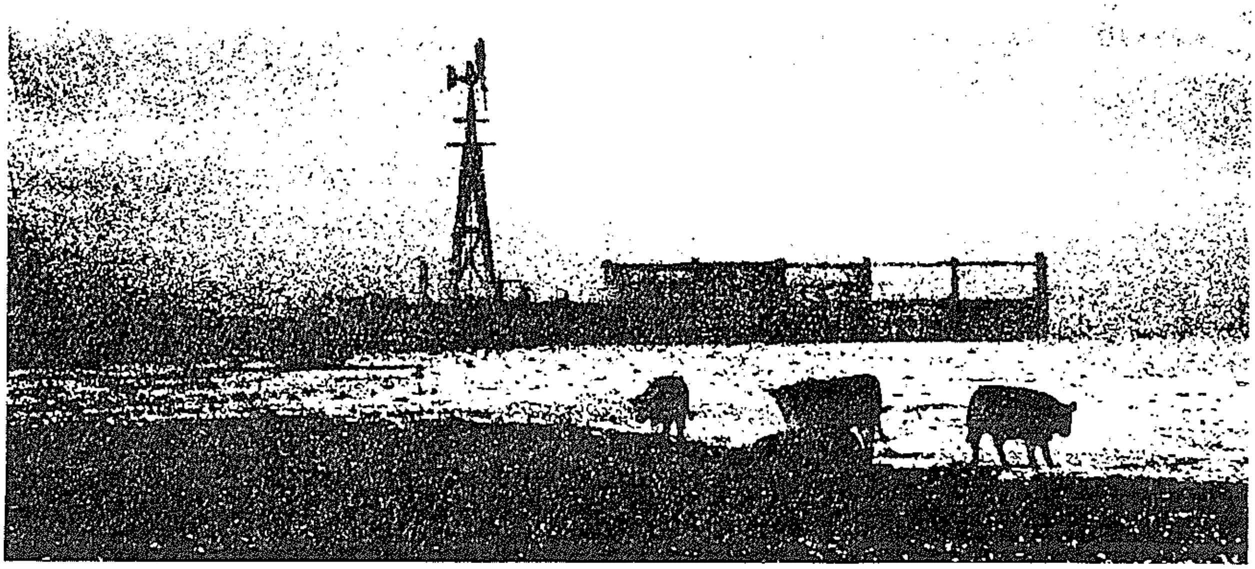
HIGH PLAINS-OGALLALA AQUIFER REGIONAL STUDY

STUDY FINAL PRODUCTS

- FOR THE STATES INVOLVED, THE REGION, AND THE NATION, THIS STUDY WILL EVALUATE THE EFFECTS OF CONTINUING EXISTING TRENDS AND POLICIES ("NO-ACTION") AND THE EFFECTS OF IMPLEMENTING EACH OF THE ALTERNATIVE DEVELOPMENT STRATEGIES ON:
  - THE ECONOMY
  - THE ENVIRONMENT
  - THE QUALITY OF LIFE

- THE STUDY WILL ALSO DETERMINE:
  - THE COSTS OF IMPLEMENTING EACH OF THE ALTERNATIVE STRATEGIES
  - THE LEGAL, INSTITUTIONAL, FINANCIAL, AND ORGANIZATIONAL CHANGES NECESSARY TO IMPLEMENT EACH OF THE POSITIVE ALTERNATIVE STRATEGIES
  - THE CONSEQUENCES OF THE "NO-ACTION" OPTION COMPARED WITH THE RESULTS OF IMPLEMENTING POSITIVE ACTION ALTERNATIVE DEVELOPMENT STRATEGIES

These study results will provide the High Plains Study Council, Department of Commerce, the Congress, State Legislatures and others an informed basis for reaching decisions as to the future of the High Plains-Ogallala Aquifer Region.



160-ACRE LIMITATION: CURRENT STATUS

Frank DuBois
New Mexico Department of Agriculture

In order to bring you up-to-date on the various issues surrounding reclamation reform, I will try to do the following in the time allotted: 1) to put things in their proper perspective, I will give you a chronological listing of events which bring us to the present; 2) I will briefly summarize the major sections of Senate Bill 14, as passed by the U.S. Senate, and of HR 6520, the so-called "Ullman-Udall" bill, as introduced in the House of Representatives; and 3) I will provide the most recent information I have with respect to activities of the House Committee on Interior and Insular Affairs, and raise some questions about the future.

A fairly complete list of chronological events concerning this issue would be as follows.

In early 1976, the National Land for People organization, representing persons who unsuccessfully sought to purchase excess land in the Westlands Water District of California, brought suit in the U.S. district court for the District of Columbia against the Bureau of Reclamation, alleging failure to comply with the Administrative Procedure Act in providing regulations for the sale of excess lands in the district. The National Land for People requested rules and regulations that would require the enforcement of the acreage limitation provisions of the Reclamation Act of 1902 and the Omnibus Adjustment Act of 1926.

On August 9, 1976, the court ruled that the Bureau of Reclamation had not complied with the Administrative Procedure Act, and several days later issued a preliminary injunction to prohibit the Bureau from accepting or approving any new contract for the sale of excess land in the Westlands Water District until rules and regulations could be properly promulgated.

On June 27, 1977, Secretary Andrus issued an administrative order which put a moratorium on all sales of excess land and on entry into recordable contracts for all reclamation lands in the 17 western states.

On August 25, 1977, the Department of the Interior proposed regulations to implement acreage limitations and the residency requirements.

On November 22, 1977, the Department of the Interior held the last of ten field hearings on the proposed regulations.

Opponents of the proposed regulations filed suit against the Department of the Interior to prevent the implementation of the final regulations until a comprehensive environmental impact statement had been prepared. On December 2, 1977, the U.S. district court in Fresno issued a preliminary injunction to prevent implementation of the regulation until such an environmental impact statement was completed.

On January 7, 1978, the Department of the Interior announced it would prepare the environmental impact statement and now expects the document to be ready in late 1980.

On January 15, 1970, Senator Frank Church introduced Senate Bill 14, and on September 14, 1979, the U.S. Senate passed the final version of Senate Bill 14.

On March 20 of this year, the Water and Power Resources Subcommittee of the House Committee on Interior and Insular Affairs completed four days of hearings, with 16 different bills pending before the subcommittee.

Let's review the main provisions of Senate Bill 14 as passed by the Senate, and of HR 6520 as introduced in the House.

Senate Bill 14 provides that a recipient of federal reclamation water may be either an individual or a legal entity of not more than 25 individuals, and that a "landholding" of up to 1,280 acres is eligible for federal reclamation water. Leased land is eligible for federal reclamation benefits, but must be included in the 1,280 acreage limitation. Holders of excess leased lands are provided a grace period of ten years to dispose of these lands.

Senate Bill 14 abolishes the residency requirement and with some exceptions, exempts Army Corps of Engineers' projects. This bill has an equivalency provision, based on Class I land, and provides for exemption from the acreage limitations after payout over the full term of the contract.

I chose HR 6520 from the various House bills, because of its cosponsors, because it stakes out a middle-ground position in the House, and because it seems to have generated the most comment and activity.

HR 6520 provides that a recipient of federal reclamation water may be either an individual or a legal entity of not more than 18 individuals, or two or more individuals under concurrent ownership, if all such individuals maintain among themselves an immediate family relationship. A landholding of up to 1,120 acres is eligible for federal reclamation water, and leased land is eligible for federal reclamation benefits, but must be included in the 1,120 acreage limitation. Holders of excess leased lands are allowed three years to dispose of such lands. In addition, those who would acquire a landholding subsequent to the passage of HR 6520, may not lease their landholding unless the Secretary of the Interior determines the owner has, during the five-year period following the acquisition, derived a significant percentage of his or her income from direct involvement in agricultural production. The Secretary may waive this requirement for reasons of disability or retirement, or exempt the landholder for one year for reasons of economic viability.

HR 6520 abolishes the residency requirement, except for when it is used as a substitute for the "income" and "direct involvement" provisions. Army Corps of Engineers' projects are exempt unless: 1) the project has, by law, expressly been designated, made a part of, or integrated with a federal reclamation project, or has been made subject to the federal reclamation laws as of January 1, 1980; or 2) is made explicitly subject to the acreage limitation provisions by statute.

The bill has an equivalency provision, based on Class I land and a growing season of 180 days. It provides for exemption from the reclamation laws on the date of the completion of the construction charges as required by the contract, provided the landholding meets the acreage limitation requirements of HR 6520. If the repayment contract is silent as to the effect of repayment on acreage limitations, those limitations should cease to apply: 1) when the Secretary determines the reclamation project has substantially achieved a pattern of family farms; or 2) 20 years after completion of repayment.

Next, I will relay to you some of the most recent conversations I have had with Congressional staffers on the House side. I should also caution you that none of these prognostications are written in stone.

First, a new and revised version of HR 6520 will be introduced in House during the first week of May. The new legislation will clear up some technical questions and refine the language in the bill. I am told the new version will clean up the language dealing with: 1) some ambiguities concerning state water rights; 2) the "grandfather" clause dealing with payments of construction charges; and 3) the voting of irrigation districts in reference to the equivalency clause. Finally, the new version will add an inheritance provision to the agricultural participation section.

I have also been advised that it is very likely Representative Tom Foley will cosponsor the new version. This would mean the new bill will be cosponsored by Al Ullman, Chairman of the Committee on Ways and Means; Moe Udall, Chairman of the Committee on Interior and Insular Affairs; and Tom Foley, Chairman of the Committee on Agriculture -- a rather formidable group of supporters.

Secondly, I have been advised the subcommittee will start mark up in mid-May. Apparently the subcommittee's deliberations have been "held hostage," if you will forgive that phrase, by the May 3rd primaries in Texas.

I will conclude this presentation, not by trying to predict the outcome or final form of reclamation legislation, but instead by posing some questions which may give us some insight into the problems ahead of us. Here are the questions:

Will the subcommittee on Water and Power Resources report a bill to the full committee in a timely manner?

Will the full committee hold additional hearings on the legislation, or will they move straight to mark up?

Will the full committee report out a bill that is susceptible to "gutting" on the House floor by reform-minded members?

Will the Senate and House conferees be able to reach agreement on a final version of the bill?

To what extent will the lengthy Congressional recesses this summer for the Democratic and Republican national conventions delay action on this issue?

Will the final version of the bill be acceptable to the Administration and would the President, in an election year, veto a bill that affects thousands of farmers, and hundreds of rural communities in 17 western states?

If Congress does not complete action on the bill, or if it is vetoed by the President, will the Secretary of Interior move to enforce his proposed regulations?

And finally, of course, will Cecil Andrus be the Secretary of Interior come January, 1981?

I sincerely hope that I, or someone else, will have the answers to all of these questions at next year's Annual Water Conference.

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2. Udall, Congressman Morris. "Reclamation Reform Act of 1979." Congressional Record, 8 November 1979.
3. Ullman, Congressman Al. "HR 6520 - The Reclamation Reform Act of 1980." Copy of statement provided by Mr. Ullman's office.
4. Farm/Water Newsletter, 22 February 1980.
5. California Westside Farmers Newsletter, 8 April 1980.

MEET THE SPEAKER
BANQUET

Pat O'Meara

J. W. "PAT" O'MEARA is the Executive Vice President of the National Water Resources Association. He has had a long and distinguished career in the nation's development of a saline water conversion program. Formerly Director of the Office of Saline Water when that agency was merged with the Office of Water Resources Research to form OWRT in 1974, he has seen it become an internationally-recognized leader in developing processes for the desalinization of water. O'Meara's services for the Department of Interior earned him the coveted Distinguished Service Award.

SWEEPING SAND IN THE DESERT

Pat O'Meara
National Water Resources Association

It seems fitting and appropriate, at the very outset of these remarks, to take a few minutes this evening to make some comments about a very special guy. A down-to-earth, intelligent, aggressive, and exceptionally perceptive person.

Born just before the great depression, he lived in and endured, poverty and want. The good things in life were denied him during his boyhood and the simple pleasures of life were denied him during his boyhood. The little luxuries that bring joy, like a baseball, glove and bat or a bicycle were beyond his financial ability to acquire.

But, by sheer determination and initiative, he literally pulled himself up by his bootstraps. He obtained his grade and high school education, even though he had to work after school every night, at all kinds of menial jobs, to help support his family and to put aside a nest egg to pay for his golden dream -- a college education. He had early come to realize, through hard and bitter experience, that education was his only hope of breaking the shackles of poverty. He relentlessly pursued his golden dream. In spite of adversity and tribulation, he worked his way through college and graduated magna cum laude from one of the finest engineering schools in the country.

Almost immediately he applied his talents to water resources conservation and development. Shunning more lucrative offers of employment in the private sector, he devoted his energies to improve the water posture of his state, and indeed the nation, through government service. Widely recognized and admired by his peers for his inspired leadership and continuing contributions to his chosen field of endeavor, his unique record of service is without parallel. Well, Steve, I think that's enough about me -- I had best get on with my remarks.

