WATER
RESOURCES
RESEARCH
INSTITUTE

THIRTEENTH
MARCH 28,29-1968

ANNUAL WATER CONFERENCE

THEME:

Water for New Mexico
to the year 2000 and 2060

New Mexico State University, Las Cruces, New Mexico

NEW MEXICO WATER CONFERENCE
Sponsored By
NEW MEXICO STATE UNIVERSITY DIVISIONS

of

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Agricultural Extension Service
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FOREWORD

WATER FOR NEW MEXICO - TO THE YEAR 2000 AND 2060, may seem to have been a far-fetched conference topic, or possibly a "shot in the dark." When we look at the records of the past and some of the things we have reason to expect in the future, these two periods may not seem so long.

It is true that the 32 years to the year 2000 seems a long time. However the first Annual Water Conference was held 13 years ago, or nearly one-half as far in the past as the year 2000 is in the future.

The year 2060, 92 years away, can be compared with development of the Navajo Indian Irrigation Project in San Juan County. One of the first plans was published in 1902; but the first water is to be delivered in about 1972 to 1975. This project has been in the planning and construction stages for nearly 70 years and it may take another 20 years before as much as 75 percent of the project land is irrigated. Thus, a one-hundred year period will elapse between the early planning and near completion of this project.

There were many facts, reasonable projections, and speculations presented by the various speakers during the conference and especially by the members of the two panels on the subject "Water to 2000 and 2060." These papers give us the directions which water resources supply and use problems will take in the near and more distant future. They indicate which way the trends are going. The future will determine how far they may lead us, either with and/or without planning to meet our expected water supply and demand problems.

Much credit is due to the various people who prepared papers and presented them. Many hours of work and much detailed research work went into these presentations. Credit is also due the statewide and University water conference committees for their efforts in planning and conducting this conference.

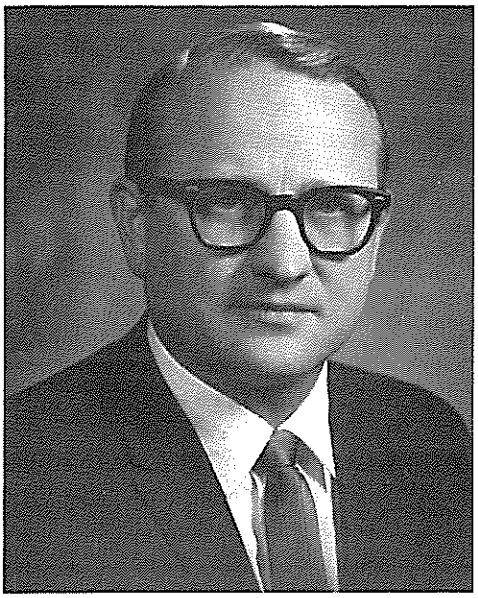
We believe a real contribution has been made here to help us project our thinking, planning and action to the year 2000 and 2060. The actual projections may fall short or in other ways be wide of the actual situation at those dates. However we are sure that these facts and projections will lead New Mexico closer to a sound solution than if they were not available for discussion and possible future planning and action.

Part of the funds required for the publication of this proceedings report were provided by the United States Department of Interior, Office of Water Resources Research as authorized under the Water Resources Research Act of 1964, P.L. 88-379.

The program which follows will serve as an index to the papers.

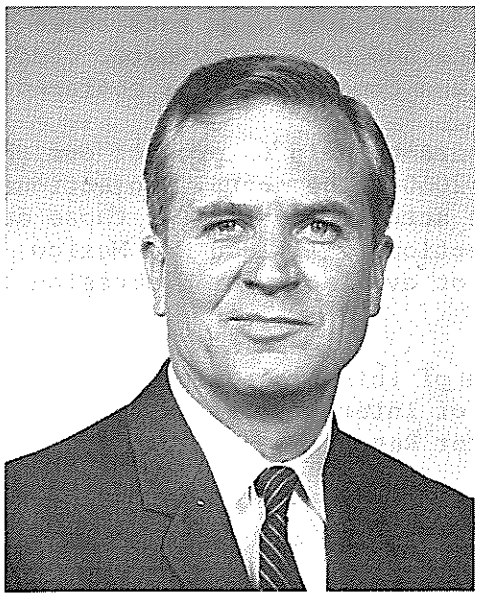
H. R. Stucky

H. R. Stucky, Chairman
Water Conference Committee

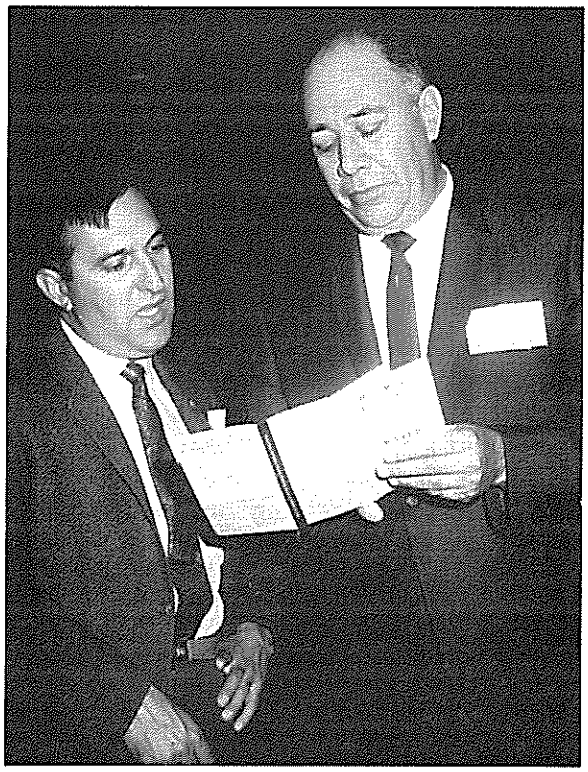


Governor David F. Cargo

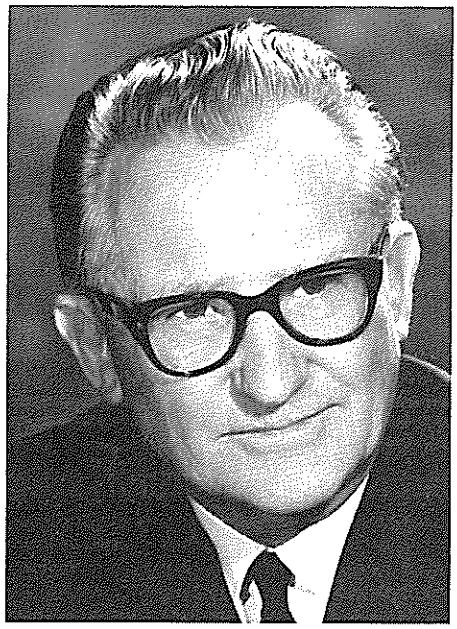
Mrs. L L. Lyon - President of the New Mexico League of Women Voters, Los Alamos, New Mexico, visits with Floyd Dominy - Commissioner, Bureau of Reclamation, Washington, D.C.



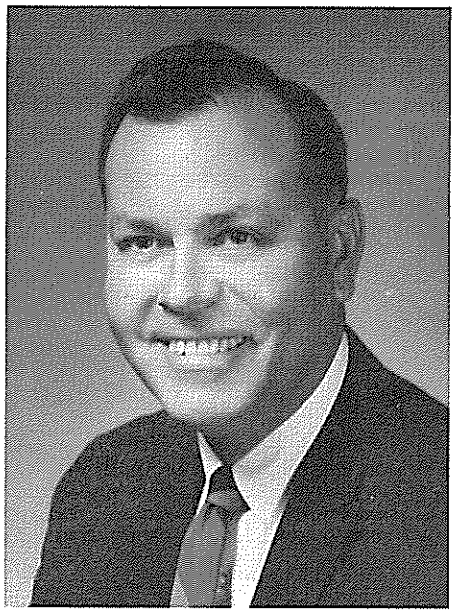
Orren Beaty - Federal Co-chairman, Four Corners Economic Development Commission, Washington, D.C.



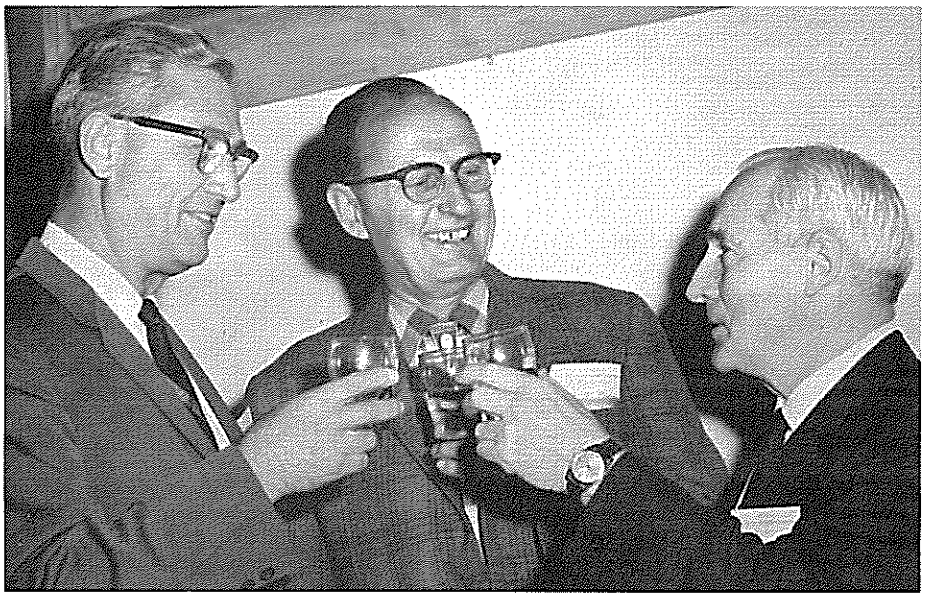
Ing. Carlos Carvajal Zarazua, Secretary for Water Resources (R), Chihuahua, Mexico; and Ismael Rodriquez, also from Chihuahua, Mexico. (L)



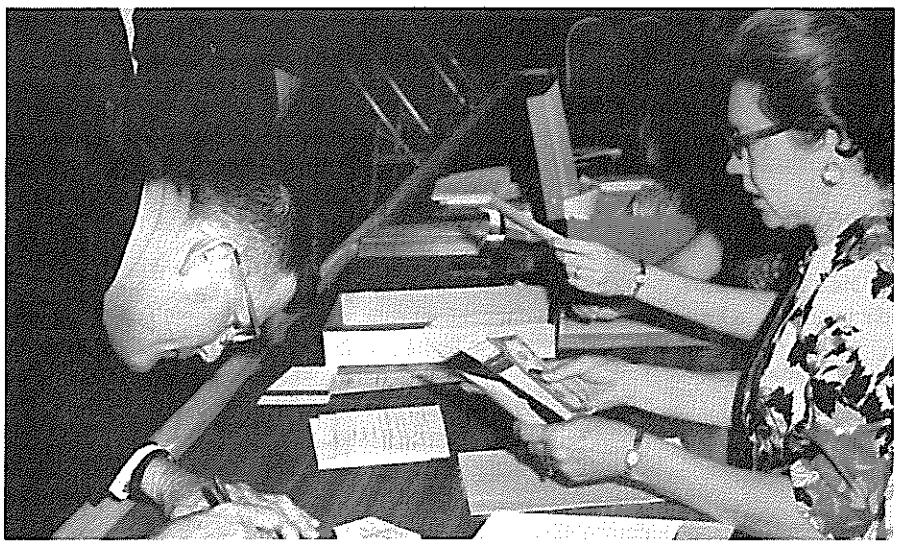
President R. B. Corbett, New Mexico State University, presented the address of welcome.