Over the years it has been my pleasure to be involved in several New Mexico activities. The first, was say back in 1958, when I was on the program of the third New Mexico Water Conference to report about the new U.S. program to produce fresh water from sea or brackish water sources. I used to know a lot of fine people from New Mexico. Now I find they are all buildings -- Clinton P. Anderson Physical Science Lab, Stucky Hall, Roger B. Corbett Center. One guy I met then who isn't a building yet was the State Engineer. It was the same one then as it is today, the nation's most durable Steve Reynolds.

I went back to my files and dug out the remarks I delivered at that third annual meeting because I am just vain enough to want to know if anything I said at that time was sufficiently incisive to stand the test of nearly a quarter of a century of time. 300 months, 1300 weeks, 9125 days -- a whole lot of water under the bridge.

To my surprise and pleasure, I noted one remark I made way back then is almost as germane today as it was when Eisenhower was President.

For those of you who are here tonight and were present when I spoke at the third annual meeting, I apologize for the re-run, but since some time has elapsed, perhaps it will serve to jog your memory. I quote, "The challenge of providing adequate supplies of water to meet our growing demands is indeed great, but to me, this conference is witness to the fact that you, here in New Mexico, firmly resolved not to let the lack of water curtail the future expansion of your population, your agriculture, and your industry. By drawing on your inspiring heritage of water resource development, groups such as this will provide the necessary leadership to meet and answer the challenge."

I'm glad I said that. I think it was worth repeating, because we have much the same challenge in water resources development today that we had 25, 50, 75, or 100 years ago. Steve, not much has changed.

You may think it is arid here in New Mexico, but it's like the guy who asked, "How's your wife?" And the fellow responded, "Compared to what?"

When I worked in the U.S. desalting program, I made several trips to Saudi Arabia. Once when I disembarked from a plane in Jiddah, at the foot of the steps there was an old Arab dressed in his flowing white robes. He had a long stick in his hands to which was tied a bundle of twigs. With this primitive broom he was industriously sweeping sand from the walkway to the terminal building. As I watched him dutifully perform his never-ending task, the thought went through my mind, "Wow! Sweeping sand in the desert, that's really job security!"

I would like to tell you a couple of things I learned about Saudi Arabia. First of all, the Arabian penninsula is a land mass approximately the size of the United States east of the Mississippi River, and in that entire area there is not one single flowing stream.

With the enormous financial income the Saudis now enjoy from the sale of oil, the government is desperately trying to advance their nation almost overnight from the 16th century to the 20th century. One thing they must do to create a modern society is to provide a reliable and adequate source of water. Since dams to create reservoirs are infeasible and known resources of underground water supply are virtually nonexistant, the government has apportioned funds for a modest initial desalting plants construction program. (You will note that I said apportioned. In a democracy you appropriate, in a monarchy, you apportion.)

The Bureau of Reclamation, from its inception in 1902, until its name was changed last year to the Water and Power Resources Service, has completed $6.3 billion worth of project facilities. I repeat, $6.3 billion investment in reclamation project facilities in 77 years. The Saudi government has embarked on a five-year program to build power and water desalting plants for which they have apportioned $15 billion. Plans now being developed for a second five-year program are being drafted in the range of $20-$30 billion.

One of my past trips to New Mexico was to escort a group of Russian nuclear desalting experts on a tour of U.S. facilities. As we were sitting in our plane at the Washington National Airport, the head of the Russian delegation was studying the route I had sketched on a map of the tour we were about to undertake. From D.C. we were going to North Carolina, then Oak Ridge, Tennessee; Freeport, Texas; and Roswell, New Mexico. He looked up from the map, and through the interpreter he asked, "In Roswell, is it arid?" I asked the interpreter to inquire if the Russian knew the Bible. He answered, "Yes, a little." I asked if he knew the parable of the deluge, when it rained for 40 days and 40 nights. "Yes, yes," he said, he knew that. "Well," I told the interpreter, "tell him at that time Roswell got a quarter of an inch."

I got to thinking the other day about that poor old Arab sweeping sand in the desert, and it occurred to me that he did not have near as good job security as working on water resource development in the United States. Yours truly, Ralph Stucky, and Steve Reynolds are living proof of that.

I think part of the problem we have had is that every new administration brings a bunch of new bureaucrats to Washington and they energetically set about to solve the problem. Each new group comes to town with the bright idea that within four or eight years of enlightened leadership they can wrap up our water problems in a pretty box and tie it with a bright blue ribbon.

Of course, that is not true of the present administration. It seems to me that they have decided if they ignore the problem it will go away, so they have promulgated a program that is based on hit lists, conservation without storage, flood plain management and nonstructural development. They seem to think they discovered conservation and it will cure all our ills.

You know, and I know that ever since the first white settler arrived in the West, water conservation has been a way of life. When the Carter administration developed a water policy that deliberately eliminated the word storage, Governor Scott Matheson of Utah, one of the many western water leaders who were deeply concerned by the new policy, worked diligently, but unsuccesfully, to get the administration to broaden its definition of conservation. He has emphasized that conservation also means storage of excess water supplies in times of abundance to be used in times of scarcity.

There is an old truism that says: "It doesn't rain in the West -- it snows!" The essence of conservation in the west means the storage of spring run-offs for use later in the year. As you know, the President vetoed the $1.8 billion public works bill in October 1978, and he has indicated he will veto the public works bill approved by the House and now awaiting action by the Senate.

The administration has proposed a cost-sharing program for water projects. Your Senator is a cosponsor of S1241, the so-called Domenici-Moynihan bill which proposes some radical changes in the way a water project is authorized and funded. Among other provisions, it would require a 25% front-end contribution by the state in which the project is located. It provides for an annual federal appropriation to be divided among the states on a formula that is based on square miles and state population.

I haven't figured out just why Senator Domenici is pushing for such a bill, but I can understand Senator Moynihan. He is from New York and the formula certainly augers in favor of his state. While New Mexico has more than twice the area of New York, New York has 18 times as much population, and lots more rain! The formula says nothing about need, conservation, wise use, planning, operation and maintenance, or a host of other factors essential to a reasonable and responsible water resources program.

Neglect might be a good word to describe the current situation in Senator Moynihan's state and other states in the New England area, a region richly endowed with a generous average rainfall. I remember back about ten years ago, they had a severe drought in New York. It lasted nearly three years. If you had received the same rainfall here in New Mexico that they received in New York during the drought, you would call it the three wet years!

But for all of their God-given water, the New England states face severe water problems. They have recently estimated it will require $25 billion to bring their water systems up to acceptable standards. It is mostly a distribution system problem brought on by neglect; and now they want Uncle Sam to bail them out -- with grants.

For example, Boston embarked on a long-delayed maintenance program to replace all city water lines that were 100 years old by the year 2000. But they now are so far behind on the schedule that they now plan to replace all lines that are over 150 years old by the year 2000. Meanwhile, 50% of the water delivered to the city is lost through leakage.

New York City gets a major share of its water through two huge tunnels. The water demand is so large that they can not close down one or the other tunnel for maintenance, so they must build a third tunnel which is currently estimated to cost $5 billion! If either of the present tunnels fails before the third is completed, we will have 8 million people without an adequate supply of water. A mass exodus would be the only answer. Good planning.

I don't know how an engineer determines the age of a system and its maintenance requirements; I'm sure there are many variables.

I would like to talk briefly about the Association I represent, the National Water Resources Association. We are a confederation of the state water associations in the 17 western states and Hawaii. Our New Mexico affiliate is the New Mexico Reclamation Association. The water concerns of the state of New Mexico and the policies you espouse relative to water development have been expertly articulated by your representative to the National Water Resources Association

Board of Directors, Mr. Wayne Cunningham. The Board has recognized his ability and capability by electing Wayne Treasurer of the National Association. It has been a great pleasure working with Wayne, and I want you to know it is also very comforting and encouraging to know that we have the strong support and backing of Steve Reynolds!

In my invitation to speak to you this evening I was asked to say something nice about Steve Reynolds. Kinda reminded me of the time a reporter asked President Eisenhower to say something nice about Nixon. Ike said if they gave him a week he would think of something. Well, I've had more than a week, and like Ford (not Jerry), I thought I had a better idea.

I asked some distinguished Americans to say something nice about Steve, and I want to share with you what they had to say:

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
WASHINGTON, D.C. 20510

April 22, 1980

It has been my good fortune to work with the best State Engineer in this country during my eight years in the Senate. Steve Reynolds is widely recognized in the water business as an expert in the field and considered by many to be the best of all. New Mexico is indeed fortunate to have Steve running its water business.

I need not repeat my firm beliefs on our impending water crisis nor my desire for wise management and innovative solutions to the problem nor New Mexico's specific problems. However, I firmly believe that Steve Reynolds has guided our state down a path of wise water management and has helped to prepare us for future water demands.

As energy development begins to consume our water resources in New Mexico, I believe we are prepared to meet those demands because of the firm direction we have received from Steve Reynolds during the past 25 years.

The honors that have been conferred on Steve and the offices that he presently holds are staggering. He seems to live and breathe water. He has not only carefully guided water uses within New Mexico, but has well represented our state on numerous compact commissions.

The State of New Mexico will sorely miss Steve Reynolds, but I know that he will never acutally "retire" in the sense that he will continue to play an active role in ensuring proper water management in New Mexico. I want to pay the highest tribute to Steve Reynolds, a man who has not only served New Mexico, but its elected representatives in Washington.

Pete V. Domenici
United States Senator

HARRISON SCHMITT
NEW MEXICO

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION

COMMITTEE ON APPROPRIATIONS

SELECT COMMITTEE ON
SMALL BUSINESS

United States Senate
WASHINGTON, D.C. 20510

April 24, 1980

Mr. Pat O'Meara
National Water Resources Association
955 L'Enfant Plaza, S. W.
Washington, D. C. 20024

Dear Mr. O'Meara:

Steve Reynolds is a man of whom all New Mexicans can be proud. In a state where water is its lifeblood, he has handled his critical duties in a most dedicated manner.

There is virtually no question Steve cannot answer with respect to water in our state, and my staff has affectionately awarded him the title, "Mr. Water." Never has he been accused of being "all wet;" Steve, however, has gone to bat at every occasion in support of water rights and equity for the State and its citizens. While there are times when we may have disagreed with some of his decisions, I have found that working with Steve has been an experience in cooperation and mutual "give and take."

Certainly there is no one in the State of New Mexico more knowledgeable about specific water problems and about the general problems of the western United States. We wish that Senators and Congressmen from other states had one percent of his understanding and, if they did, the West would have a lot easier time resolving their basic water problems with the federal government.

I am pleased to join in honoring "Mr. Water" today and hope that our efforts to resolve the water problems of our state and the West will continue in the cooperative and productive spirit which has been the case thus far.

Sincerely,

Harrison Schmitt

HS:co

MANUEL LUJAN, JR.
1ST DISTRICT, NEW MEXICO

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April 21, 1980

J. W. O'Meara
Executive Vice President
National Water Resources Association
Suite 1202 North
955 L'Enfant Plaza, S. W.
Washington, D.C. 20024

Dear Pat,

I am delighted to hear that my good friend Steve Reynolds is being honored at the New Mexico Water Conference in Las Cruces. The water folks couldn't have chosen a more appropriate time nor a more deserving person for the honor.

Never have western water rights and water laws come under such heavy attack as they are today. The administration appears determined to bring under federal control every drop of water that's not closed up in a bottle with a heavy stopper. And all of the carefully worked out agreement of the past, such as the agreements in the Colorado River Storage Project Act, are to be consigned to limbo if the President and Secretary of the Interior have their way.

Steve has been the strong right arm as we have fought for the retention of traditional western water law, states' rights and the honoring of the interstate agreements that were ratified by Congress. He knows what he's talking about because he helped make those agreements, and he helped write those water laws. When facts are needed, a phone call to Steve gets the facts. When we need testimony before our Committee to refute the weird water law opinions of the Solicitor, Steve is there. And he not only refutes those opinions -- he demolishes them.

The West in general, and New Mexico in particular, is very fortunate to have a nationally-respected man of Steve's stature standing in the breach in times like these. Because of the knowledge and dedication of men like him, state water jurisdiction and the time-tested application of prior appropriation water law will be around long after the strange philosophies of the current White House have retired to a brief footnote of history.

Sincerely,

Manuel Lujan, Jr.

ML/jdjk

HAROLD RUNNELS
2D DISTRICT, NEW MEXICO

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SUBCOMMITTEES:
RESEARCH AND DEVELOPMENT
INVESTIGATIONS

COMMITTEE ON
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April 24, 1980

Mr. Steve E. Reynolds
New Mexico State Engineer
Bataan Memorial Building
Santa Fe, New Mexico 87503

Dear Steve:

It is an honor for me to be among your many friends who are formally recognizing your long service to New Mexico and your profession.