Lloyd Calhoun - President Eastern New Mexico Inter-community Water Supply Association, Hobbs, New Mexico.



A Toast to the Importance of Water to New Mexico and the Nation (Left to right), H. C. Fletcher, Assistant Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado; Fred Thompson, Planning Officer, State Department of Game and Fish, Santa Fe, New Mexico; and Dr. R. R. Renne, Director, Office of Water Resources Research, Washington, D.C.



Registering for the conference is Chester L. Davenport, Acting Chief of the Las Cruces Field Branch, Bureau of Reclamation. Taking the registration is Mrs. Helen Hudson, Secretary, Water Resources Research Institute, N.M.S.U.

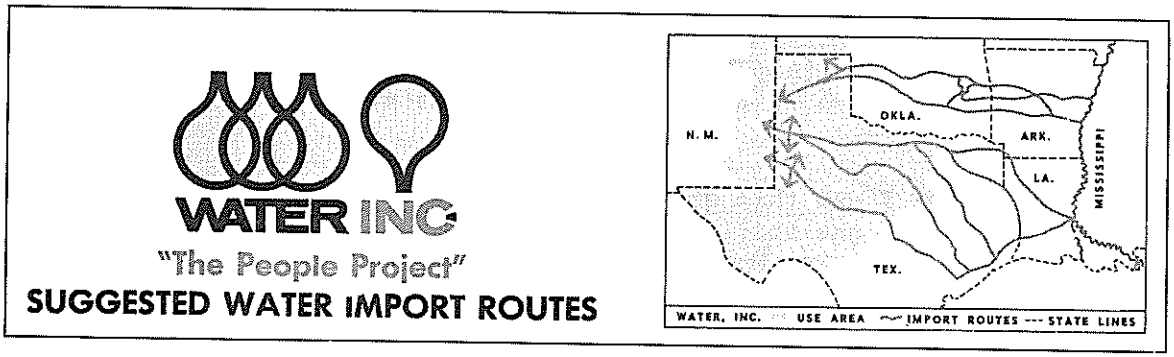
PROGRAM

NEW MEXICO WATER CONFERENCE

March 28 - 29, 1968

THEME OF THE CONFERENCE - WATER FOR NEW MEXICO TO THE YEAR 2000 AND 2060

Mr. Cliff Chamberlain, Executive Director, (L), Lubbock, Texas, and Mr. John Kendrick, President of Water, Incorporated, (R) Lubbock, Texas, looking over the plans for importing water from the Mississippi River to the High Plains of West Texas and New Mexico. Water, Incorporated was organized in 1967 by the citizens of the area who are concerned about rapidly declining water supply in the area.



Water, Incorporated is promoting the study of seven possible import routes to bring water to the High Plains.

WELCOME

President Roger B. Corbett

New Mexico State University

Welcome to the Thirteenth Annual New Mexico Water Conference. Particularly, welcome to those who are here for the first time, and a real strong welcome to the many who have attended before. All of us are needed in the battle to solve our water problems.

We need to make some long-range plans that show a real understanding of the problem. We have had too much of a period of drought when all became alarmed, and following a few rains the alarm was laid aside, as well as the planning. Essentially, we can't be excited and afraid, and then go to sleep on the job.

Some have criticized this Conference because it is too long-range in its thinking. A short time ago I saw a headline in a newspaper that said, "Water for Columbus from Canada." Being so highly oriented to New Mexico, I thought of Columbus, New Mexico, and knew how short water was there, but I couldn't believe that that little town was planning to get water from Canada. It turned out that it was Columbus, Ohio - looking ahead for many years and predicting that it, a large city in a humid part of the country, would need water from Canada. They were thinking 100 years ahead.

It is my understanding that a nearby state, looking many years ahead, has decided that it must find $400,000,000 to carry out its plans, even if the taxpayers of that state alone foot the bill.

The other day I saw this quotation, "Responsibility is like a hot poker" - no one really wants to take hold of it, but this is a problem that New Mexico as a whole must grasp. It is the "hot poker" of responsibility for our future water supply. This Conference has come nearer to grasping this "hot poker" than any other program in New Mexico. One of our big jobs is to get more persons to take responsibility for the problems.

WATER FOR NEW MEXICO TO THE YEAR 2000 AND 2060

Governor David F. Cargo[1]/

The Water Resources Research Institute and the Statewide Advisory Committee are to be commended for their foresight and initiative in organizing this conference to look at the subject of "Water for New Mexico - To the Year 2000 and 2060."

Our present water supply comes essentially from an average precipitation of about 13 inches per year, for a gross product of roughly 85 million acre-feet. But this precipitation is characterized by wide variability from place to place and from time to time. Average annual precipitation varies from about 8 inches in the desert valleys to more than 30 inches in the high mountains. This has provided New Mexico with a wide variety of vegetation.

River inflow into New Mexico from other states totals about 2.5 million acre-feet. Yet approximately 3.4 million acre-feet per year is discharged to downstream states. It is hoped that in the not too distant future, the outflow will approximately equal the inflow.

Now, in addition to the measurable flow in her rivers, New Mexico is fortunate in possessing large quantities of water in underground storage. The United States Geological Survey estimates these at 20 billion acre-feet of which roughly one-quarter, or five billion acre-feet is thought to be fresh or only slightly brackish. (The State Engineer Office has estimated that 20 billion acre-feet is enough water to cover the entire state to an average depth of 260 feet.) Not all this underground water is physically and economically extractable, unfortunately, but these reserves do represent a tremendous asset that can be developed as the needs for water increase.

Current estimates are that New Mexico's population will more than double by the year 2000, and that by 2060 it will have increased tenfold or more. This places a heavy responsibility on all of us that are concerned with water, its sources and the demands that will be placed upon it. Proper planning is indispensable. Careful studies of our laws that govern the appropriation and use of water should be undertaken and revisions recommended where necessary. Our compacts with other states should be continually reviewed. It is vital that our negotiations with other states be conducted from a sound base of knowledge and understanding of our present and future requirements. I offer the services of my office, the State Planning Office, the State Engineer Office and any other state agency under my jurisdiction

1/ Governor of New Mexico. Statement made to the Thirteenth Annual New Mexico Water Conference, March 28, 1968, on the subject "Water for New Mexico to the Year 2000 and 2060." Governor Cargo served as chairman of the opening session.

to aid in this regard. The Interstate Stream Commission, which carries the prime responsibility for the negotiation and administration of our interstate water compacts and for the conduct of litigation over interstate waters, should call on us for help whenever they may need it.

WATER IN NEW MEXICO'S FUTURE

Lloyd A. Calhoun[1]/

Historical items on New Mexico are replete with recordings of drought, crop failures, water hole fights, and tribal migrations within this semi-arid Land of Enchantment. Scarcity of water has been the lot of New Mexicans for centuries. There is evidence that fully 800 years ago the art of crop irrigation was practiced with a high degree of skill and efficiency.

William A. Keleher, in his book The Fabulous Frontier, quotes from an interview by Charles B. Eddy for the "Golden Era" in 1885 in which he said, "It is the want of water that makes New Mexico the worst place on the face of the earth for small settlers to go to." Eddy concluded his dismal interview on the cattle raising prospects in Lincoln County with the note that costly efforts to locate water wells in the area had failed utterly.

Keleher added a footnote to the effect that artesian wells subsequently were developed in the Pecos Valley near Roswell, resulting in one of the great agricultural and livestock areas of the West.

Fortunately, since Eddy's time, we have learned a great deal more about the water resources in New Mexico. Thanks to extensive agricultural and industrial developments since the turn of the century and to those dedicated professionals connected with the several federal, state, and local agencies and foundations concerned by water resources development in all its many facets, we have this knowledge.

We know that, in spite of an average annual rainfall of slightly over one foot, there is, in the aggregate, a vast storehouse of underground water available both for present and long-range future use. A relatively small percentage of the supply is fresh and therein lies one of the problems facing us in planning our water supplies for the future.

In a recent address before the Lea County Chapter of the New Mexico Society of Professional Engineers, Steve Reynolds, out State Engineer, cited the U. S. Geological Survey estimate of some 20 billion acre-feet of underground water in storage within the State's boundaries. That amount of water is incomprehensible unless it is figuratively brought to the top of the ground and poured over the surface. This is what Steve did in his paper and came up with a body of water of sufficient volume to cover New Mexico to an average depth of 250 feet! He did not represent all of that water to be either economically extractable nor usable in its native state. However, ultimately much of it can be and, we know, will be put to use.

President, Eastern New Mexico Inter-Community Water Supply Association, Hobbs, New Mexico.

New techniques will be developed for more economically pumping from greater depths than known heretofore. High-volume, deep well submergible electric pumps are presently lifting water from great depths at unprecedented low costs for oilfield secondary recovery projects. Costs of electric energy have declined steadily in recent years and are expected to continue on the trend in the foreseeable future. Lifting costs, it follows, will be reduced likewise. One manufacturer of submergible pumps specifies that a barrel of water can be lifted from 8,000 feet for 4½ cents at a power cost of one cent per kilowatt hour and at a 1000 barrel per day pumping rate.

In addition to the large underground water resources known to exist, there are believed to be undiscovered reservoirs in large areas of the State where detailed groundwater studies are yet to be made.

New Mexico, in comparison with most other states, is relatively underdeveloped. It has great potential for growth, socially and economically. Fifth in size among the 50 states, with a total area of 121,700 square miles, it ranks fifth from the bottom with a population spread of 7.8 people per square mile. It also stands fifth from the bottom in inland water area, with a total of 155 square miles being covered by water, the smallest such area of any of the 50 states.

What are the prospects for growth between now and the turn of the century?

Five years ago, U. S. News and World Report projected the following picture of America for the year 2000 A. D.:

> "People in the U. S.: 350 million
> Total output of the nation (in 1959 dollars): $2,000 billion, or about four times the 1963 level.
> Jobholders: 135 million, about twice the 1963 number.
> Average family income (after taxes in 1959 dollars): $14,750.
> Travel: 11,000 miles a year per person, on the average, nearly triple 1960's pace."