There is an old expression that, "We never know the worth of the water until the well runs dry." I cannot think of a more appropriate comment on your importance to our state, and I don't know what we will do when you finally step down.

Virtually every water project in New Mexico that I have dealt with as an elected official I have relied on your expertise and your knowledge in my evaluation. You have developed and maintained a reputation for thoroughness and fairness that many, many people in our state, and around the nation, have come to depend on. We appreciate all you have done.

The only thing in New Mexico more valuable than water is our people. You have built a career that combines both and doubly enriched our state.

With best wishes.

Sincerely,

Harold

HAROLD RUNNELS, M.C.

gec

MEET THE SPEAKERS
SESSION III

LARRY KEHOE is Cabinet Secretary of the New Mexico Energy and Minerals Department, having been appointed by Governor Bruce King. He has served in the New Mexico state government as: Project Coordinator for federal mandatory fuel allocation program; Deputy Director, Legislative Committee; and Liaison Officer, Energy Resources Board. He graduated from New Mexico Highlands University with a Bachelor of Arts in History and Political Science.

MICHAEL CAMPBELL is a partner in the firm of Campbell and Black, P. A., of Santa Fe, New Mexico which specializes in oil and gas law and water law. Campbell is a graduate of the University of New Mexico. He was a law clerk to the Honorable Oliver Seth, Chief Judge of the United States Court of Appeals for the Tenth Circuit, in 1976; and is a member of Natural Resources Journal, and Chairman of the National Conference of Law Reviews.

HAL BRAYMAN is the Assistant Minority Staff Director for the Senate's Committee on Environment and Public Works. For the past decade, he has been the principal minority staff member working on legislation involving national water policy and water resources development projects. A graduate of Princeton University, the London School of Economics, and the Columbia University School of Journalism, Brayman wrote for The National Observer newspaper before coming to the Senate in 1969.

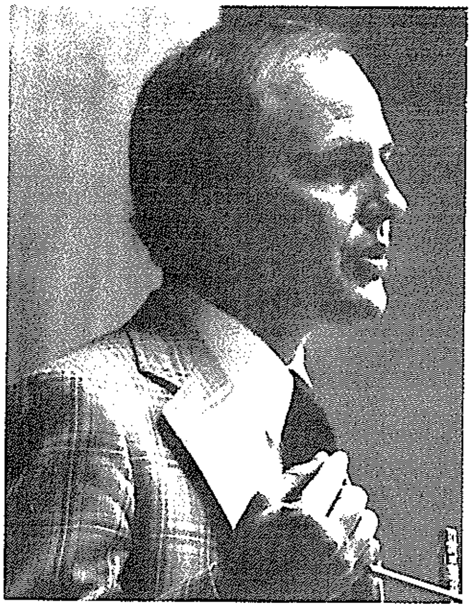
DON DES JARDIN has 21 years experience in all aspects of civil engineering, including design, project management, and construction supervision. Recent project management experience has included major wastewater treatment facilities, sewer systems, water systems, and water treatment facilities. Des Jardin has been the project manager for most of the complex projects designed by the firm in the last ten years. He was named to the Board of Directors of Gordon Herkenhoff and Associates, Inc. in 1977, and made Vice President in 1980. He is a graduate of the University of New Mexico.

PETER ASHTON KRENKEL is the Executive Director of the Water Resources Center of the Desert Research Institute at the University of Nevada in Reno, Nevada. The author of numerous papers, Krenkel is a graduate of the University of California at Berkeley, having a Master's Degree in Civil Engineering and a Doctoral Degree in Sanitary Engineering. His special interest is in water quality and pollution control.

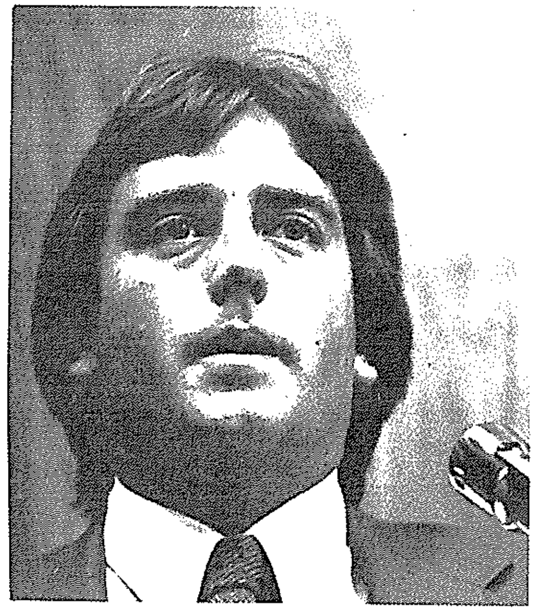
COLONEL BERNARD J. ROTH became the 18th District Engineer of the U. S. Army Corps of Engineers' Albuquerque District in July 1978. Colonel Roth is responsible for water resources development in New Mexico, parts of Texas, southern Colorado, and western Kansas. He holds a Bachelor's Degree in Civil Engineering from Polytechnic Institute of Brooklyn, New York, and a Master of Science in Civil Engineering from Ohio State University. In addition, his military education includes attendance at the Army Command and General Staff College and the Army War College.

GEORGE R. DAWSON is Professor and Head of the Department of Agricultural Economics and Agricultural Business at New Mexico State University, where he is involved in administration, teaching, and research. Dawson is currently a member of Governor Bruce King's Council of Economic Advisors. He is a graduate of New Mexico State University, and has a Master's of Science from the University of Missouri and a Doctoral Degree from Cornell University in Farm Management.

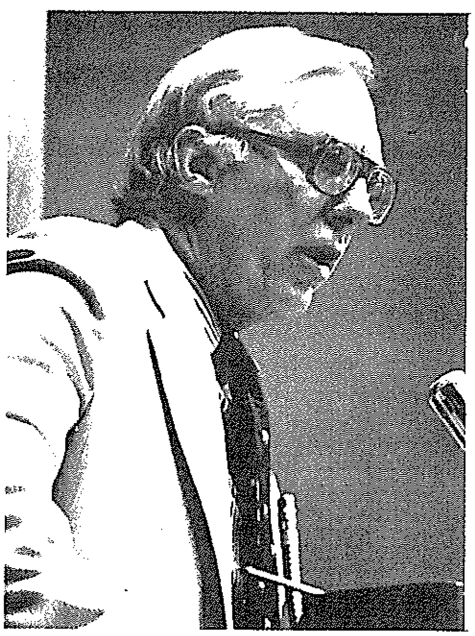
Session Three: What Does the Future Hold?
Speakers



Larry Kehoe



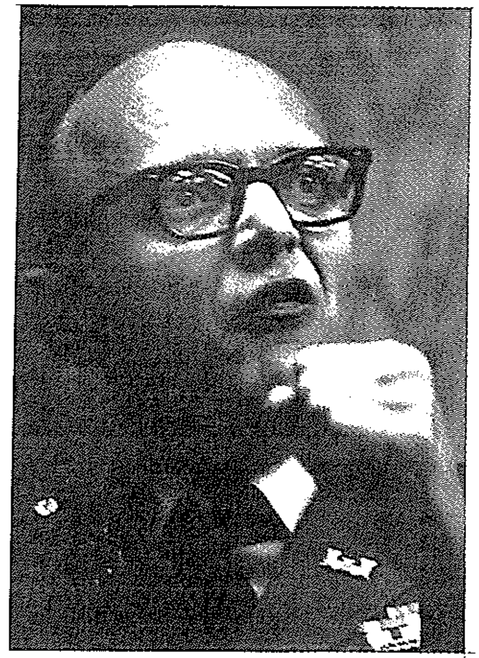
Michael Campbell



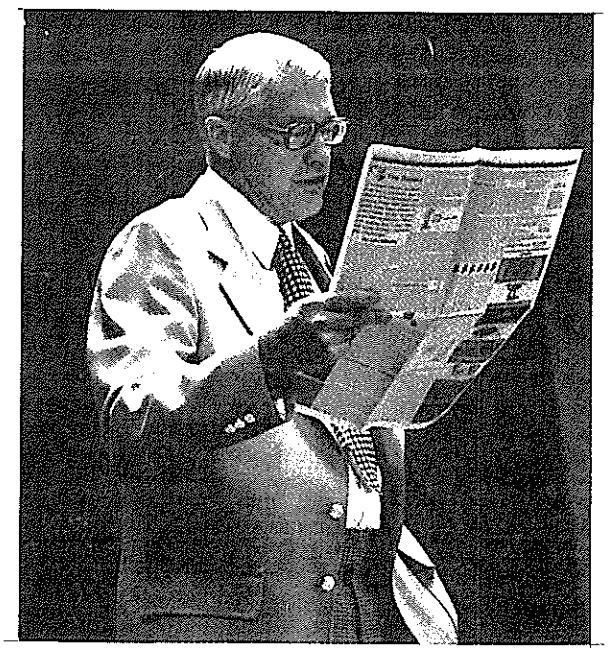
Hal Brayman

Don Des Jardin

Peter Krenkel



Colonel Roth



George Dawson

THE IMPACT OF ENERGY DEVELOPMENT ON WATER RESOURCES

Larry Kehoe
Secretary
New Mexico Energy and Minerals Department

When I accepted the invitation to speak to this group on the occasion of its Twenty-fifth Annual Conference, I asked myself, "What can I say to these people that is new, exciting, or different? I am sure they have already heard many arguments about water quality and quantity for energy development. They must have debated over whether we will even have enough water in the West for continued development."

What I have chosen to discuss with you today, while not likely to bring you to the edge of your seats, is very definitely an issue of importance to this nation and to the state of New Mexico: the President's synthetic fuels program, and its relation to water usage and the New Mexico resource base.

The major elements of my talk today are five:

1. A brief overview of the President's proposed synfuels program.
2. A quick look at the potential for synfuels in New Mexico due to our extensive coal reserves, with some cautions added.
3. A focus on the water thirstiness of synfuels production.
4. Some very interesting and frustrating results of a survey on attitudes toward water use.

5. An attempt to put the significance of future synfuels and other energy efforts into some perspective, while gracefully admitting how many questions we do not have answers to.

The President's Synfuels Program

In July of last year, the President announced his synfuels program. He expects that by 1990 the United States will produce the equivalent of 2.5 million barrels of oil a day from synthetic fuels including coal liquefaction, coal gasification, oil shale, biomass, and unconventional gas.

Along with this major announcement, the President submitted to Congress proposals to develop an energy mobilization board to "fast track" these and other "priority energy projects" and an energy security corporation to fund, to the tune of $80 billion, synthetic fuel development and production. These two proposals are presently undergoing that wonderful art of compromise in House-Senate conferences. One major action taken there was to cut the funding to $20 billion.

Even though the Administration's synfuels proposal has yet to make it through the legislative process, it is worthwhile to take a brief look at the magnitude of the program as envisioned by the Administration.

The first two figures I am about to show will give you a feel for that magnitude and for the wide variance in production goals for synfuels.

Figure 1. <u>President Carter's Synfuels Program -- Three Scenarios</u>

The three bars on the left represent total projected U.S. synfuels production in 1985, assuming three different program levels. These scenarios were provided in testimony before the Senate subcommittee on Synthetic Fuels in September 1979.

Case I: Represents a low level of production related to a good commercialized test program, equivalent to less than 100,000 barrels of oil per day.

Case II: The middle bar represents an accelerated engineering program with removal of impediments.

Case III: The solid colored bar represents an all-out crash program, equivalent to roughly 250,000 barrels of oil per day.

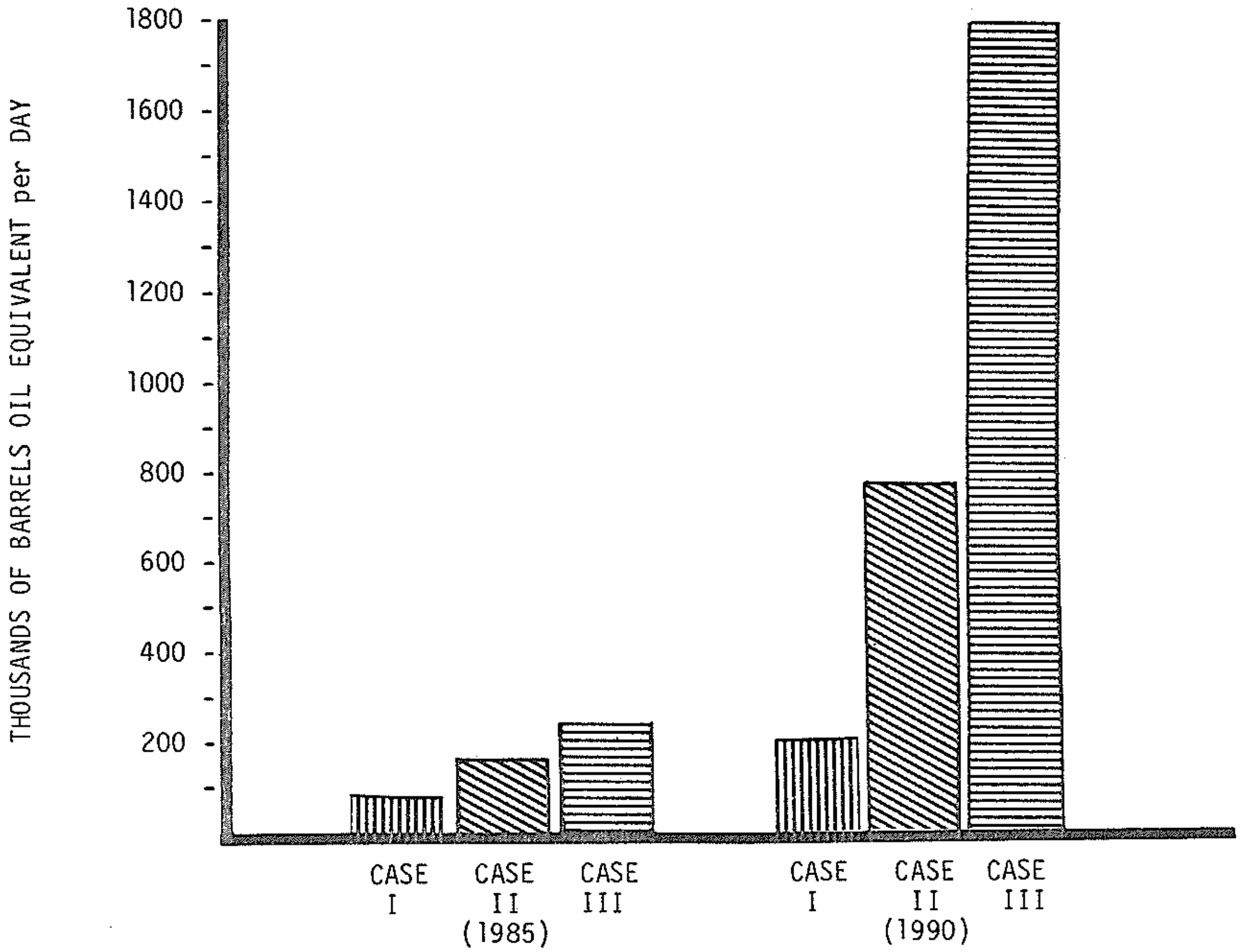
Now look at the three bars on the right which show anticipated growth of production under the low-, medium-, and high-effort scenarios by the year 1990. Obviously, the spread of production between the three scenarios has widened considerably.

Case I: At low level there is a doubling of production in a five-year period.

Case III: At high level there is a seven-fold increase in a five-year period to a production equivalent to nearly 1,800,000 barrels of oil per day.

Such tremendous increases would make corresponding claims on the materials used in the production of synthetic fuels -- the great variation in these potential claims is quite remarkable.

FIGURE 1. PRESIDENT CARTER'S SYNFUELS PROGRAM
Production Goals Under Three Scenarios



Case I: A good commercialized test program

Case II: An accelerated engineering program with removal of impediments

Case III: An all-out "crash program"

Source: Testimony before Senate Subcommittee on Synthetic Fuels, Sepetember 5-6, 1979

Figure 2. President Carter's Program -- Synfuels in 1990

So far I have spoken of total synfuels production. But what are the most important types of synfuels in the program envisioned by the President's proposal?

This second figure, based on information from the Western Interstate Energy Board, shows the relative magnitude of production by 1990 of the various synfuels.

The first thing to note is that this is a diversified synfuels program with production from coal, oil shale, biomass, and unconventional sources.

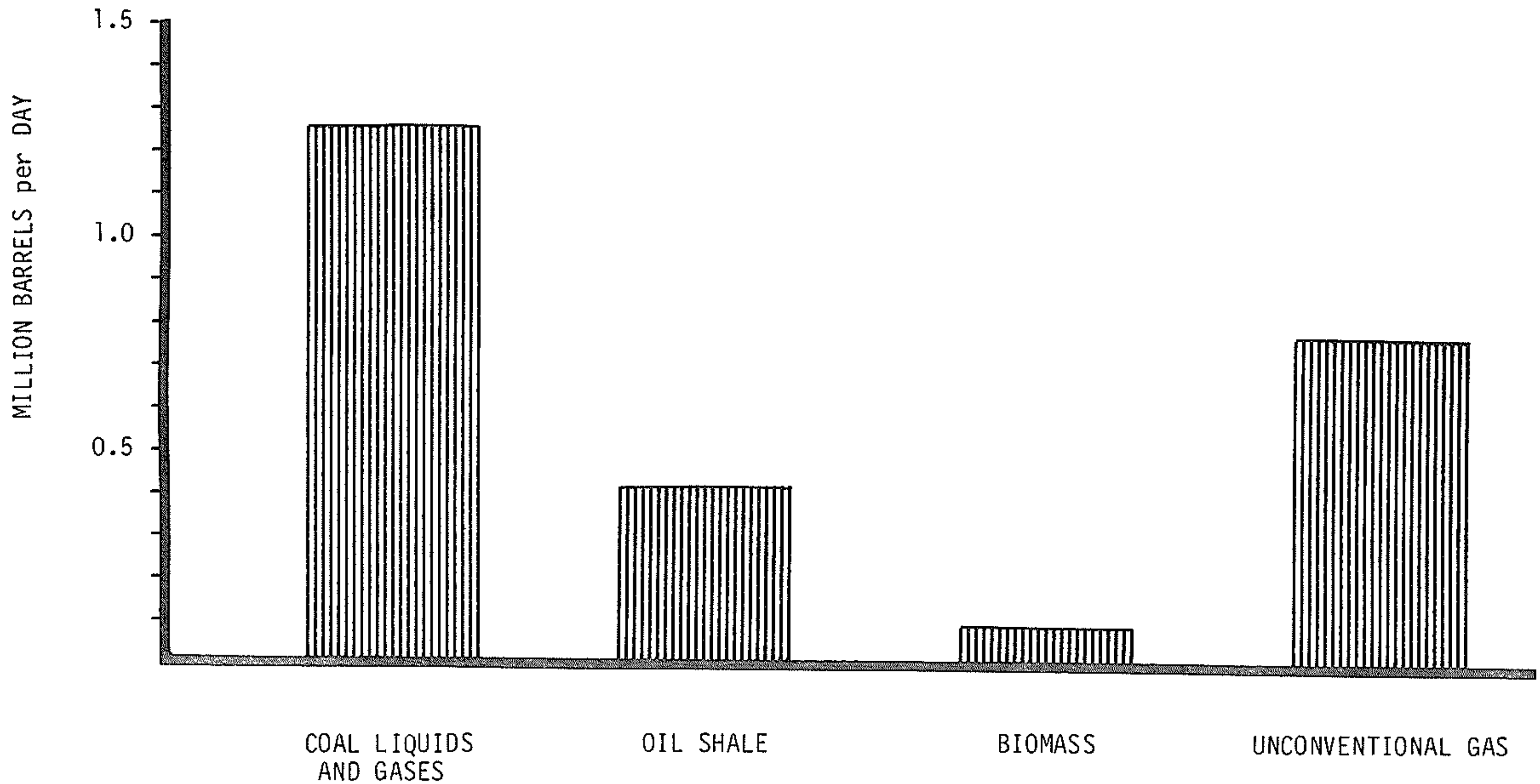
The real story told by this figure, however, is that almost one-half of the total production goal is expected to come from coal in both liquids and gasses.

Now, where does this brief picture of this proposed Federal program for future energy development leave New Mexico? It leaves us, initially, with the obvious fact that there will be a need to develop new energy resources for the Nation. As you all know, historically, New Mexico has always played a major role in energy resource production to help meet the nation's energy needs. Present statistics for the state show that we are fourth in the nation in total gas production and reserves, seventh in crude oil production and reserves, eleventh in coal reserves, and fourteenth in coal production. We rank among the top twelve states in reserves of every major energy category.

Remembering how important coal-based synfuels are proposed to be, let's take a look at the next figure.

FIGURE 2. PRESIDENT CARTER'S PROGRAM

SYNFUELS PRODUCTION BY 1990 - ALL SOURCES NATIONWIDE



Source: Western Interstate Energy Board

Figure 3. Proved Reserves of Fossil Fuels in New Mexico

Of New Mexico's fossil fuel supply, more than three-quarters is coal; and coal is the resource which is projected to provide one-half of the President's synfuel production goal.

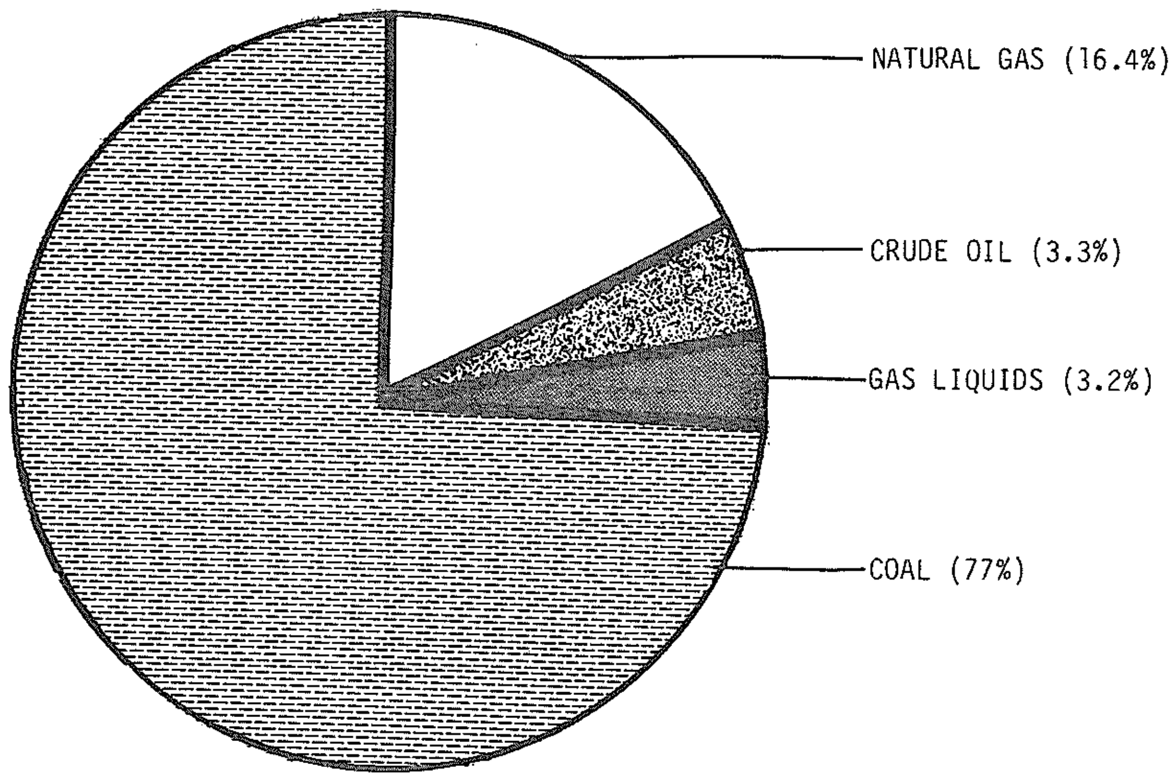
If synfuels really do become a significant part of our nation's energy future, New Mexico's extensive coal resources may well play a significant role in that development. There are a lot of ifs in our energy future, especially as it relates to synfuels.

Careful thought must be given to international developments, the supply of other energy resources, and more specifically for our New Mexico future, the quantity and quality of coal available in other states. One must look closely at national energy-demand trends, and be prepared for the shocks of changing policies in Washington, D.C. In looking at past and present policy decisions with regard to energy, one's crystal ball threatens to go from cloudy to a complete blackout.

Let me just give you one brief example of the confusion of energy policy-makers, which will also serve to connect synfuels to a resource which most interests this audience -- water.

When the President's coal commission, in two lengthy reports supporting the replacement of two million barrels of oil per day by 1990 with various coal technologies and coal conversion processes, does not even devote one sentence to the water usage involved in such a major switch in resource usage, it makes my job and your work twice as hard when we try to look at the future.

FIGURE 3. PROVED RESERVES OF FOSSIL FUELS IN NEW MEXICO
(ECONOMICALLY RECOVERABLE WITH EXISTING TECHNOLOGY)



Source: EMD Bureau of Geology, 1979

I believe my next figure will amply demonstrate the important consideration which must be given to water in an attempt to discuss the feasibility of synfuels production in New Mexico.

Figure 4. <u>Water Consumption to Produce one Quad of Energy -- Traditional Sources vs. Synfuels</u>

This figure is based on information from the EPRI -- Lawrence Livermore report, dated August 1979.