Taken from a report of the Outdoor Recreation Resources Review Commission and included in the above forecast was the estimated growth of population in the 8 mountain states - New Mexico included - of from 6.9 million in 1963 to 16.2 million by 2000 A. D.

Almost invariably, projections of U. S., and especially southwestern U. S., population growth turn out to be on the low side. Ten years ago, here at the Third Annual Water Conference, Albin Dearing, then Executive Vice Chairman of the Water Resources Council, quoted the following statistics. He told us, "The estimates now are that we will have, at the end of the century, between two and three hundred million people, in fact

we will pass the 190 million mark before 1975." As we all know, we passed the 200 million mark several months ago!

Ralph Edgel, who will address this conference tomorrow afternoon, will make projections on New Mexico's population growth to the year 2000. His projections - and he will no doubt make it clear that they are projections, not prognostications - will underscore the need for ever increasing fresh water supplies to meet the demands of a rapidly growing populace whose individual's daily requirements also grow. Ralph Edgel will possibly tell us that his projections will likely prove to be conservative.

But regardless of the ultimate accuracy of population forecasts, we know for certain that New Mexico's water supplies cannot be produced for the needs of year 2000 and beyond from sources as we now know them to exist. Where then will they come from?

Those of you who have been privileged, as I have, to have attended the previous twelve Annual Water Conferences and who have retained your copies of the proceedings of those meetings, can find in them many answers to the great problem facing us in the years ahead.

Dr. John W. Clark, Jr., then Associate Professor in the Civil Engineering Department, of a small institution known then as the New Mexico College of Agriculture and Mechanic Arts, presented an excellent and in several ways, a prophetic paper on New Sources of Water for Irrigation, Municipal and Industrial Uses. He stressed the importance of cleaning up and reusing our sewage effluent. Never have I seen a point so graphically illustrated as when, at the end of his theme, John reached into the lecturn, pulled out a pint Mason jar and drank it dry. He then told his unbelieving audience that the contents had been dipped from the campus sewage treated effluent pond that same morning. He had earlier told his audience that the water you drink today may once have been in Cleopatra's swimming pool! I believe there remains a doubt in the minds of his listeners as to whether or not that possibility made the Mason jar contents more or less palatable.

Not much, if anything, has been done in New Mexico in the twelve years since that first meeting to increase the beneficial use of the potentially valuable municipal effluents. Every municipality, with the possible exception of one, within the State has a sewage treatment system. There are in our society qualms which would prevent reuse of treated effluent for domestic purposes without considerable pre-conditioning measures, both to the effluent and the society. It constitutes much too valuable a resource, however, to be wasted as is done in too many cases.

Approximately 65 to 70 percent of water pumped into municipal water mains, except for that which is diverted to lawn and garden irrigation, ends up at the sewage treatment plant. With an estimated 160 gallons per day per person supplied through public water systems in New Mexico in 1962 it might reasonably be expected that a yield of something over a hundred gallons per day per person was made available for re-use as sewage effluent.

Also, presented at the First Annual Conference in 1956 was a paper by Dr. Buel W. Beadle, then Chairman of the Chemical Engineering Department at the Southwest Research Institute of San Antonio, Texas. Dr. Beadle discussed work then being done at Southwest on control of water evaporation losses by the application of monomolecular films. Earliest work in the field had been done by I. Langmuir in 1917.

One can appreciate the importance of achieving success in this experimental program when it is seen that from the 155 square mile inland water surface of New Mexico's lakes and streams, the annual evaporation loss totals 942,000 acre feet of water. This statistic was published in the 1956 World Almanac and cited in Dr. Beadle's paper. The author said that savings of evaporation of 45-50 percent for as long as 5-8 days in the field had been achieved by the experimental use of monomolecular films. He concluded, "The ultimate objective will be to develop a practical and economical method for reservoir evaporation control - one that will be of maximum benefit to water users in the Southwest and other portions of the United States, and, indeed, the world."

A 50 percent control of evaporation, if and when practically developed, could save enough water each year from the 155 square miles of New Mexico inland surface waters to supply twice our nonirrigation requirements and have enough left over to supply the State's oil industry secondary recovery demands for three full years.

Continued work is needed in areas of Watershed Management, Flood Control, Fish and Wildlife Development, Geologic and Topographic Mapping, Phreatophyte Control, Water Quality, Reforestation and Erosion Control, River Basin Studies, Development, Inventory and Conservation of Mineral Resources, Population Growth Studies, Industrial and Tourist Development, Weather Modification, Reclamation, Desalination, Reservoir Recharge, and Water Resources Research.

All are key programs which will need to be pursued and even expanded upon for maximum development of the State's water resources. All of the agencies, institutions, firms and individuals involved in these massive efforts are too numerous to list here. You all know who they are. Most, if not all of them have participated in the twelve excellent programs that have preceded this one.

Review the proceedings of those conferences and you can't help being impressed by the deep concern in New Mexico's future which has been recorded by the dedicated people involved.

Assuming success in all of the programs mentioned above there still will not be enough water to meet the needs of the long-range future.

Food production, not only for our own population but for others outside New Mexico and even outside the United States, will be our most critical need from beyond 2000 A. D. William A. Hewitt, Chairman of Deere & Company (or John Deere, as we better recognize his company), referred in a recent address to the job as that of "Feeding a 'Second World'." Hewitt predicted the doubling in the world's population, which is now 3.2 billion, within the remainder of the twentieth century. "This means," he said, "that in the short span of less than 35 years an ability to feed a 'Second World' must be developed."

The 1962 Agriculture Yearbook tells us that United States water requirements for agriculture, industry and municipal use will double by 1980; triple by 2000 A. D. The Department further predicts that, with expected improvements in conservation technology, 85 percent more land will be irrigated with only 2 percent more water in the year 2000 than was used in 1954.

There are today under serious consideration several large-scale plans for importing supplemental water supplies into New Mexico from far distant sources. Two years ago, Roland P. Kelly, Technical Program Manager of The Ralph M. Parsons Company, addressed this forum on the projects conceived by his company and named the North American Water and Power Alliance, better known as NAWAPA. This venture, as you know, would involve the importation of surplus water from source points in southeastern Alaska and the Yukon Territory of western Canada. A system of canals and tunnels would carry the water southward through British Columbia, across the Rocky Mountains, trench and make deliveries into Utah, Nevada, Arizona, California, New Mexico, Texas, Colorado, and Old Mexico. The project, as then viewed, would require about 20 years to complete after the resolution of political and international features, as Mr. Kelly expressed the view. Estimated cost would be about $100 billion.

The NAWAPA project would include power generation of some 38 million kilowatts in addition to water transport of an estimated 78,000,000 acre-feet per year. Forty million acres of new farm land would be put into production and $30 billion added to the United States economy each year upon completion of the project.

Yet another water resource plan of unprecedented magnitude has been researched by R. W. Beck and Associates, and would involve the transportation and delivery of some 10,200,000 acre-feet per year of water to the Great Plains regions. Source would be the Missouri River below Fort Randall, Nebraska. New Mexico would be one of the delivery points.

But the one great alternative plan given the best promise of success at this time is the importation program under investigation by the United States Bureau of Reclamation and other agencies, both federal and those of the states involved. Water Inc., is a corporation, not yet a year old, which has a most intense interest in this project. John J. Kendrick, who will next address this meeting, is president of Water Inc. and he will tell us as much as is presently known of the plans and investigations of the project. I shall not impose further upon his time or subject.

One, by comparison, small project being considered by twelve communities on the eastern side of the State is that of pipelining some 42,000 acre-feet per year of water from Ute Reservoir on the Canadian River for municipal and industrial use. The member communities in the Eastern New Mexico Inter-Community Water Supply Association are San Jon, Clovis, Texico, Melrose, Portales, Elida, Roswell, Tatum, Lovington, Hobbs, Eunice, and Jal. The Bureau of Reclamation is approaching completion of a preliminary cost and design study of the pipeline and pumping facilities of this system to provide supplemental water to these towns.

Let there be no misunderstanding regarding resulting costs of water from this or any other source not already in existence. The costs will be higher, regardless of the means employed for providing any new source of water from this time onward.

Municipalities of west Texas, where the prototype plan upon which the Ute project is largely patterned, are already paying higher prices for their municipal water as the result of joining in the West Texas Water Project. There is no known alternative if future water needs are to be met.

In conclusion, I believe we would all agree that we in New Mexico must continue to do everything - and more - that we have been doing for a good many years to conserve our natural, in-state water resources. Use not misuse nor nonuse, must be a full partner in any conservation-of-water effort.

While doing all that can be done by all that we know how to do in this regard we, at the same time, must investigate all reasonably attainable

sources of out-of-state water for importation to those areas in New Mexico where other means will, in the years ahead, fall short in meeting water requirements. Transportation of water in large volumes over long distances is feasible and operable in many areas of the world. While economics may not always be the criterion in first consideration, it probably will be satisfied in future, large scale, long-range projects.

Water is the world's number one migrant. It has been since the beginning of time. There is no more nor less water today than in the beginning. Remember Cleopatra's bath? The growing problem in water supply is that of logistics; not enough where it is needed and, quite as often, too much where it is not. Water needs to be moved from areas of surplus to those of scarcity. Flood or drought, feast or famine, life or death together compose the history of mankind. We can't entirely control the eternal pattern, but we can try. The future of coming generations will depend upon the ultimate success of our efforts. We really have no choice but to plan and act with all possible diligence.

We'd better be caught trying.

WATER IMPORTATION TO WEST TEXAS AND NEW MEXICO

John J. Kendrick[1]/

Governor Cargo, Gentlemen-

Water, Inc. recently held its first annual membership meeting. There were about 400 people in attendance. We could not call this meeting a birthday celebration as the Corporation will not be one year old until month after next. We are proud of our accomplishments to date and I am happy to have this opportunity to tell you about Water, Inc., to discuss our water problems, and tell you of plans for bringing water to west Texas and New Mexico.

In the High Plains of west Texas we have over 70 thousand irrigation wells which annually draw from the ground water sources about 5 million acre-feet of water. This makes it possible for our farmers to produce agricultural products which in 1965 were valued at over 550 million dollars. This agricultural income, added to mineral production and industry, easily represents an income to the area of over a billion dollars a year.

Not much of the 17 million bushels of wheat, 128 million bushels of grain sorghum, and 1¼ million bales of cotton produced on the South Plains in an average year stays on the High Plains. I am sure you are aware of the significance to the economy of having millions of bushels of grain and hundreds of thousands of bales of cotton shipped through the ports of Texas; stored in warehouses in the states where it was produced; or processed in plants located in central, east or south Texas or New Mexico or Oklahoma. Thus, these states and the whole nation have a stake in the prosperity of the High Plains area.