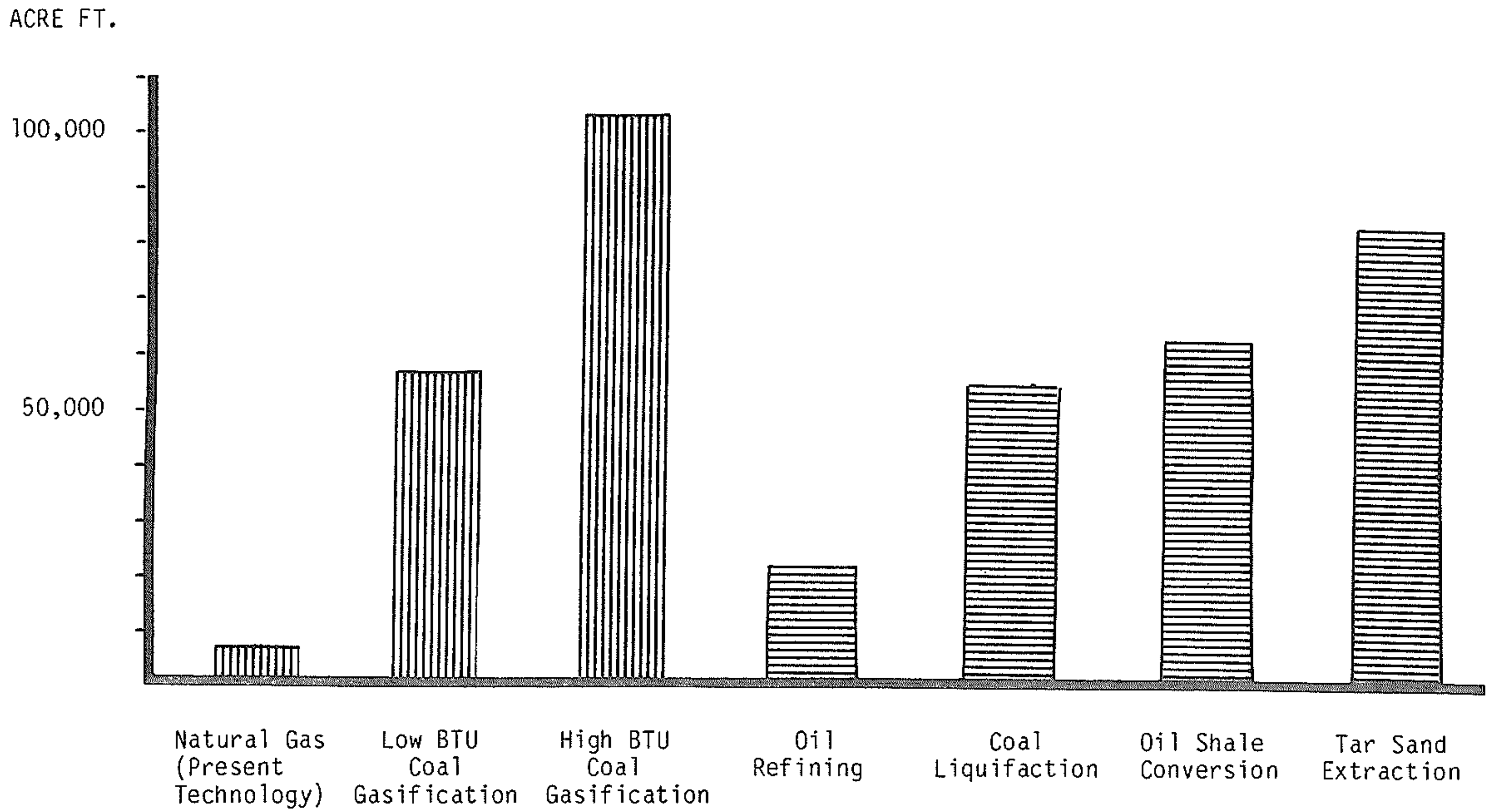
The three bars on the left show relative water consumption in the production on one quad (10^{15} BTU) of energy in gaseous form:

1. Natural gas by present technology is the lowest bar.
2. The second bar shows that in the area of low-BTU synthetic gas production each unit of energy requires seven times as much water as current production methods.
3. The third bar shows that production of high-BTU gas requires almost 15 times as much water.

The four bars on the right show relative water consumption in the production of energy in various liquids.

1. The lowest of those four bars shows water consumed in traditional oil refining.
2. The next bar shows that in the area of synthetic liquids, any coal liquids produced in New Mexico will require more than double the present water use per unit of energy.
3. The next bar relates to oil shale conversion.

FIGURE 4. WATER CONSUMPTION TO PRODUCE 1 QUAD (1×10^{15} BTU)



Source: EPRI-Lawrence Livermore Report
August, 1979

4. The last bar illustrates that any production from New Mexico tar sands will require more than three and one-half (3 1/2) times as much water per unit of energy as does current oil refining.

As you can see from this figure, these new technologies will require greater amounts of water than the main technologies they will be replacing, that is, oil and gas production and refining. Of course, there will be substantial variation in the amounts of water required within each technology. For example, with the new coal technologies, water use will vary depending on the moisture content of the coal and the types of cooling techniques applied.

What does the future hold for energy development and its impact on water resources? I cannot honestly predict that future for you. But one thing I do feel certain of: to the extent that synfuels are produced in that future, they will tend to require significantly more water than do current, traditional energy sources.

The President's program for development of synthetic fuels is not the final word for our energy future. It is a best guess at this time and is definitely subject to change. But, as the figures indicated, whatever the "real future" in energy development holds for our nation, New Mexico will be expected to provide significant amounts of these energy resources.

Now let's look at the public's attitude toward the future as it relates to water and energy.

Attitudes Toward Water Use

A group at the University of Arizona recently completed a very interesting survey of public and state legislators' attitudes regarding water and its applications (survey conducted in 1979 by Professor Helen Ingram, et al., University of Arizona, in conjunction with Resources for the Future). They conducted their study in the Four Corners region where agriculture is presently the predominant consumer of available water resources, but where energy resources and energy development also play a major and growing role in the total social and economic structure. The results of this survey are quite interesting, and I would like to share some of the statistics on New Mexico with you.

While a clear majority of those surveyed agreed with the seriousness of the issue of air and water pollution, 58% also supported spending more money on energy research and development, and 34.3% agreed to spend at least the same levels as we are at present. Over half of all those surveyed disagreed with policies which would allow more pollution to insure plentiful supplies of energy, and over 70% also disagreed with allowing further damage to water supplies and the environment for energy production used outside the state. At the same time, 33% of those surveyed agreed with increasing future water allocations for energy production, and 50% agreed with keeping it at the same level as the present.

The most interesting results from the survey centered around the statistics on future water allocations. The following statistics represent the percent of persons responding in favor of having more, or the same amount, of water dedicated in the future for various uses. For New Mexico, the following results were obtained:

Electrical Energy Production	83.1%
(We should note here that electrical energy production consumes more water than even the new coal technologies.)	
Irrigated Agriculture	94.6%
Industry and Manufacturing	79.3%
Municipal and Residential	88.0%
Water-Based Recreation	60.2%
American Indians	75.3%

Ladies and gentlemen, it is obvious that we cannot expect to devote significantly more water or the same amount of water to each of these uses in the future. Public opinion and proposals out of Washington for high water-use energy development must confront our western state reality: water is a coveted, valuable resource!

Now let's put synfuels and the President's program in perspective. We do have to take synfuels seriously with regard to our energy future -- such development can make a contribution. But, let's keep it in perspective. For example, right now current U.S. supplies, in quads, are as follows (1 quad equals 172 million barrels of oil or 60 million tons of coal):

Natural Gas	20 quads
Domestic Oil	19 quads
Imported Oil	18 quads
Coal	14 quads
Hydro and Geothermal	4 quads
Thermal/Nuclear	4 quads
Other (Solar, Renewable, Synfuels)	1 quad
	80 quads

In our figures, we showed you the Case I, II, and III synfuels estimates for the next fifteen years. Estimates have also been made on the ultimate contribution of synfuels in these cases -- from one quad in Case I, to six in Case II, up to ten in Case III. I think this is another good example demonstrating that synfuels cannot be the total solution to our energy problems or anything near that. That is why it would be misleading to cover only the Administration's synfuels program, show you the estimates of production and water usage, and simply leave our energy future at that.

However, whatever the major emphasis of this nation's energy program, the main thrust which we must base our work on is the fact that we must try to attain a more balanced system of energy resources and a more balanced system for water usage. We cannot, as the survey participants seemingly desired, devote the same or greater amounts of water to all sectors of society. We cannot devote all our time and efforts to developing water-consumptive synthetic fuels. We cannot ignore the other possibilities of our future, such as the influence of market forces on fuel costs and energy conservation efforts.

Sooner or later, some very hard choices will have to be made. I wish I could tell you right here and now just what those choices will be and how much impact on water resources they will have. But, as I indicated earlier, my crystal ball is cloudy. However, this does not mean we should hang our heads in despair over the future. A lot can be done by the members of the New Mexico Water Resources Research Institute and all of you present at this conference.

I think your agenda for this conference reflects what has been done already, what we are doing today, and raises some of the issues for the future. Technological improvements by you folks will be of vast importance.

The work we do now and the decisions we make now for the future will be critical to the well-being of our state. It is my belief that in New Mexico we have an opportunity to manage our resources effectively so that at least in this state we attain a balanced system for resource development.

In the meantime, our department and other state agencies, our mining industry and utilities, our research institutes, and the federal government, all of us have a lot of work to do in seeking some answers.

MINE DEWATERING

Michael B. Campbell
Campbell and Black, P.A.

I think it would be appropriate to initially define the problem created by mine dewatering in New Mexico.

Mine dewatering is simply what the term implies: it is the extraction or discharge of water encountered in mineral production. Dewatering is necessary in several mining operations. For example, the Kaiser coal mines in the Raton area are now encountering significant quantities of water. Significant amounts of water are encountered in the production of molybdenum in the Taos and Questa area. Exxon, in its planned copper mine near Silver City, anticipates they will encounter water in significant amounts.

Of course, the dewatering controversy has focused primarily on the uranium industry. Dewatering has occurred in the Ambrosia lake district, north of Grants, since the late 1950s. Today there are approximately 35 active uranium mines in the Grants area. Not all of them are wet mines; that is, not all of them encounter water. Those that do are presently discharging water in the vicinity of 35 to 40 thousand acre-feet a year. Most of this water is coming from the Westwater Canyon Members of the Morrison Formation. The New Mexico Department of Energy estimates that by the mid-1980s New Mexico will have 72 active uranium mines discharging water in quantities of approximately 90 cubic feet per second. Of course, that estimate depends on the economics of the uranium industry which, if today's indications hold true, are unsettled.

In any event, we are speaking about a significant amount of water. The water encountered in these mining operations cannot all be beneficially used by the companies. Some is consumed in the leaching process, some is consumed in dust control and other operational needs; but the vast majority of the water is simply discharged into surrounding arroyos and allowed to percolate back into the groundwater system. In order to comply with state and federal water quality standards, it is necessary for mining companies to clean the water encountered prior to discharging it at the surface.

In the uranium industry, that cleaning process is usually accomplished with what is known as an ion-exchange facility. One of the consequences of this cleaning process is that uranium particles drop out of the water. Mining companies estimate that the process does not yield enough uranium to pay for the ion-exchange facility. In any event, the use of the ion-exchange process and the consequential recovery of uranium has significant legal effects. It is the law of New Mexico that a permit to appropriate water is necessary when water is beneficially used. Applied to the dewatering situation, as long as water encountered in the mine shaft was not beneficially used, no permit to appropriate that water was required.

As you might expect, given the quantities of water involved here, the fact that mining companies were not subject to the jurisdiction of the State Engineer caused significant public controversy. On the other hand, once companies began to clean that demined water with an ion-exchange facility, they are considered to be beneficially using the water, since that process does drop out uranium particles. Accordingly, those companies using the ion-exchange process must obtain a permit from the State Engineer. Again, given the quantities of water involved here, and given the state of New Mexico water law prior to the enactment of the Mine Dewatering Act, companies were rightfully afraid that a permit to appropriate water would be very difficult to obtain. Without a permit from the State Engineer to appropriate the water, a mining company's operation of its ion-exchange facility would be significantly clouded. If the mining company were not able to operate its ion-exchange facility, it, therefore, could not clean the water that it was encountering. If the water was not cleaned, water-quality discharge regulations provided that no discharge could be made, and without the ability to discharge the water, mining operations would have to cease. So I hope you can appreciate that the problem of mine dewatering was a very difficult problem, given the state of the law prior to the enactment of the Mine Dewatering Act.

The mining industry began studying the problem in earnest at the close of the 1979 legislative session. The New Mexico Mining Association appointed an ad hoc committee composed primarily of technical and legal people. The committee actively consulted and received the advice and input of other interested groups, primarily, the New Mexico Cattle Growers Association and the New Mexico Farm Bureau. The State Engineer was, of course, consulted throughout the drafting process. The resulting legislation, known as the Mine Dewatering Act, was passed by the 1980 session of the New Mexico Legislature and was signed by the governor in March of this year.

There are two very basic provisions in the law. The first subjects companies engaged in mine dewatering to the jurisdiction of the State Engineer. As I have mentioned, prior to the Mine Dewatering Act, those companies that were simply dewatering their mines were not subject to the State Engineer's jurisdiction. Now under the bill, prior to engaging in mine dewatering a company will have to seek a permit from the State Engineer to dewater; the company will have to assume the traditional burdens of proof on the issue of nonimpairment before the State Engineer. The second significant provision in the bill deals with the right of replacement. The bill provides that companies engaged in mine dewatering and, in fact, all appropriators of water will be given the right to replace the water of other water owners whose activity is impaired by the applicant. If the State Engineer finds that impairment will occur, an applicant will have the ability to submit a plan of replacement to the State Engineer. In that plan, an applicant will outline a process by which he or she, or the mining company, attempts to cure any impairment found to exist as a result of its activities. That cure can come in many forms: the applicant can propose to drill the impaired owner a new well; can deepen the existing well of an impaired owner; can seek to assume the additional lid costs which are incurred as a result of his activity; and finally, a company can tender a substitute water supply to the impaired owner. If the State Engineer finds that the plan of replacement is adequate, he will grant the permit to appropriate. If the plan of replacement is found to be inadequate, or will not cure impairment, the State Engineer, of course, denies the permit.

There are several other factors or provisions in the bill. In order to implement a plan of replacement, an applicant is given a right of condemnation. The condemnation right is not dissimilar to existing condemnation law in the area of water rights; we do not believe it to be a significant new development. It is intended to permit an applicant to implement the plan which he believes, and which the State Engineer would have to find, cures any impairment caused by his activity. The State Engineer retains jurisdiction to supervise the maintenance and implementation of the plan of replacement. It is important to recognize that the bill provides that a mining company cannot dewater for the life of its mine - say 30 years - then simply pick up and leave. A mining company will be accountable for all impairment that it causes, even if that impairment occurs after the mining company has departed the state.

We suggest that, while the right of replacement is available to all appropriators, its use will be limited, at least initially, to mine-dewatering circumstances, since mine dewatering presents one of the few times that an appropriator has excess water to tender to an impaired party. We believe that the act is a sound and reasonable response to the problem created by mine dewatering. It provides a degree of flexibility to the State Engineer, to the general public, and to the mining companies which was not previously available under law. Yet, at the same time, we believe that the bill does nothing to disrupt the traditional doctrines of prior appropriation, which have served the state so well in the past.

FEDERAL WATER LEGISLATION

Harold Brayman
Senate Committee on
Environment and Public Works

It's a pleasure to be here. I attended last year's conference and enjoyed it very much. I seem to be unable to stay away from Las Cruces. I was here a couple of weeks ago and, hopefully, I will be back again soon.

It is a great pleasure for me to participate in this 25th Conference. I congratulate Tom Bahr and the staff of the Water Resources Research Institute. They have done a fine job.

Our committee handles the work of the Office of Water Research and Technology in the Department of the Interior, which helps to fund the Water Resources Research Institute. I know the respect that the New Mexico Institute has in Washington is very, very high. What I'm here to talk about is not a very happy story. I'm not going to talk about Iran, which is another unhappy story; I'm going to talk with you about water, and what's happening with federal water policy in Washington.

The first thing I must say is that if the water programs in all states were run as effectively as the state of New Mexico is under Steve Reynolds, we really would not have a problem. But, unfortunately, New Mexico and its problems with water are dragged down by the fact that not all of the 49 other states have as effective a program, and as cooperative an attitude between themselves and Washington, as does New Mexico. The water program in this country is in real trouble. You may or may not think that, because things are going pretty well here; but, when you look at what has happened with federal water-resources development spending in Washington, it is really a tragedy.

In the last 15 years, the amount of real dollars, uninflated dollars, that have gone into water-resources projects, at least through the Corps of Engineers (and I think the figures are about the same for what used to be the Bureau) spending is down about 50 percent from where it was in the mid-sixties. And it is not going to get any better. It is an easy thing to cut; it is a program that does not have a broad constituency.

Look at the projects of the Corps of Engineers. The General Accounting Office did a study of the Corps of Engineers' flood control projects and found they took an average of 26 years from the time the study was authorized until construction began. Even if that figure is a little inflated, if you are talking about waiting a generation to get a project started, it is a program that is just not working very well. There are no priorities in the program, the selection of projects, to a great extent, is simply an "ad hoc" process of "you give me mine and I'll give you yours" -- whatever pops to the top of the barrel gets plucked off. There is a backlog of some $30 billion dollars, including a project to make Dallas a port for barge traffic, at a cost of $2 billion, and a lot of other projects that some people may not think of as being excessively valuable.

One of the great problems with the current water program is the general public perception that it is the last vestige of the nineteenth century, where the Congress selects the projects and specifically appropriates money for them, line by line. The public perceives that the water program and the water-development program in this country is "pork barrel"; and as long as you have that public perception, I think you are going to lack public support -- the kind of broad public support we need for water-resources development. And Lord knows, we have water-resources problems and we need more water-resources development. So, as I see it, you have basically two choices: you can let the program drift along at its current level and be the subject of hit lists and laughter on "60 Minutes," or you can try to reform it and try to make it work better.

I work for Pete Domenici. Pete Domenici is not the type of Senator who likes to sit around and let things drift. In the last couple of years he has taken a great interest, as the ranking Republican on the Senate's water-resources subcommittee, in the whole process of how you make the water-resources program in this country work better. He believes very strongly in water-resources development. Anybody from New Mexico does. But he believes that water-resources development needs to be, the system needs to be, made more effective so that there will be greater public confidence in the whole program of water-resources development. If that occurs, then you will have the kind of investment in water resources in the West, the East, the North, and the South, that we need to meet this growing crisis that is going to occur in the next 15 to 20 years, if we do not do something about it.

Senator Domenici set out a year or so ago, shortly after I participated in last year's conference here, to try to develop, if you will, a better system. He came up with three criteria by which he wanted to move ahead. The first was to try to find some way to move the program ahead more rapidly, to put more money into the program.

Second, to create a system, or create an atmosphere for selecting priorities so that somebody is making a choice, not just saying "whatever comes along, we'll take," but making a choice and saying "yes, we need this flood control project more than we need this water-supply project, or vice versa." That will provide a real decision as to where, in a particular state or in a particular region, the money ought to be invested in order for it to do the most good.

Third, is to broaden the constituency for water-resources development in this country, as well as lessening the public perception that it is just your old fashioned nineteenth-century pork barrel.

To those ends he introduced a bill, which Pat O'Meara discussed somewhat last night, not in the most flattering terms. That bill was S1241, which was introduced last May, with sponsorship of Senator Domenici and co-sponsorship of Senator Moynihan of New York. The object of S1241 was to remove Congress from the individual selection of projects and the individual appropriation of projects, and turn that process back to the states. The states, where the knowledge is far greater than it is in Congress, would make the decisions as to what kind of projects would go forward. They came up with a figure of $4 billion a year for construction, which is about a billion and a half more than is currently expended for construction in the three major water-resources agencies: the Soil Conservation Service, the Corps of Engineers, and the Bureau of Reclamation. And they decided to distribute the money on a formula based half on the population of the state, and half on the land area of the state (with special exception for Alaska because of its size). The program would require that before the states could spend any money, they would select what projects would be pursued and at what speed. They would have to do this annually through a public hearing process. The design of a project and the construction would be overseen by the Corps or the Bureau, but the selection and speed of projects would essentially be dictated by the state, rather than the vagaries of the Congress.

Now, let me just say one thing about what Pat O'Meara had to say last night. If you listened to Pat -- and I like Pat very much, but he does tend to, shall we say, overemphasize the demerits of S1241 -- he implies that all of a sudden all this money is going to be flowing back East, and the West isn't going to see any money. Strictly on a percentage basis, not counting real dollars, but strictly on a percentage basis, the reclamation states essentially get the same percentage of money under S1241 as they are currently getting through the three programs of the Bureau, the Corps, and the Soil Conservation Service. The reclamation states would receive on the order of 25 to 27 percent of the national water budget. There obviously are some changes within individual states: some states are winners, some states are losers. The state of New Mexico happens to be a winner, by an order of eight times, going up from something like $10 million a year now to on the order of $80 to $90 million a year under S1241. I think that it is a little unfair to characterize S1241 as an effort to remove or to take money away from the West.

But at the same time, Senator Domenici recognizes the need to broaden the constituency for water programs. And the only way you are going to broaden the constituency and develop a national interest in water resources in this country is to begin to involve the northeast -- the many legislators and many people that live there -- in a strong water-resources development program.

Obviously, the needs for water-resources development in the northeast are entirely different than they are here. And the flexibility in S1241 was designed to meet that need by saying, in effect, you, the state, pick the projects. If you want to spend your water-resources money on rebuilding New York City's water supply system, fine and dandy! There is a set amount of money you get every year. You spend it the way you want. The state of New Mexico gets a set amount of money every year, selects its priorities, and moves ahead on its program. The priorities are ones imposed by Albany and by Santa Fe. I think Senators Domenici and Moynihan believe that in the long run you are going to get a lot wiser development and a lot wiser decisions. This may not necessarily be true in the state of New Mexico, because of the very effective work of Steve Reynolds and others; but in most states you are going to get stronger and more effective decisions on water-resources development when you have the state directly involved in that choice, rather than being involved by sufference.

There's nothing very sacred about the specifics of S1241. It was designed, and Senator Domenici spoke many times about the fact that its purpose was to serve as a starting point to try to get people to work toward a more effective system of water-resources management. To a degree that worked. It became the subject of discussion. Realizing that you cannot completely alter a process that's nearly a century old with one bill in one week, the Senators sealed it back to a compromise proposal, which some people call Son of 1241. The Senate subcommittee on water resources adopted this compromise last week.

It is a five-year demonstration program of the block allocation process, which I described earlier in S1241, at $1 billion per year. Money is to be distributed based half on population, half on land area, which means New Mexico gets something on the order of $20 million a year, with the state selecting the priorities of how that money is to be spent among the Corps, Bureau, and SCS programs.

That program, the demonstration program, is over and above the existing line-item, ad hoc pork barrel approach currently in place. In effect, you will have both systems running in tandem. You will develop a record which you can look back upon three or four years from now, and see which system is working better. Whether, in fact, the projects that are going ahead under the ad hoc approach are going ahead as fast as you'd like them, whether you are picking the good projects, or whether the demonstration program (with a set amount of money, priority setting, and the participation of the state) is actually developing a more effective system than is currently in process.

The Son of S1241, which is amendment 1660, makes no changes in current cost-sharing arrangements. It makes no essential change in the process, except it says there is a certain amount of money per year per state that the state can use to select for work by the Corps of Engineers, or the Bureau, or whatever, to move ahead on those projects.

Now, where do we go from here? It is really hard to say. I think the likelihood that there will be an omnibus water-resources bill passed by Congress and enacted by the President this year is exceedingly remote. The chances are that we may not even have a bill out of Congress. We have not had one since 1976. Traditionally, we have them every two years; but did not have one in 1978, and it is very unlikely we will have one this year.

There will obviously be some other bills. Another committee will move ahead on some Bureau of Reclamation bills, and I expect we will move ahead on a bill for the Office of Water Research and Technology and the Water Resources Council. But we will not have a major project's bill -- a $3, $4, $5 billion bill, with the Albuquerque levies in it, and a number of other projects that interest New Mexico and other states. It is probably doomed because President Carter has indicated that he will veto anything approaching the already House-passed bill, which consists of about $4 billion of everything from marinas in Texas to the building of a second power house out on the McNary Locks and Dam on the Columbia River, and other things that will cost a good deal of money. I think that President Carter can win that veto fight with ease, as I said before, because of this public perception that water projects essentially are pork barrel. I do not think -- and this is something we are still trying to explore with the White House (and Lord knows what effect last night's events might have on anything) -- that the Administration is in a position at this point of wanting to work out a new system. I think they would rather have the great public glory, from their point of view, of a veto, showing how they are standing firm against "wasteful spending."

I do not think the basic attitude is Washington is going to change very much toward water projects, regardless of who the President is - President Reagan, President Bush, President Mondale, President Carter, or President Kennedy. I do believe that at some point in the next year or so we will get a compromise that is not going to make anybody very happy. But we hope that in the long run it will move this program ahead faster, and that it will end the guerrilla warfare currently going on in Washington over water projects.