Producing this billion dollar income in 1964 took 26 million dollars worth of fertilizer and about 40 million dollars worth of gasoline in the operation of farm machinery. We are talking about a sizeable slice of the nation's agricultural economy.

The Texas State Water Development Board has established through its preliminary study that there is not sufficient water in Texas to satisfy the states predictable and forseeable needs. The effects of insufficient water on the farms, the urban areas, and industry are well known to all of us. The towns on the High Plains that are having difficulty getting enough water or the farmer whose irrigation wells are drying up are well aware that in their area the situation is getting critical. You are all familiar with facts of the decline in the ground water levels in the Portales Valley of New Mexico and the fact that irrigation has essentially ceased in part of the Valley.

1/ President, Water, Incorporated, Lubbock, Texas.

In the general vicinity of Lubbock, Texas, where large scale irrigation developments first occurred on the southern High Plains, and where total groundwater withdrawals have been the largest, the process of groundwater depletion, and the decline in groundwater level is well advanced.

Recharge of water to the Ogallala Aquifer is only a minor fraction of current withdrawals. The rate of withdrawal may increase as industry expands and new land is brought under irrigation. In this area, most of the irrigation must stop within the forseeable future unless imported water supplies are made available to the irrigator.

Conservation practices can extend the time for depletion of our water and the proper agencies are hard at work enforcing conservation measures and seeking new ways to conserve water. For example, one of the utility companies has had a generating plant in operation in Amarillo for several years using sewage effluent for plant water. A plant is being designed for construction by a public utility company in the Lubbock area which will make use of the sewage effluent from the city of Lubbock. We are fortunate in Lubbock in that the effluent has been used for many years for irrigation purposes. It has been accumulating in the ground, particularly in the winter months. Shallow wells will be drilled to recover this water as an additional source for the proposed new steam electric generating plant. This is just an example of the steps that are being taken to make maximum use of what water we have.

The Texas Water Development Board has done a tremendous job in the time it has been in existence. It is limited, however, as New Mexico or any other state is limited and looking across the boundaries of the state seeking new water sources is probably beyond what the Board could or should do. The federal agencies are not so limited and neither is Water, Inc.

This fact is increasingly important as we believe studies now under way will prove conclusively that even if the state of Texas could agree to supply 4½ million acre-feet yearly from Texas sources, this would be only a starter. The system of importing water to our area must be designed to meet the total requirement of 18-20 million acre-feet annually. Thus, it is absolutely imperative to the success of this plan that an out-of-state source be assumed. This interstate and interbasin transfer of water is definitely a job for the federal agencies. It is an area where the states will certainly be called on for data, for suggestions and for assistance. The local interests will be called upon and we must have the required data available and in presentable form if we are to expedite this program.

We are looking East for our water. The surplus flood waters of the Mississippi now appear to be our most practicable source. We believe this water can be brought to the High Plains at a cost we can afford to

pay. Everyone along the import route will benefit and Water, Inc. is actively seeking their assistance in making this import program a reality.

Water, Inc. is an organization of people who recognize the need for additional water supplies for the High Plains area. It is a nonprofit corporation created to be a spokesman and leader in the long and difficult task of securing additional water for users in the Panhandle of Oklahoma, the High Plains of Texas and in eastern New Mexico. This means agricultural water as well as water for municipal and industrial use. A supplement to the dwindling water supply on the High Plains is necessary to the economic well-being of the area. It is a matter of the utmost urgency.

We recognize that we must constantly work to keep the public aware of our need for additional water. We know, too, that if we are to be successful, we are going to need the help of all of the friends we can muster - not just the people in the High Plains area. New Mexico, Oklahoma, and Texas must join together as users who will derive direct benefit from the water. Louisiana which will benefit from creation of an import route through that state, should join us as soon as the benefits to its people become apparent. This public information program and creating an awareness of the problem is one task that has been undertaken by Water, Inc.

When federal agencies such as the Bureau of Reclamation or the Corps of Engineers begin an investigation for a project, usually a reconnaissance report is prepared. The reconnaissance report on water importation into west Texas and New Mexico is now under way. A joint study by the Bureau and the Corps of Engineers financed by almost ½ million dollars of federal funds is now being prepared. Historically, preparation of the reconnaissance report has required anywhere from one to several years. If after the report is in and the project appears justified, and (this is important) if sufficient interest is evident, Congress is asked to authorize a feasibility investigation.

Representing this local interest and overcoming public apathy is another task of Water, Inc. Speeding up the process is important to all of us as our water production potential is being reduced yearly. Working with local business leaders to insure that our political representatives are aware of our interest is another function that Water, Inc. can accomplish for us.

If the feasibility report indicates the benefit to cost ratio is favorable, then Congress may authorize the project. The federal government must also have assurance that the local sponsors and beneficiaries are willing to contract for repayment of reimbursable costs. Once the task is authorized, then funds must be voted for construction to begin. From planning to

completion of construction is a long, drawn-out process. Normally, a 25 to 30 year job. Our concern is that all agencies are aware of the urgency with which we view this project and that they continue to press on with the job.

The strength of Water, Inc. is measured by the number of people it represents. Supplemental water sources for our area can be developed only if we can demonstrate a need and speak with a strong voice in those places where our story needs to be told. We have about 1500 paid-up members now and we are continuing to grow. I think I would be remiss if I did not offer each of you now the opportunity to join our organization.

The Texas Water Development Board projection of west Texas requirements for importation of water for irrigation shows that by the year 2020 the High Plains area will require 15-1/10 million acre-feet annually. The eastern New Mexico area will require 3-1/10 million acre-feet by the year 2020. Thus, we expect a demand in excess of 18 million acre-feet by 2020. The magnitude of this requirement fairly well establishes the fact that we must investigate all possible sources to water and all alternative import routes.

The alternative routes which show the most promise are shown on this chart. The northernmost route is by diversion through the White River up the navigation channel now being constructed on the White and Arkansas to the Kerr Reservoir, then by canal to the Eufaula Reservoir, then by canal along the divide south of the Canadian River to the Texas High Plains. This route will offer maximum benefit to Arkansas and Oklahoma along the route and will reduce the lift required as we take off considerably above the mouth of the river. It is also the shortest route to the High Plains. It will probably be the most difficult route to use as the downstream users will be apprehensive of draining off "their" resources.

The next route is to take off at the start of the Atchafalaya River Floodway, move the water up the Red River to the mouth of the Sulphur River, then up the Sulphur to the Cooper Reservoir, then by canal generally along the divide between the Red River Basin and the adjoining basins on the south. This route will benefit Louisiana and east Texas as navigation on the channel would be feasible and the Fort Worth-Dallas area would benefit by aid to navigation and increased water supply.

Another route is to take water from the Atchafalaya Floodway at a point below where it takes off from the main stem river, then up the Sabine River to Lake Tawakoni, then by canal to join the previous route. Navigation potential and benefit to Louisiana and east Texas is great by using the Sabine, the same benefits to the Fort Worth-Dallas area will accrue as were present in the previous route discussed.

Other routes make use of gravity flow canals across southern Louisiana and Texas to divert flood waters from the Atchafalaya Floodway. The route would then be up the Brazos River or the Colorado River or both. These routes would provide navigation and irrigation benefits to Louisiana and the Gulf Coast area of Texas. It would provide additional water for Houston and the central portion of the state.

The Trinity River is also being considered as a possible import route.

The imported water would be pumped upstream along the various routes through existing or authorized reservoirs or through potential reservoirs and canals which would be constructed. Power plants and pumping stations would be built as required to lift the water about 3500 feet from sea level to the High Plains for storage and distribution. We are thinking of accomplishing this task in phases with the first phase providing about 1½ million acre-feet per year for New Mexico and 5½ million acre-feet for west Texas. This will be increased to a total project requirement of about 18 to 20 million acre-feet yearly by the year 2020.

The final route or combination of routes to be used, is the route which will provide the best benefit to cost ratio in the feasibility studies of the Corps of Engineers and the Bureau of Reclamation. The engineering problems to accomplishing the movement are not nearly as difficult as the "people problems" which must be overcome. We are working on those and are confident that they will be solved in timely fashion.

Once we get the water to the High Plains, what then? Who has responsibility for contracting for the water? Where is it stored for use? What local distribution system will be best? The time of greatest need to the irrigator is in early spring and summer with about 25 percent of his need in August. Economics will demand, however, that the pumping system be designed for practically year-around operations. We must store water near the source or upstream from the intake in order to use the flood run-off and provide enough water for pumping year round. The question of underground storage versus surface storage at the terminal location will have to be answered. We do have a "can do" attitude and are confident we will find acceptable solutions to these perplexing problems.

The state of California is completing a project which gathers water on the Feather River behind Oroville Dam, from where the water is released to flow by gravity to a gathering basin at about sea level just east of San Francisco. From this basin the water is pumped up several hundred feet to the west side of the coast range of mountains. The floor of the San Joaquin Valley rises in elevation toward the South, but the water is moved in that direction by gravity flow in an open canal following the contour of the low mountain range. As the elevation of the valley floor meets the elevation of the canal, another pumping station lifts the water

to another canal at a higher elevation. This process continues for a distance of about 425 miles to the Tehachapi Mountains where, in one lift, the water is pumped 1900 feet to the top of the mountain. The total lift from the basin just east of San Francisco to the top of the Tehachapi Mountains is just about 3165 feet. The distance involved is about 425 miles and the quantity of water is about 4½ million acre-feet each year. These very nearly approach the parameters of our water import scheme. California is in the process of showing us it can be done because they are doing it.

We have heard it said recently that some people oppose taking water from another basin and moving it to Texas. Their statement is that they do not have enough water for their potential needs. I think that these friends misunderstand our intention. We recognize that the people in whose area the water is located have first claim on that water. The water we want is that water which is surplus to their needs and which flows daily into the Gulf of Mexico without further benefit to anyone now or in the forseeable future. We do not wish to divert what is being used. We want the people of the Mississippi Valley to join us in developing this resource for their use and for our use - for the benefit of us both - and for the benefit of the whole nation. We recognize that before any export of water from one basin to another becomes feasible, certain criteria must be satisfied. These include:

1. There must be a surplus of water over the needs in the source basin.

2. There must be a need for this surplus water in another basin which can be filled at a cost which does not exceed the local cost of the water.

3. There must be some advantage to both the exporter and the importer.

4. Operational plans must be agreed on to include amount of water to be withdrawn, when it is to be withdrawn, and numerous other regulatory measures.

I do not wish to leave anyone with the impression that I believe the economy of the High Plains area is going to stagnate because we don't get water here next year or within the next few years. Our economy is too stable for that to happen. The scope of the job we have undertaken is of such magnitude, however, that if we are to reap any benefits within the next quarter century, we must begin to show progress now.