I will just outline for you what I think that compromise will be (and that is a very general thing; I do not know what the specifics will be), but I would think that it's going to have basically three components. First, a lot more projects. Second, some variation on the Domenici-Moynihan block-allocation system -- some variation that does move some of these decisions out of the hands of Congress, whose hands are already full with a lot more important issues than selecting three or four million dollar flood control projects, and into the states, where decisions can be made far more effectively than they can be in Washington. Third, the Administration's eventual demand for some sort of compromise will probably make changes in the cost-sharing process in the development of water projects. I suspect there will be a system that will require more local cost-sharing on water projects, because I think that the perception in the East is very strong that the West is getting off too easily on the reclamation program. Even in the old days when the capital cost of irrigation projects was paid back without interest, it usually amounted to something like 10 or 15 percent of the cost of the project. (I cannot imagine what it would be at 20 percent interest.) I think that perception needs to be lessened in order to move the program forward; that perception needs to be altered with at least the appearance that the West and those who are benefiting in the West and in the other parts of the country are paying a fair share of the projects from which they benefit.

I do not know when that compromise is going to occur. I do not know if it is going to occur this year, which I think is very unlikely, or next year, or the year after. But I doubt very much that you are going to have significant water legislation out of Washington until some sort of resolution occurs along these general lines. I think once that resolution occurs -- painful as it may be in some areas -- in the long run the nation as a whole is going to be far better off, and we are going to see more water projects, and we are going to see greater water development.

I do not see how it can get any worse than it is now. When you have got a program that is going downhill, 50 percent of what it was a few years ago, you have got a program in real trouble.

Each of you should think very seriously about how we can move this program forward; what kind of initiatives can be made that will overcome the problems that I have tried to outline. I believe that your thoughts on this would be very helpful, and I hope you will communicate them to us.

THE IMPACT OF DESALTING ON WATER SUPPLY - ALAMOGORDO, NEW MEXICO

Don Des Jardin
Consulting Engineer
Gordon Herkenhoff and Associates

I want to thank Tom and the Institute for inviting me to speak, from a consulting point of view, on what is happening in the water industry today. We are dealing with almost every major city in the state of New Mexico, plus many of the small communities. All of them, with the possible exception of one or two, have the same problems: water quantity and water quality.

Each city government spends a lot of time planning, and a lot of money trying to figure out where the next quantity of quality water is coming from. The state appropriated money to help some communities look into the possibility of using desalting. The Office of Water Research and Technology (OWRT) came forth with a program to study various communities throughout the United States. Alamogordo and Virginia Beach were selected to have a demonstration program of desalting technology: to prove that a community could hire an engineer, spend the money, design the plant, and go from there. We are at the point right now where the tentative agreement, or preliminary agreement, between the city of Alamogordo and OWRT has been approved, has been sent on to Washington, and we are awaiting final funding of the first phase of the Alamogordo desalting plant. However, final approval, final acceptance, of this plant still lies with the voters of Alamogordo.

Alamogordo parallels many other communities. They have very good quality of water, but it is very limited: about 4 million gallons a day that will meet federal standards of 500 parts per million TDS, or less. Unfortunately, their consumption in the midsummer is about 12 million gallons a day. Their only additional water supply is groundwater. Groundwater goes into their system at approximately 1,500 to 2,000 ppm TDS. As people move here from the east because of snow, lack of energy, retirement, these communities are starting to grow, and consequently, their need for water is increasing. As more wells are drilled, the community's water is of poorer and poorer quality. Steve Reynolds, our state legislators, our senators and representatives in Washington, have seen this.

The plant itself--total operation, maintenance and construction--is going to cost somewhere around $13 million. About $9 million of that will be for construction, and $3 to $4 million will be operation and maintenance for the first four years. The new proposal is that Alamogordo will put up 15% of the project, OWRT will put up 85%. This means that the voters must put in approximately $2 million.

In deciding how big the desalting plant should be, we, as working consultants for the city of Alamogordo, with OWRT and their engineers doing the feasibility study, came to an agreement. We took several things into consideration. One, we wanted to make an impact on Alamogordo's water system which would show people what good quality water will do. Second, we knew that a small community could not come up with $5 or $10 or $15 million to build a plant; and third, the federal government, through OWRT, had limited its expenditure to $50 million for a total of five plants, or approximately $10 million per plant (some plants will spend more than that, some will spend less, according to size). Looking at Alamogordo's water quality, we settled on two million gallons a day for the plant. We wish we could have gotten four million gallons a day. They could use it today. However, we worked a trade off on cost and need, and settled on two million gallons a day.

Now, what does good quality water mean? You have good drinking water, better tasting foods and beverages, reduced soap use in laundry and showers, as well as reduced replacement of water heaters. The life of anything that uses water will be considerably extended with high quality water. It also will reduce corrosion and scaling in the municipal system.

The average cleaning product cost, with added treatment from desalting (getting the hardness down to just a little less than 300 parts) would be around $11.00 a month. If we kept the hardness where it is now without treatment, which is just above 500, the cost would be a little less than $15.00 a month. This means that in soap costs alone the customer could save $4 or $5 a month. The estimated extended life for appliances, for instance, of garbage grinders, would be a year, or two, or three. In every case--coolers, water heaters--we would extend the life two or three or four years.

What does this mean to the average homeowner? We looked at the cost it would save the homeowner in Alamogordo strictly due to maintenance, soap savings, and municipal costs. The average homeowner would save approximately $9.56 a month, or $114 a year, that they could put into additional water costs by adding desalting. This does not even include the $11.80 a month that could be saved if they got rid of a water softener.

The figures that we have come up with are very conservative. It is obvious why. We want to be able to prove: (1) that we are saving money, and (2) we want to be fair and honest with everybody, including the citizens of Alamogordo. At the Buckeye treatment plant in Arizona, they proved that they were saving $120 a year (or $10 a month), which is more than we are estimating for today. However, they were treating drinking water at 3,000 parts per million, and here we are talking about water in terms of 1,000 to 1,500 parts per million TDS.

Alamogordo has the opportunity: to be the leader in a breakthrough in desalting technology for the state, to produce high quality water, to work with the local universities, New Mexico and New Mexico State University in research, and to work with the federal government as well, so that every community in the state can learn from this technology how to improve their water supply.

THE FUTURE OF WATER QUALITY

Peter Krenkel
Director
Nevada Water Resources Center

Due to the audiovisual nature of Dr. Krenkel's talk, no paper has been included.

FUTURE ROLES FOR THE CORPS OF ENGINEERS

Colonel Bernard Roth
District Engineer
Albuquerque District
U.S. Army Corps of Engineers

While I certainly appreciate Tom Bahr's kind invitation to address this year's conference, I must admit that talking to this distinguished group about the Corps' future roles in New Mexico, sort of puts me in the position of the seven foot cowboy who confronted the eight foot cowboy. The point is that it does not matter how big and tough the seven foot cowboy is, the eight foot cowboy is going to call the shots...and if I want to leave anything with you, it is the point that in my business the eight foot cowboy is you, or more precisely, the public we serve. I'm going to have more to say about that as we go along, but perhaps the best way to start is by looking at why we're here, and what we're doing right now.

For an organization that is over 200 years old, the Corps' public works presence in New Mexico is relatively recent, dating back to the mid-1930s with the construction of Conchas Dam on the Canadian River. In the past 45 years, a number of major multipurpose water projects in the state have been completed, the latest being Los Esteros Dam on the Pecos at Santa Fe, which, while operational for flood control for the past six months, began storing irrigation water just this past Monday. In addition, of course, are a whole host of completed local flood protection projects throughout the state, with many new and urgently needed ones still on the drawing boards.

Our operating projects are, as I noted earlier, generally for multipurpose use, and that includes not only flood control, sediment retention and irrigation storage, but of equal importance to a large and growing segment of the public -- recreational use. In that regard, you need to know that we have well over a half-million people visit our Corps lakes each year, for the boating, swimming, and fishing opportunities so rare in the Southwest.

On the local protection side, as New Mexico's urban development gains momentum, we are continually asked to develop flood control projects for new or growing communities. While you all are aware of the long congressional approval process required for these efforts, you might be interested in knowing that given enough impetus and urgency, the system allows a more rapid response. For example, last year we were able to provide protection for a new junior high school in Santa Fe in less than two years from conception to completion -- a monumental achievement in the federal water projects business.

From the standpoint of flood protection there is, of course, the Corps' historic mission of emergency flood fighting and post-flood rehabilitation. And while my friends in Washington like to remind me that I'm located in the desert, in the two years I've been in Albuquerque, we've had one constant flood. Starting in 1978 with the Rio Grande at the Presidio of Texas, moving through that winter's devastating floods in southwestern New Mexico (an effort in which we finally spent some $15 million) and with the efforts required as a result of last year's record snow melts throughout the state -- frankly, I'm water-logged. Unfortunately, with this year's runoff forecasts, and associated problems like Bluewater Dam, it does not look like there will be much time for drying out.

To round out the water resource picture, you need to know that our current missions include a number of water quality tasks, ranging from our section 404 permit activities to our charter to act as construction consultants and inspectors for EPA's water treatment and sewage disposal grant programs.

So 1980 finds the Corps alive and well in the Southwest. What then of the future?

Certainly the Corps' current missions of flood control and protection efforts will continue in the next decade. With the increasing population and shifts in water usage throughout the State, I expect these will take on added importance. Unfortunately, while the clamor for local flood protection will dramatically increase, I see our ability to provide what is needed decreasing. The reason from my standpoint is, quite simply, public commitment.

While we are determined to help solve flooding problems, we are even more determined not to waste money on studies when the community does not take strong interest in its own problems. The community must be willing to stand up, give us a hand, and commit itself to carrying some of the financial burden. A burden, which I might add can surely be expected to increase in the years to come, and may increase dramatically if new federal cost-sharing proposals come to fruition.

In addition to flood protection, I believe you can expect the Corps, as well as all southwestern federal water interests, to now become much more active in our long-standing, but previously passive, concerns for resource management. If successful, such initiatives may very well delay and perhaps even avoid the need for large new dams and reservoirs. Recently, the Chief of Engineers, General Morris, commented to the Water Resources Congress that, "This new emphasis on conservation may turn out to be one of the most significant features of water resources management and development in the decade ahead. I believe we are going to see the conservation ethic dominate public policy in the 80's as strongly as the environmental ethic dominated the 70's."

Since I believe conservation is not merely using less, but that it means making the most effective use of a very limited resource, I would suggest federal agencies are going to have to take a closer look at institutional and legal constraints, operation of existing facilities, more efficient hardware, and reuse of water.

Simply stated, from the federal perspective, in the next decade, all water agencies will need to demonstrate that even with the best possible stewardship there is still a remaining need for federal projects. This is of major concern since my operational options are constrained by the states, Interstate Compact Commissions, other federal agencies, and water users.

While in New Mexico the state carries the principal burden in these areas, I assure you I do not view my role as passive. I am particularly anxious that the federal projects for which I am responsible are operated to the maximum public benefit. We simply cannot stand by and quietly tolerate a less-than-optimum use of water dictated by outdated operational charters. For example, politics aside, it makes no sense at all to have to store water in areas of high evaporation and loss, when low-loss storage is available higher in the watershed.

Because of this concern, I would expect a strong role in the 1980s for the Corps in support of those having state and local responsibility and accountability to southwestern water users and beneficiaries. To accomplish that, we intend to maintain and strengthen a sizeable water management expertise for our own work and to provide technical expertise to others. For example, we are currently studying reallocating a considerable portion of available storage at the Abiquiu flood control project to meet needs for storage, municipal and industrial, irrigation water and hydropower. And, I would note that the Corps' research and development community currently has a number of major conservation activities underway, particularly in the area of reservoir management. Finally, the future holds for the Corps a continuing and an ever-increasing charter for public involvement.

That role requires an understanding of what the public needs and wants (and they are not always the same), the development of a solution or action to meet those needs, and support for the local sponsors in explaining the action or project to their constituents who have to provide the dollars or property. The problem is, of course, identifying who the "public" is and what its real needs are.

As we all know, the complexity of problems, interests, and attitudes in today's society will not permit a simplistic approach to all public needs in water resource planning. Rather, complex "publics" require complex, yet flexible and adaptable solutions. Public involvement is a continuous, two-way process; but regardless of the problems' complexity, there is definitely and appropriately an increasing public demand to participate in decisions which deal with natural resource development.

You can, therefore, expect the Corps to continue to improve our public interaction and to strengthen our responsiveness to your valid water needs of the 1980s. Well, I've talked too long, and have only touched on a few of the Corps' future roles in New Mexico...flood protection, conservation, and hopefully, acting as honest broker in local and state resource-management responsibilities. Realistically, the public, its needs and wants, its support, and its satisfaction form the common thread of our concerns for the 1980s.

In the final analysis, I am still optimistic enough to believe that it is what you eight foot cowboys (and cowgirls) want of the Corps that will shape its role for the future. And, that's just the way it ought to be.

THE FUTURE OF AGRICULTURAL WATER USE IN NEW MEXICO

George Dawson, Head
Department of Agricultural Economics
and Agricultural Business
New Mexico State University

> The great majority of men attend to what is necessary only when they feel a need for it -- the precise time when it is too late.
>
> Napoleon Bonaparte

Clearly established at this and previous conferences is the fact that New Mexico's most obvious socio-economic problem is the meagerness of its water resources. With demand and potential demand being far greater than the available supply, its distribution and use are of exceptional importance in shaping the state's future. The question we ask this morning is, "Do we want an irrigated agriculture in that future?"