The federal agencies are working under congressional direction "To Determine Physical and Economic Feasibility of Importing Water to West Texas and New Mexico." This means determining among other things, source of water, best

delivery routes, source of power, staging requirements, benefits expected, costs and facility design.

The Texas State Water Development Board is cooperating with federal agencies to the maximum extent possible. We are the local interests - we are the users - we must establish the requirement - we must continue to urge completion as soon as possible.

There are many, many questions which as yet have no answer but which must be answered before this project has a chance of success. Just to mention a few:

What are the practical limits of the area to be served?

What state and federal legislation is going to be required?

What are the cost factors going to be?

What type of project financing and reimbursement will be most advantageous?

What can be done about the 160 acre limitation?

What type of storage is best and where?

What type of local distribution system is necessary?

Some of these questions that must have answers provided by the local interest are those by the state or federal agencies. Our role as the local interest is only limited by our ability to demonstrate a determination of purpose, unity of effort and technical expertise competent to meet the challenge. We must and will get our share of the work done and we need all the assistance we can get. We know that the economic aspects are favorable because the cost of capital improvements and recurring operational costs can be paid by the users and by taxes to be collected from those on the High Plains area who will benefit directly.

We recognize the difficulties and know that time, patience, cooperation and understanding will be required by all of you here, by all the residents of New Mexico, all Texans and all Americans. We want everyone to be aware of our determination to make this plan a reality. It can be and should be and if this area and the affected states are to reach their maximum potential, it must be. Your acceptance of this problem as your problem and acceptance of a share of the responsibility is a major step in our success. It is my hope that you will assist, that you will be cooperative and that each of you will contribute to helping find a way to solve the many problems and move the many roadblocks that will be put in our way.

Thank you for having me on your program.

FOUR CORNERS ECONOMIC DEVELOPMENT, WATER AND PEOPLE

Orren Beaty, Jr.[1]

The prospector who roamed the West in search of valuable metals was a lone wolf. He neither expected nor needed anyone's help in finding the water he required to sustain himself and his burro and to wash the sand and gravel from the gold in his pan.

Neither were the early stockmen of the Southwest concerned about cooperative efforts to develop water supplies. They took the water where they found it and based their cattle or sheep operations on the available sources.

But from the time men began to use the land and water of this region for crop production on a scale more extensive than the family garden, cooperation of a progressively higher level has been demanded. Diversion of water from even a small stream and construction of canals to get the water to the fields must have required the participation of every able-bodied person in the community in earlier days - from prehistoric Indian dwellers of the region through the Indians who were here at the time of European settlement, the Spanish and Mexican periods and, finally, to the coming of the Anglos, Mormon settlers along the Gila and San Juan rivers and their tributaries and those of other faiths along the Rio Grande, Pecos and Canadian.

Earlier, the settlers in a valley tried to do the job they had to do alone. And history of every river basin is spotted with stories of washed-out brush and earthen dams followed inevitably by summer drought and ruined crops. The wonder is that there was not more despair and out-migration.

With the enactment of the Reclamation Act more than 60 years ago, the federal government became a partner in development of the West, and the circle of cooperation expanded. Elephant Butte Dam which brought stability to agriculture in this valley is an early monument to that program. But the planning effort still related only to segments of river basins. There was plenty of land and, if it could be stored and regulated, there was sufficient water for the existent population. The larger look, the regional, full river basin, or national planning for water development and use, could and would come later.

We have now reached that point, and on behalf of the Four Corners Regional Commission and the relatively new concept of regional planning for economic development, it is a privilege for me to be here today to discuss what the Commission can contribute to that development. Further economic growth will be limited by the amount of water available, so the Commission must be every

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[1] Federal Co-Chairman, Four Corners Regional Commission, Department of Interior, Washington, D. C.

bit as concerned about water for New Mexico, to the year 2000 and beyond, as are you and the various federal and state water agencies represented at this conference.

Among other things, we will play a coordinating role - our primary responsibility does not concern water directly. But if in coordinating federal and state programs which affect this region we succeed in proving that regional cooperation of this type can work, I believe we will be providing a vehicle for assisting more sophisticated and successful large-scale water development planning.

Certainly large-scale planning is already being talked about. The speaker who preceded me covered some of these plans, Reclamation Commissioner Floyd Dominy who follows no doubt will discuss others. When parts of the arid Southwest look to the Missouri and Mississippi for increased water supplies other parts look to the Pacific Northwest and Canada, and everyone looks hopefully to desalination and weather modification, we are reaching the highest scale of thinking and planning.

Our hopes are becoming truly continental in scope. I don't have to tell you that this involves political and economic considerations - and complications - equally continental in scope. Solving them is not the problem of a small federal-state agency such as the Four Corners Regional Commission. At the top, it will require the best efforts of national governments. At the state and river basin level, it may well require the assistance - just as did construction of pioneer irrigation works - of every able-bodied citizen.

Your concern is evident, in that this is the thirteenth time that New Mexico State University has made its facilities and services available for such a conference. The response each time and the quality of speakers indicates that the concern is shared by all those in public and private life, in government and in the universities, who are responsible in one way or another for meeting the water needs of tomorrow.

Last year's conference was devoted to water quality, and the problems of pollution remain unsolved despite the intense efforts made so far. Both the United States and Canada seek ways to abate and reduce pollution of the Great Lakes, and a lowering of the water levels there has inspired some of the continental thinking I mentioned earlier. Mexico is as interested as we are in finding new water supplies for this dry region - participation by a water expert from that nation in this conference is most appropriate.

Of course, water problems are not confined to this continent. You may have read recently of a plan by Russian scientists to build a canal up to 1,300 feet wide and 2,000 miles long from the Ob River of Siberia to the Aral Sea

in Kazahkstan to restore the level of the lake, to salvage a diminishing irrigated agriculture, and preserve fish and wildlife values.

The magnitude of the Russians' problems and project may rival our own more ambitious proposals, but they have the advantage of already having full authority over the entire area. No international agreements must be painstakingly worked out. Not only must we work with at least two other nations to develop continental water plans, we must work with a number of different states and river basins, all understandably jealous of their own water rights. West Texas and eastern New Mexico, for example, will not get any water from the Missouri or Mississippi until the people now served by those rivers are satisfied that their interests have an iron-clad protection.

This - and similar situations elsewhere well known to all of us - will serve to emphasize my point that regional cooperation, encouraged by success of such experiments as the Four Corners Regional Commission, must be obtained if New Mexico and the rest of the Southwest are to meet the water needs of the future.

Under the leadership of President Johnson and Secretary of the Interior Stewart L. Udall, many new federal-state programs related to water needs and water development have been instituted. Comprehensive river basin planning under the Water Resources Planning Act is one. The state water institutes which were strongly supported by such western members of congress as Senators Clinton P. Anderson of this state and Carl Hayden of Arizona - part of the Water Resources Research Act - is another. You have heard - or will hear - from all of these, and I trust I have not infringed on their territory. And now, before any of them gets into my area, I'll discuss the organization and hopes of the Four Corners Regional Commission.

There is a trend toward more and more regional efforts for planning and action, and if the hopes of the planners are realized, joint action by federal and state governments and private enterprise will in time produce some remarkable results - but not before the passage of several years. As you well know, the time between conception of a water project, for example, and the first flow of water through new canals can often be measured in decades.

If our long-term planning brings results, a high level of economic activity can replace the present uncertain condition in many of our counties.

The Four Corners Regional Commission is charged with coordinating the planning of our four states for resource development and coordinating the many federal

programs which have an impact on the states and their political subdivisions. Along with this, I believe we can find ways to eliminate duplication and overlap and, I hope, ways to resolve conflicts. At the same time, I think we can serve as innovators and expediters.

Economic development regions, such as the Four Corners, were authorized by Congress to provide assistance to parts of the country which were not fully sharing the nation's prosperity. Appalachia was the prime example. A lower level of income, a higher level of unemployment, loss of population and changes in basic industries or defense establishments which helped cause the other problems were the criteria for designation of such a region.

Those basic industries for this region were mining and agriculture. Changing markets, changing technology, depletion of ore bodies and other factors have adversely affected employment in both industries, but both remain important to the region and must figure prominently in plans for future economic development. The thriving agricultural economy of Dona Ana County is evidence that properly planned, properly operated and adequately watered farms can bring stable prosperity to an area. Unfortunately, most of the other agricultural counties are not faring so well.

The region's widely-varied resource base includes tourist and recreation attractions which are far from being fully exploited. There is an unparalleled assortment of scenic wonders, recreational attractions, Indian reservations and archaeological treasures. But the potential won't be fully realized until there are more improved highways, more usable airports, improved commercial air service, and greatly expanded tourist facilities. Obviously, tourism and transportation are two of the closely related areas in which the Four Corners Regional Commission expects to be working. Agriculture, mining, and industrial development are three others, and all require water.

A moment ago I mentioned some of the criteria for establishing an economic development region. The governors of the states of Arizona, Colorado, New Mexico and Utah met with the Secretary of Commerce in Washington about 15 months ago to attend to the formalities for designating this region because, among other reasons:

> At the time of the 1960 census the unemployment rate for the region was six percent while the national rate was only 5.1.
>
> Only 31 percent of the adults of the region were gainfully employed, compared with 39 percent nationally.
>
> More than 25 percent of the families had an annual income below the $3,000 poverty line, while nationally the figure was only 21 percent.

While the nation's population was rapidly increasing, and while that increase was shared by places like Denver, Albuquerque, Salt Lake City and Phoenix, 83 of the counties in this region either remained about the same or lost people. Actually, about 160,000 persons moved away, but growth in the other nine counties made up for all but 10,595 of this loss.

Let me mention one other problem. Seven percent of the population of the region is Indian, another eighteen percent is Mexican-American. Many of these people have a language problem at the time they start to school. Some overcome it, but others never quite catch up, and have difficulty in competing for jobs. We intend to give some attention to vocational training to help correct this situation until the regular schools can fill this deficiency.

I have listed some of our resources and some of our problems. Now let me discuss our organization. The Region's affairs are handled by a commission made up of the four governors and the federal co-chairman. One of the governors is the state co-chairman - at the moment it is Governor Love of Colorado, but that position will be rotated.

We have a small staff of planners, economists and project specialists, a little money for planning and technical assistance, and great opportunities for constructive action if we do our planning right and if, when we are ready to move, the national budgetary situation is favorable.

At the beginning, we will find ourselves engaged in a lot of studies and surveys. We soon will have an inventory prepared by the Denver Research Institute of existing studies with an appraisal of their value to the Commission. This will enable us to avoid duplicating some studies which already exist, to avoid wasting time examining studies which have no value to us, and to discover the areas where additional current information must be obtained.

Wherever possible we expect to turn to other federal agencies for this information, or to cooperate with them in obtaining it. We must make full use of available manpower and capabilities in the states and in those federal agencies with important programs in the region.

We need this help because the region covers 288,460 square miles - that's a bit larger than the state of Texas and larger than any of the other five economic development regions, including Appalachia, which covers parts of 13 states. We have 91 full counties and part of another; 40 out of 63 counties in Colorado; 21 out of 29 in Utah, nine out of 14 in Arizona, and 21 full counties, part of another, out of New Mexico's 32. We have about eight percent of the land area of the nation, but less than one percent of the population.

What we are involved in is an experiment with a relatively new form of government - the limited regional government. It is neither a federal agency nor a state agency, but is federal-state. There is a full federal-state collaboration in as near an equal partnership as congress has been able to devise. And we have to think about the region, not about the individual states. A man elected governor of one state will find himself making decisions which affect the other three. Each governor will have to be officially concerned with some of the problems of his neighboring states - and, by so doing, he may find solutions to long-standing problems in his own state.

Our job - to put it briefly - is to inventory the resources of the region, analyze its problems, establish economic goals, and come up with a plan for achieving these goals. With federal and state governments working together with localities and private enterprise, we expect, through what President Johnson calls "creative federalism" to achieve improved economic development throughout the region.

As I noted earlier, if we succeed, I believe this will also show the way to cooperative, regional efforts to get the water on which future growth of New Mexico and the rest of the Pacific Southwest must be based.

WATER SUPPLIES FOR THE SOUTHWEST - WHAT OF THE FUTURE

Floyd E. Dominy[1/]

The subject of my discussion here this morning is "Water Supplies for the Southwest - What of the Future." This question is central to the theme of your conference. It is also one of the major resource questions confronting the nation today.

The problem of providing water supplies for an expanding national economy and an exploding national population extends to all regions of the country. The specific technical problems, policy issues, and projected times of crisis vary. In the East, pollution of what is still an overall abundant quantity of natural water places the technical emphasis on pollution abatement and control. At the same time, however, the potentials of drought shortages are serious enough that many localities are investigating costly desalting technology to avoid possible shortage conditions.

In the West specific problems also vary. In many areas intra-regional redistribution of available natural water supplies by means of major storage and conveyance systems will have primary emphasis for many years to come. This is true, for example, in California.

The Southwest, reaching all the way from Texas to the Pacific Coast, is unique among the regions of the nation in that it is the only major geographic region which now is approaching full development of existing surface and groundwater resources. In many localities within the region, which depend to a large measure on groundwater, these resources are already overtaxed. Along the Colorado River, a situation of general shortage is anticipated to occur about 1990, or before.

Water resource planners in the Southwest, therefore, find themselves at the forefront of the effort to exploit more ambitious and unconventional means for augmenting the essentially limited natural water supplies of the region. Augmentation, as you are aware, has been one of the major considerations of the long deliberations over the Central Arizona Project which are currently in progress. A number of the foremost authorities in water resource planning have turned their attention to the problem of augmenting the Colorado River in the course of these deliberations.

Aside from the limited opportunities to conserve the available supplies within the region through water salvage measures, three major alternatives remain as potential sources of new supplies. They are a major interregional

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1/ Commissioner of Reclamation, United States Bureau of Reclamation, Washington, D. C.

importation of surface water from areas of surplus, desalting of sea water and brackish groundwater and augmentation of natural runoff by means of weather modification. It will be worthwhile to review briefly the Bureau's experience in studying each of these alternatives in relation to the Colorado River. I believe that they represent the major new sources of water in the foreseeable future, not only for the Colorado River Basin, but for any water-short region of the country, including the upper Rio Grande.

The controversy concerning importation of water into the Colorado River Basin is perhaps illustrative of the major problem of any long-range transfer of water. The success of any such proposal must rest primarily upon positive assurances to the area of origin that the water to be taken is truly surplus to the future needs of that locality. The most comprehensive knowledge possible of available supplies and requirements, both present and projected, must be obtained before exportation can be seriously considered.

There appear to be no absolute physical barriers to even the most ambitious transfers of water which have been suggested for the North American continent. Modern engineering skill is adequate to construct the required works. Aside from the political-social questions raised, the most significant consideration will be that of economics.

It is obvious that major interbasin transfers of water will be costly. A sizable component of the cost will be the cost of power to pump the water. This cost, at least, will be heavily dependent upon the technological advances made in power generation. Both of these factors, availability of water for import and the cost of pumping power, will weigh heavily in our study of the potential import to Texas and New Mexico.

We are well into our second year of reconnaissance study on a proposal to augment the water supplies of the High Plains of west Texas and eastern New Mexico. Other papers on your program discuss many aspects of this program in considerable detail, so I will not dwell on it to any great length. It would be appropriate, however, to emphasize again two basic points which have great relevance to this study, indeed to any scheme involving the movement of water among political jurisdictions.

First, major transbasin and interstate water movement programs should not be undertaken until local resources have been developed fully and efficiently. No state or river basin has a right to seek the property of another until it has exhausted its own capabilities. Simple economics will usually dictate adherence to this rule.

Secondly, interregional movement of water should not be contemplated to a degree that the basin of origin would be deprived of water which it could

reasonably and rationally expect to need as a basis for its own economic growth.

There is no question that the first of these points applies to eastern New Mexico. That area has substantially utilized its water supply and is up against an immediate crisis. The west Texas area is not far behind. The Canadian River Project which is now essentially complete will help but is not the total answer. We know that there does not exist within the states of Texas and New Mexico sufficient surplus water to underwrite the High Plains economy.

Our cooperative study of augmentation for west Texas and eastern New Mexico has its most critical aspect, the determination of what can be said to be truly surplus to the lower Mississippi River, both in terms of times and places.

The second major source of augmentation of regional water supplies is desalting of sea water or brackish inland waters. As I have mentioned, this source of water is now being considered on a major scale by metropolitan areas on both coasts. Dr. Ralph Stucky of New Mexico State University is negotiating with the Office of Saline Water on studies proposed by the University of the potential of desalting the brackish water reserves of this state. Office of Saline Water is also establishing a brackish water test station at Roswell.

The Bureau of Reclamation, at the direction of the congress, recently completed a reconnaissance report which appraises the potential for augmenting the Colorado River by desalting of sea water. The basic plan which was evaluated consisted of dual-purpose nuclear desalting and thermal-electric plants located on the coast of southern California and a conveyance system from the desalting complex to the Colorado with delivery points reaching as far upstream as Lake Mead. These works would be constructed in stages with deliveries initiated in 1990 and reaching two million acre-feet annually by 2010. Plans were also analyzed, but in less detail, for locating the desalting plant on the Gulf of California and for alternative routes and discharge points for the conveyance system.

The basic cost estimates of the dual-purpose nuclear desalting and powerplants were developed by the Atomic Energy Commission and Office of Saline Water. Because the augmentation will not be required until 1990, these data reflect technology projected for the period 1990-1995. Fast breeder nuclear reactors were assumed to be available.

It was assumed that the federal government would obtain only desalted water and project pumping power from the dual-purpose nuclear desalting plants and

that nonfederal entities would participate to the extent of financing and marketing the commercial power component.

The nonfederal entities would construct and own the electric turbine-generator plant. The United States, through prepayment of an appropriate share of the capital costs, would obtain the rights to the electrical capacity and energy necessary for project purposes. Through such an arrangement, the United States would retain the benefits of federal financing for the prepaid portion of the electrical plant.

Because of the somewhat unique financial assumptions involving provisions of pending legislation for a Colorado River Basin Development Fund, the financial repayment scheme assumed in our studies is not generally applicable elsewhere. The unit costs for product water and pumping power, however, reflect only the technological projections coupled with the provisions of conventional Reclamation financing. These costs are particularly interesting.

The estimated average cost of producing water for the three stages at the desalting plant boundary, before conveyance costs and transportation losses en route, amounts to about 32 dollars per acre-foot or 9.8 cents per 1,000 gallons. The related cost of generation and transmission of project pumping power was assumed to be 1.5 mills per kilowatt hour.

The estimated total economic cost for water delivered to Lake Mead averages 81 dollars per acre-foot or 25 cents per 1,000 gallons.

We believe there are significant opportunities for reducing the cost of the conveyance facilities by going to the Gulf of California as a source of sea water. Should such opportunities be realized, conveyance costs could be reduced as much as 20 dollars per acre-foot. Of course, conveyance costs of a larger capacity aqueduct, such as that envisioned for New Mexico, would show lower unit costs for water because of economies of scale.

During the recent hearings before the House of Representatives Committee on Interior and Insular Affairs, some skepticism was expressed concerning the technological projections utilized in the studies.

I believe it to be appropriate to base the study upon the level of nuclear and desalting technology which is expected, in the judgment of technical experts in these respective fields, to exist in the 1990 to 1995 period when initial construction of the facilities would take place. I do not share the skepticism concerning the anticipated advancement.

We are talking about conditions which will occur 25 years in the future. Such discussion must involve considerable speculation. However, some interesting perspective may be gained by reflecting on the past.

Twenty-five years ago, for example, there were no electronic computers. As recently as the early 1950's, there were only about 10 electronic computers in existence in highly specialized scientific uses. Their dependability was low and their cost high; 100,000 average computations cost 25 dollars. Widespread application seemed distant. Today, there are tens of thousands of computers in use; many in mundane business applications. A similar 100,000 average computations cost less than ¼ of a cent.

Similar illustrations are possible in the air transport field and, of course, most dramatically in space technology. In 1946, it was newsworthy that a radar beam had reached the moon. Today we accept the fact that manned space vehicles will reach it within a few years.

But to be more specific, in December of 1942, almost exactly 25 years ago, the first controlled nuclear chain reaction took place under laboratory conditions at the University of Chicago. The subsequent technological progress on the peaceful use of nuclear energy has surely been beyond the expectations of even the informed participants in early research. In the late 50's and early 60's nuclear reactors were demonstrating the practicability of electric generation but, with production costs of 10 mills per kilowatt hour and higher, they had not reached the level of economic acceptability.

These earlier reactors did provide the basis for future application as demonstrated by the fact that approximately ½ of the new thermal generating capacity ordered by the American utility industry during 1966 and 1967 was for nuclear plants. Expected costs by the industry are reported to be in the range of 4 to 5 mills per kilowatt hour in the 800 to 1,000 megawatt size. Recent economic studies by the Tennessee Valley Authority estimate the cost of power at less than 2.5 mills.

Only in recent years has desalting of sea water come to be considered an important source of supply except in the most extreme need. Just 14 years ago only a few small plants were in existence and the cost of fresh water produced was in the order of 4 dollars per 1,000 gallons. Present day costs of operating plants in the million-gallon per day size show a reduction in costs to 90 cents per 1,000 gallons.