The nature of New Mexico's water law -- doctrine of prior appropriation is an important and useful system for recognizing right to, or changes in, the use of the water resources of the state. The concepts of "beneficial use" and "prior right" are key elements of that law.

In New Mexico, agriculture has put most of the state's water to beneficial use and has the prior right to most of the state's water. As we look to the future, the property right in water will of necessity and of economic pressure shift both the nature of beneficial use and the use right away from agriculture.

Exactly which force will eventually play the dominant role in executing such a shift in use is not known, that is, be it by political decree, or by way of the market system. It will be assumed for this discussion that it will be the market system. Namely, that to cause a change in use, a price must be paid to a current water-right holder to transfer use privilege.

What is the market value of water for agriculture as compared to other uses such as in uranium production, coal gasification, electricity generation, municipal, or recreation? While we do not have good numbers for these values, it is safe to say that currently and in the projected future to 2000, agriculture will be the least able to compete in the market for water. That is to say, that even with the water currently in agricultural uses, it will be purchased away for the other uses as it is demanded.

Land and water use policies are inseparable. The rights in land and water -- property rights -- give value to each. Land without water has limited value (except in an urban development path). Thus, irrigated land, upon severance of its water right, regardless of the method used, drops dramatically in asset value.

Concerns over the decline in the water table in several areas of the state and projections of impact upon the resulting local economy reflect clearly this condition. If the Portales valley is drained by 2020, as estimated by others, and agriculture is abandoned, what will be its replacement as an economic base for that community? Irrigation -- water or municipal water is a question already being vocalized.

Policies to preserve an irrigation agriculture in a given area should be established only with a knowledge of the condition of the water supply, namely a mining versus a recharge situation. The future of agriculture in mined water areas is at the best bleak, if we look to the long run.

To make predictions about the future for water in agriculture is no less than foolhardy, but to stand before you today with intent to do so for a third time in 12 years must qualify me as a fool of the first order. To make projections of the future, a good solid data base would normally be massaged and huge computers utilized to run out a series of alternative conclusions based upon a combination of assumptions. All such calculations assume some degree of credibility resulting from the tumbling of data through the machine -- which in my judgement, is not necessarily true. It is not possible to duplicate future social-political behavior in a computer.

Therefore, we are left to add our personal judgement -- and feelings about what we see as possible events and to draw our own conclusions to what such needed and helpful data analysis can tell us. Each of us will not draw similar conclusions after having examined the same data -- and that is, of course, where we are today: a wide variety of opinions as to what the future should be or will be.

My attempt through the years has been to provide thinking -- to prod the data manipulators to get on with their analysis of water requirements which could help us plan for the future, to urge decision makers to take all available information into account as futures are charted by their actions. Unfortunately, the same barrier exists today that has hampered decisions in the past, namely the political and economic expediency associated with political term of office and the individual drive to make the quick profit now. Welfare of a people 20, 50, or 100 years in the future gets lip service only, when these barriers carry so much influence on shaping current and future policies.

We are in a crucial time period insofar as planning and executing a policy for both land and water use in New Mexico. While progress has, in fact, been made in this effort over the past 30 years of my personal experience, I must charge that it falls pitifully short in accomplishing what needs to be done, and, as usual, time is our worst enemy.

Agriculture is easily forgotten in planning since it is not concentrated into great plants like steel, electronics, and autos. It creates no parking problems and farms are scattered across the countryside. Yes, the pure count of dollars generated causes most observers to conclude that agriculture is not economically important; therefore, let it fall by the wayside so that its land and water can be put to "higher-valued" uses.

How should our water be allocated to the many competitive higher-valued uses? Who will make those allocation decisions? How, or by what process will what players have voice in those decisions?

The public-choice process deals with the mechanics by which society makes decisions about their collective lives. It is not solely based on economics, but on a ranking of alternatives which assumes a personal knowledge of the well-defined alternatives or preferences. I suggest to you that while this is desirable, it is dangerous to assume the basic assumptions of public-choice theory. We must deal with a messy set of conditions and facts -- and the general public neither has the knowledge nor, in most cases, does it give a hoot about learning. Now before you charge me with suggesting a dictatorial decision-making process, let me quickly add that I do not favor such, but am suggesting that we collectively must examine the existing process and come up with some new strategy that does a better job -- not for our generation, but for generations yet unborn. If we do not, their future is in grave danger.

Now let me focus on water as a part of the grave danger I see in a future for agriculture. In New Mexico, we will face an absolute scarcity of water before 2000 in some production areas and in others soon thereafter.

Scarcity simply means that if other demands increase, even without a water-mining condition, agriculture will be the provider of that water. Importation schemes, though possible, are really not visible in the time future of 2000.

Our dwindling water supplies must somehow be stretched to meet an uncertain and growing demand. This we can surely agree upon.

Why do I express any feelings of grave concern for the continuance of irrigated agriculture in New Mexico? I wish now to briefly highlight just a few situations which exist currently and which will, in all likelihood, have major impact on the economic survival of irrigated agriculture.

Situation:

The current need to develop energy resources will bring national and even international pressures on New Mexico's water supply. Current and foreseeable future economic benefits to New Mexico from such development will be quickly accepted, for political and economic reasons, as the thing to do. Prices can and will be paid to shift water from agricultural uses to the "higher-valued" use.

Farmers had poor prices in 1979 for some crops, and disaster losses on others; and 1980 promises to be a year of significant decline in farm income. Under these and a complex set of other circumstances, farmers might well be inclined to sell their water. I foresee such a situation as being the probable course of action for several years to come. In the long run, I predict a reversal in the concept of higher-valued use, but that is too far away to attract even measurable concern in today's condition of an abundant food supply.

In 1968, four NMSU professors "imagineered" the future of water demands to the year 2060. Our projections at that time did not include this recent new demand for water associated with energy development. (That demand was outlined earlier today and underscores the magnitude of the concern for agriculture.) We projected a strong likelihood that irrigation agriculture would be obsolete by the year 2060. It now appears safe to conclude that for the largest part of irrigation agriculture as we know it today, that date of obsolesence will come much earlier. The projected nonagricultural demands equaled or exceeded the total water depleted by agriculture in those estimates. Thus, it was a dismal future reported at that time, and I cannot honestly brighten that projection at this time.

We concluded at the 1968 Conference that there existed a critical need to establish a priority plan for water development. I conclude that same counsel could be emphasized even more so today.

Situation:

Farmers are staying in business at this point in time by heavy borrowing of short-term capital at high interest rates.

The Federal Intermediate Credit Bank of Wichita states in its 1979 Annual Report that loans for production purposes were up 32 percent over 1978 and at an all time high. The debt to asset ratio reflected an 18.7 percent erosion of assets in a one-year period.

Also, farmers are borrowing heavily on their long-term credit capacity and living off of appreciation. Such borrowing through the Federal Land Bank (FLB) of Wichita (the bank for New Mexico farmers) was up 56 percent in 1979 over 1978. This was through 10,155 new loans.

Locally, the FLB office loaned 232 percent more in 1979 that in 1978 (10.6 million to 4.6 million). In 1978, 500 borrowers had a $39 million land debt to the bank, and in 1979, 514 borrowers had debt of $47 million for a growth in such debt of $8 million in one year.

Such record borrowing signals clearly that there is trouble down on the farm. If farm incomes were as good as some reporters and the federal government would have you believe, then why should that be occurring? Double, triple, or multiply the price of water 10 to 20 times, and what additional impact will that have on farmer's ability to continue in irrigation?

Situation:

Land values for irrigated agriculture are skyrocketing due to a number of pressures and social-economic factors. If you assume a land value of $2,700 per acre in 1980, and an inflation rate of only seven percent, that same acre will have a value of more than $10,000 in the year 2000. Shocking? Yes. But valley irrigated-land values have been increasing at a rate faster than seven percent, and the future certainly indicates no decline in that rate to a stable seven percent.

If farmers must pay such prices for land having water rights, what will farm prices have to be? Can a farmer borrow the money and even pay the interest on land debt? Also note that the projection in land value was for only 20 years in the future.

Will agriculture be the cause of the increased land prices? No, it will be pressures for that land and its accompanying water right from nonagricultural users. Agriculture will be forced off the land (through voluntarily selling to highest bidder) and away from its water.

Situation:

Most Indian water rights have not been clearly quantified and generally they tend to be prior to all other rights.

All water users are, therefore, somewhat vulnerable until the exact magnitude of such rights is determined.

A good series of articles regarding this important aspect of water rights and future use is in the January 1980 issue of the Natural Resources Journal. I recommend it to your reading.

The Navajo Indian Irrigation Project, (NIIP) is the latest and largest irrigation project in New Mexico, but with the water demands for energy developments in that corner of the state now and likely to occur, water may not necessarily be committed to a permanent agricultural use.

Situation:

A report published in the Des Moines Register on March 9, 1980 of a National Lands Study made for high government officials reflects another dimension that should cause us concern. By the turn of the century, it is reported that we will loose half or more of the prime farm land from five states. These are: Florida, all or nearly all; West Virginia, 73 percent; Connecticut, 70 percent;

Massachusetts, 51 percent; New Mexico, 50 percent; and Iowa will loose 345,000 acres, or the production equivalent of 41 million bushels of corn.

You ask what has this to do with a future for water in New Mexico agriculture? You say we have national surplus capacity in agriculture anyway; so what! Well, here is where Dawson's philosophy and continuing concern is about to be expressed again.

We have behaved like the ancient Romans at a harvest feast and orgy in our use of petroleum. I suggest that we are assuming that same posture about food. What would our attitude be today if the tables were reversed and we were told that our food supply was threatened like our oil supply -- not just because of volatile OPEC country policies, but in an absolute sense? Shock over $1.30 gasoline is nothing compared to shock over what food prices can and will be in a similar setting. We are threatened by and afraid of a cutoff in imported oil. What if that threat should be over your food supply?

My point is, we can run out of land, and the water which makes that land productive. Nationally, in the next twenty years, we face losing about 40 million acres in total, including 20 million acres of prime farm land.

Will our children look back on what we opted to do with land and water with similar disgust as we currently do at the way we wasted the U.S. petroleum resource? I predict they clearly will.

Situation:

Latin America in the next 25 years will have a doubling of its labor force from 98 to 195 million people with unemployment as high as 45 percent. These people now have annual incomes of less than $200; one child in four dies before age two; others will receive no more than three years of schooling, and most will not live past age 50.

Are these statistics unrelated to my topic? That region of the world, with its high rate of population growth has contributed to the overuse and misuse of land and added environmental problems that have reduced agricultural production. Are we immune from such a result?

Situation:

Four agricultural engineers have done some forward looking at farming in 2025. A few highlights of their predictions are:

1. Marked change in transportation restricting production flow, and a greater consumption closer to the point of production.
2. Processing, etc. will be more localized.
3. Economic entities will be more localized and regionalized.
4. Recycling will be a way of life.
5. Municipalities and surrounding areas will become more water-dependent.
6. Society will not compromise agricultural production.

7. First priority will be to supply food in quantities needed for U.S. consumption.
8. Minimizing of physical resource consumption.
9. Society will aggressively restrict the use of agricultural land for nonagricultural purposes and will insist that agricultural lands be well maintained.
10. Land will not be a variable in the U.S. agricultural equation.
11. Human efforts to produce food will increase.
12. Urban dwellers will use roof space and window boxes as garden space.
13. Shift to electricity from oil and natural gas.
14. Self-sufficient farms more common than today.

Such predictions are food for thought as we ponder the advisability of keeping a viable local agriculture for New Mexico. How valid are such predictions? How much example do we need to become believers that what happened to the Romans, to our oil supply, and to Latin America's food supply, can also happen here? For us, how we answer that question, is intimately tied to a commitment to preserve water for agriculture, rather than "flaring it" so to speak as we did in profiteering from our oil-consumption orgy.

In closing, the future of water for agriculture depends on a number of factors:

1. Extent of need for energy development.

2. Population changes and water demands.

3. A land-use plan to preserve irrigated lands.

4. Energy costs and competitive position of New Mexico _vis a vis_ other producing regions.

5. Importation (not at all likely).

6. Water conservation -- across the board.

7. Legal and market conditions.

8. Utilization of saline and brackish waters.

9. Plant modification (less water, salt-tolerant, etc.).

To prescribe what water should be kept for agriculture requires that we predict what New Mexico will be like in the year 2000 and beyond. The trends are somewhat clear, but compounded by major national and international factors. We must resolve whether we believe a viable agriculture necessary in that distant future.

The distant future cannot be isolated from that future immediately ahead. Our capacity to deal with the water challenges of the next century will be determined in large part by the wisdom of our choices in the next two decades.

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