Estimates for the 150-million gallon per day desalting plant now being designed and to be constructed by the Metropolitan Water District, with participation by other utilities, indicate water product costs of 22 cents per thousand gallons. This will be the first nuclear dual-purpose water and power installation.

In this rapidly developing field which has shown a reduction in desalting water costs in 15 years from 4 dollars per 1,000 gallons to 22 cents per 1,000 gallons, I do not believe it is unreasonable to assume that technology will

continue to advance to the point where 9.8 cents per 1,000 gallons will be within reach.

It is true that costs for nuclear plants are currently exceeding estimates, but this is characteristic of a seller's market. Commercial nuclear energy demands are outstripping the capabilities of a new industry to keep pace. The economies of standardization and production capacity are certain to be realized in nuclear desalting applications within another quarter of a century.

I am speaking, of course, as an interested layman, and from a pragmatic point of view. I do not consider myself qualified to evaluate the fine points of nuclear and desalting technological projections, and I rely, with confidence, upon the experts of the Atomic Energy Commission and Office of Saline Water to do so.

I would also like to comment upon the third major augmentation potential, that of weather modification. Advancement in our technical knowledge in this field indicates that we are approaching the time when we will have developed a reliable capability to increase precipitation in the mountainous regions of the western United States through the application of weather modification techniques. From the beginning of the Bureau of Reclamation's research program in weather modification, we have realized that the Colorado River Basin incorporated the combination of an imminent need for augmentation and characteristics which promise early success in weather modification efforts. As a result, we have placed considerable emphasis upon our program for that basin.

Methods which are currently being developed, such as seeding susceptible winter storm at high elevations to increase winter snowpack, will be particularly effective in the upper Colorado River Basin. The highly developed storage reservoir system will permit capture and beneficial use of nearly all of the resulting increase in spring runoff.

We now believe that within ten years, a firm capability to augment the upper basin streamflow by nearly 2 million acre-feet annually could be developed. This would be, if our expectations are realized, the first instances of effective weather modification programs on a region-wide basis, and would provide extremely useful data for the development of programs in other areas.

Our practical research also extends to cumulus cloud seeding which will be of particular value in the high plains area. Results of this research are most promising. The fact that no one has done anything about the weather except talk about it in the past does not mean that we can do nothing about it in the future. I am very optimistic about affirmative results over the next decade or two.

I hope that this brief resume of some of the potentials for augmenting water supplies in the drier regions of the nation will help you to share my enthusiasm. I remain confident that we can develop the means to support the expansion of the economy and the population of the Southwest and the nation.

Panel - One

on

Water for New Mexico for the Next One Hundred Years

The first of two panels on the subject "Water for the Next Hundred Years," considered current developments together with plans and projections for future developments.

Those participating were: (left to right)

C. E. Jacob, Panel Chairman
Hydrologist, New Mexico Institute of Mining and Technology
S. E. Reynolds,
State Engineer
Arthur Ortiz,
Director, State Planning Office
Leon Hill,
Director, Region 5 Office, Bureau of Reclamation,
Amarillo, Texas
Ralph Edgel,
Professor of Economics, Bureau of Business Research,
University of New Mexico

PROJECTIONS OF THE POPULATION OF NEW MEXICO TO THE YEAR 2070

Ralph Edgel[1]/

When I received the invitation to speak at the Thirteenth Annual New Mexico Water Conference, I didn't know whether to feel flattered, flabbergasted, or simply foolish. I am flattered to be asked to participate in a forum which, over the years, has presented so many prestigious speakers. But I must say that I can't help but feel a bit foolish at the prospect of an undertaking that may seem to imply that I have any idea of what the population of New Mexico may be a century from now. I think that the general impression of anyone who would attempt to project the number of people who might live in a given location a hundred years hence is that he must be a fool.

Yet, given man's penchant for controlling - or attempting to control - his environment and planning for the future, projecting and projections are likely to be with us for some time. So we might as well reconcile ourselves to living with this questionable kind of activity and set about learning how to make and use projections with some degree of effectiveness.

Projections of population, sales, production, and other such phenomena are usually based upon some rationale of relationships where there is a known or assumed relationship between the item being projected and the other phenomena about which we have some notion of their course of development. Moreover, it is assumed that the identified relationships will remain constant or that, if they change, they will do so in some explicit manner. So we generally start the projecting process by identifying the relationships which we believe will be the critical ones for the period of the projections and proceed to specify the nature of the relationships and the course of development of the phenomena to which the projections are to be related.

If the projections are to be made for a relatively short span of years, we may have some chance of correctly identifying the critical relationships and anticipating the course of development of the phenomena upon which our projections will be based. Even for short periods, however, the path of the projector is fraught with peril. But when we extend our planning horizon to a full century, our chances of identifying these relationships or of charting the development of the related phenomena are pretty poor. Thus, we might well conclude that any attempt to project the size of New Mexico's population for the next 100 years is an exercise in futility. I will have more to say about that later.

What are the factors that determine the size of the population of a small or sub-national area? To what is the size of the population related? We can hardly claim to know the answers to these questions with respect

1/ Ralph Edgel, Business Analyst, Bureau of Business Research, University of New Mexico, Albuquerque, New Mexico.

to the present size of the population even though we can pontificate for hours about such things as the nature and extent of the area's resources, the number of jobs available (based upon rational exploitation of the resources), the labor force participation rate, the productivity of labor, standards of living, birth and death rates, population mobility and migration rates and so on. There are other factors or relationships that we may suspect has determining influences upon the size of an area's population, but I doubt that it is fruitful to pursue this train of thought, because, when the projection horizon extends to 100 years hence, the nature of such relationships turn out to be imponderables.

Yet, we like to think that population bears some relationship to an area's resources. Except in the broadest sense, today's resources may not be - and probably won't be - tomorrow's resources. In view of the rapidity of technological development, it is almost certain that the ways in which we use resources today will not be the same as those that will be employed 25 years hence, let alone a century from now. Undoubtedly new uses will be discovered for materials which are not now considered to be resources, and some of the materials which we now regard as resources will be exhausted.

When we stop to consider the relationship between man and resources and the pressure upon some of our resources which he presently exerts, the question might well be, "How many people <u>can</u> live in New Mexico a century from now?" rather than "How many <u>will</u> live here?" For there is little question but that some of our resources <u>as we now know them</u> will have been exhausted and others, such as water, will exercise serious constraints upon the size of the population unless our methods of utilization are drastically modified.

Changes in the ways in which we utilize resources imply changes in the relationship of man to his resources, particularly with respect to the number of jobs that a given level of resources utilization can provide, the relationship between employment and population that might result from changing labor productivity, and changes in the customary number of hours of work that will be required to support a laborer and his family - assuming that the family as we know it still exists. Indeed, it is conceivable that a century hence the economic organization of society which gives significance to the relationship of workers to total population and of worker productivity to levels of living will no longer exist. Maybe at that time each unit of humanity will simply be hooked up by tubes to some common reservoir of sustenance so that such concepts as working for a living, levels of living, and place of residence will cease to have meaning.

Turning to projections based upon birth and death rates, and migration rates, we are equally at loss to hit upon some relationships the continuity

of which we can rely upon. If one projects the United States' population for 100 years based upon the present rates of reproduction reduced in some logical progression he arrives at a figure that, when related to what we now know of our resources, boggles the imagination. Will the population continue to increase despite the restraints imposed by limited resources, or are our resources really limited only by our ingenuity which will rise to the occasion and make new resources available as we need them?

Will place of residence continue to be related even loosely to the location and utilization of resources or will developments in transportation and in production techniques make it possible for people to reside where ever they want to without reference to jobs or to access to goods and services? In that event, we hardly need concern ourselves with whether people live in New Mexico, Indiana, or at the North Pole.

Such speculations are fascinating, but they provide us with no solid points of reference when faced with the task of setting down actual numbers opposite the names of counties and under the captions "2020," "2030," on out to "2070." As a preface to its own projections of the United States economy to the year 2000, Resources for the Future has said that, "To predict what will happen in the next forty years is a feat beyond the powers of social science." A fitting preface to my attempt to project population and employment for the next century might be that, "There is only one thing about which I am certain and that is that the figures will be wrong."

"In that case," you might very well ask, "what is the point of making the projections? Aren't they useless?"

Strange as it may seem, I think that there is a real point to making such projections. In the first place, they force us to give attention to the magnitude of the problems that we, or our successor, may face in the future. In the second place, they force us to consider the nature of the variables that may determine the size of the population years hence and the ways in which their influences might change. And even though we can't know the ways in which these identifiable influences will change and the nature of other influence which might become operative, we create an atmosphere of testing ideas. The development of assumptions and the actual figures which arise out of them provide a kind of benchmark against which we may appraise actual developments as they occur and discover explanations for the departure of reality from the assumed conditions upon which the projections are based.

The Methods Employed

In making the population projections for New Mexico and its counties, we took the position that the state is necessarily an integral part of the United States and its economy. What happens in New Mexico, therefore, depends in large part upon developments in the United States and how New Mexico participates in those developments. In other words, New Mexico must necessarily play some role in the development of the nation. The job of projecting its population, therefore, consists of determining, or assuming, what that role will be and what are its implications with respect to population.

In making the projections to the year 2000, which we did three years ago and which some of you have seen, we attempted to define New Mexico's role in the United States' economy by determining to what extent it had participated historically in the nation's production and apply this role, with what we thought were appropriate modifications for changing resource conditions, to the United States' needs to the year 2000 as projected by Resources for the Future in their publication Resources in America's Future, by Lansberg, Fischman, and Fisher. The great detail in which their projections were made provided excellent guidelines for estimating what production might be expected of New Mexico and estimating the employment that would be required, or generated, in this state. From there it was relatively easy to move to estimates of labor force and population, and to assign them to the several counties on the basis of the existing location of various activities and our appraisal of what their resources might be for the next thirty years.

In moving beyond the year 2000, as was required by the present study, we had no such guidelines to follow. No one, so far as we could discover in the time alloted for this project, has had the temerity to look much beyond 2000 and to set down for all the world to see actual figures describing the size or character of the population or its economic activities. The Bureau of the Census has made some projections of the gross number of inhabitants of the United States to the year 2015, but even they won't venture fifty years beyond 1970, let alone a full century.

Projections of United States Population

Casting about frantically for some guideline to which we might attach the projections required of us, we finally decided that the most reasonable course of action would be to develop some projections of United States population and relate New Mexico's population to those. To do this, we simply extended the projections made by the Bureau of the Census by examining their assumed rates of fertility to the year 2015 and extending them with

appropriate reductions to the year 2070. This was done for both their high (Series A) projections and their low (Series D) projections. From these two projections we derived a median set of projections as midway between the high and the low.

In moving from our national projections to state projections we adopted the basic assumption that New Mexico will play an increasingly important role in the United States economy if for no other reason than that, given a United States population of the size that our projections indicated (a median of 806,600,000 with a high of 1,133,800,000), New Mexico would simply have to absorb a greater proportion of the total than it now accommodates. But in order to arrive at real figures, we had to set some limits on this proportion.

Lower Limit

In order to establish a lower limit, our rationale was as follows.

1. In view of the large size of the projected national population, it is reasonable to expect continued migration to New Mexico, and New Mexico's population will increase by more than its increase by natural means (births over deaths).

2. In view of the fact that New Mexico's natural increase has always been substantially larger than for the country as a whole, it is reasonable to assume that its natural increase in the future will be at least as great as that for the United States. We will assume that the rate of natural increase for New Mexico will be the same as that implied for the median projection for the United States.

3. Our minimum projection for New Mexico will, therefore, be established by:

    a. natural increase at the median rate for the nation and

    b. migration at a rate just sufficient to maintain the state's population at 0.86 percent of the United States median projection. This is the percentage given by our previous median projection to the year 2000.

Following through on these assumptions, gave us the low projection you find on the tables which have been distributed to you - 6,275,000 in the year 2070.

Upper Limit

In order to establish the upper limit, our rationale was:

1. New Mexico's rate of natural increase will continue to be higher than that of the United States, but it will decrease gradually until it reaches the rate implied by the high projection for the United States. That would mean a reduction from 1960's rate of 24.6 per thousand to 14.2 per thousand in the 2060 decade.

2 Because of the pressure of increasing national population density, migration to New Mexico will be such as to give the state an increasing proportion of the nation's population. That proportion will increase by gradual steps from the .529 percent in 1960 to the .865 percent of the United States high in 2000 implied by our previous projections to that year, to 2.00 percent of the United States high in the year 2070.

Median Projection

Our median projection, from which we derived the population of the counties, was derived by simply taking the midpoint (modified slightly in a few instances) between the high and low projections. The figures appear on the tables that have been distributed.

Projections for the counties

Having established the projected population for the state and the increases from decade to decade, we had to develop a procedure for allocating population to the counties. First, we assumed that on the average 95 percent of the increase in population during each decade would occur in urban areas of the state as they are now defined. Because the project was intended to provide population figures for the respective drainage basins of the state, we selected for consideration the principal urban areas of each basin and what we thought might become urban complexes, defined as those areas where the urban sprawl of two or more cities might well merge at sometime in the future. Having determined what the rate of increase would be for all urban areas, we then proceded to allocate this increase among the several drainage basins by assuming a particular rate of increase for each selected urban place and urban complex. These rates of increase were made entirely intuitively after considerable speculation concerning what we thought might be the logical course of development in the several areas considered. We then assumed that these rates of increase would apply to the counties which embraced the selected urban complexes, and we allocated population of each basin among the counties comprising it, again upon an intuitive basis.

In making the allocations to the basins, our rationale very briefly was about as follows.

The Rio Grande Basin has been the locus of most of the state's growth in the past and has accounted for an increasing share of the state's population. This trend will continue through the early part of the next century, after which growth will spread increasingly to other areas, and the Rio Grande Basin will account for a decreasing proportion of the total population.

The south High Plains and the Pecos Basin offer the greatest potentials for growth after about 2000 or 2010, and their rate of growth accelerates to 2070.

Although the population of the Arkansas Basin will grow, it will constitute a stable to declining proportion of the state total.

The central Closed Basin (Estancia to Alamogordo) will maintain about the same proportion of the state's population through 2000, after which it will gain to about 2050. Thereafter, the more rapid growth of other parts of the state will reduce its percentage of the total.

The urban centers of the San Juan Basin, centering on Farmington, will grow less rapidly than the state - and have a decreasing percentage of the population - through 2000, after which the area will gain an increasing share of the state's population.

The only urban center in the lower Colorado Basin (Gallup area) will decline as a percentage of the state through 2010 or 2020, after which it will gain an increasing share of the total population.

The urban centers of the southwestern Closed Basin (Deming, Lordsburg, and Silver City) will generally grow less rapidly than the state until about midcentury, after which their share of the state's population will stablize.

I have attempted to give you the highlights of our rationale and procedures. As you may well imagine, there are many details that I haven't mentioned and much agonizing soul-searching and a lot of number-juggling that accompanied the actual working out of the figures. The results you have in your hands, and you can draw your own conclusions concerning the appropriateness or validity of the figures. I think that I would like to say again that we have no illusions (or perhaps I should say delusions) about their accuracy so far as indicating what the actual course of events <u>will be</u> in New Mexico. On the other hand we hope that they will be useful in indicating what the future <u>may</u> hold with respect to the demands upon our resources - whatever those resources may be.

Projections of New Mexico's Population
to the Year 2070
(in thousands)

	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060	2070
Bernalillo	262.2	375.4	531.5	712.8	948.0	1,223.9	1,546.6	1,921.3	2,359.7	2,827.0	3,316.5	3,795.1
Catron	2.8	3.0	4.2	5.9	9.3	11.0	11.9	13.7	16.5	19.3	22.7	26.6
Chaves	57.6	73.3	92.4	114.8	151.4	194.0	253.1	342.8	481.8	646.1	828.0	1,003.6
Colfax	13.8	15.5	18.0	21.5	26.4	32.2	39.2	50.7	68.4	91.3	120.5	157.2
Curry	32.7	45.7	68.1	90.6	123.7	162.4	215.6	282.9	365.1	457.9	561.8	671.0
De Baca	3.0	3.1	4.6	6.3	10.1	11.9	12.9	14.8	17.9	21.0	24.6	28.8
Dona Ana	59.9	95.7	136.3	168.6	224.0	306.9	425.0	569.5	740.0	932.4	1,137.5	1,330.0
Eddy	50.8	55.1	66.5	80.6	104.2	133.4	171.9	229.2	318.2	407.9	505.3	596.2
Grant	18.7	21.2	28.6	34.9	44.8	57.5	73.1	91.9	113.8	141.3	175.6	218.3
Guadalupe	5.6	7.5	8.0	11.6	16.0	19.0	21.8	26.0	32.4	44.1	63.1	93.2
Harding	1.9	2.2	3.8	5.3	8.1	9.6	10.4	12.0	14.5	17.0	19.9	23.3
Hidalgo	5.0	7.3	7.9	8.8	11.8	15.3	19.8	25.5	32.5	41.4	52.6	66.7
Lea	53.4	65.7	84.6	105.0	140.3	184.2	245.4	332.5	460.0	612.2	795.2	1,000.0
Lincoln	7.7	10.2	13.9	18.5	23.9	28.2	30.5	35.2	42.5	49.8	58.4	68.5
Los Alamos	13.0	23.7	34.7	42.8	56.3	73.9	90.3	120.0	159.8	201.4	243.8	276.8
Luna	9.8	13.5	17.4	22.7	30.6	39.7	51.1	65.5	83.7	107.1	136.9	175.0
McKinley	37.2	41.4	58.7	70.8	88.2	111.2	145.0	188.5	250.0	342.5	486.3	710.0
Mora	6.0	4.7	5.3	6.6	10.2	12.1	13.1	15.1	18.2	21.3	25.0	29.2
Otero	37.0	44.5	60.8	77.5	102.6	138.5	194.0	265.8	350.0	444.5	542.3	630.0
Quay	12.3	15.4	16.2	19.7	26.5	31.2	35.5	41.7	49.3	57.7	66.6	77.8
Rio Arriba	24.2	22.2	26.6	36.7	43.6	57.0	70.5	90.1	119.4	150.0	180.8	204.8
Roosevelt	16.2	20.4	26.2	31.1	38.7	56.8	77.4	106.2	144.9	195.1	256.2	329.0
Sandoval	14.2	14.8	18.6	24.3	26.5	36.2	51.0	72.8	103.4	142.2	187.0	234.2
San Juan	53.3	53.3	66.2	82.6	100.5	128.6	175.0	234.5	310.0	399.9	503.9	620.0
San Miguel	23.5	25.4	30.1	36.7	49.0	59.0	69.2	84.0	107.6	148.9	216.7	326.8
Santa Fe	45.0	58.5	82.2	122.2	178.5	233.7	287.2	366.5	480.8	598.6	715.4	808.4
Sierra	6.4	7.9	9.9	12.5	18.0	21.1	24.7	29.9	36.5	48.8	71.2	109.4
Socorro	10.2	10.6	12.7	15.7	21.2	24.8	29.4	25.5	43.2	58.3	84.5	131.0
Taos	15.9	18.6	24.8	31.8	37.9	44.5	52.9	64.2	80.3	108.9	157.6	239.6
Torrance	6.5	6.0	6.5	8.0	10.4	12.2	13.2	15.2	18.4	21.6	25.3	29.7
Union	6.1	7.3	7.2	8.2	10.8	12.9	15.3	18.3	22.3	27.9	35.4	45.0
Valencia	39.1	38.9	57.5	75.9	86.5	114.0	147.4	187.1	236.9	292.5	355.2	420.7
STATE	951.0	1,208.0	1,630.0	2,111.0	2,778.0	3,596.9	4,621.4	5,948.9	7,678.0	9,675.9	11,971.8	14,475.9

Projections of Population to 2070
United States and New Mexico
(figures in 000s except percentage)

			Median**			
				Natural Increase		Migration
United States	High	Low	Number	Number	Percent	Number
1960*	180,684	180,684	180,684	22,085	12.22	4,000
1970*	208,615	204,923	206,769	28,308	13.69	4,000
1980*	250,489	227,665	239,077	34,972	14.62	4,000
1990*	300,131	255,967	278,049	39,984	14.38	4,000
2000*	361,424	282,642	322,033	47,723	14.82	4,000
2010*	437,851	309,661	373,756	53,859	14.41	4,000
2020	525,261	337,969	431,615	59,872	13.87	4,000
2030	624,333	366,641	495,487	65,910	13.30	4,000
2040	735,406	395,389	565,397	71,466	12.64	4,000
2050	858,021	423,705	640,863	75,720	11.82	4,000
2060	989,354	451,813	720,583	81,993	11.38	4,000
2070	1,133,842	479,307	806,576	---	--	

New Mexico								% of US
							Percent	Median
1960	955	955	955	236	24.71	17	1.8	.529
1970	1,326	1,114	1,208#	262	21.67	160	13.2	.584
1980	1,780	1,498	1,630#	342	20.97	139	8.5	.682
1990	2,345	1,919	2,111#	434	20.55	233	11.0	.759
2000	3,128	2,507	2,778#	568	20.43	144	6.4	.863
2010	4,072	2,908	3,490	650	18.63	481	13.8	.934
2020	5,883	3,359	4,621	822	17.79	574	12.4	1.071
2030	8,179	3,855	6,017	968	16.08	693	11.5	1.214
2040	10,958	4,399	7,678	1,168	15.21	811	10.6	1.358
2050	14,329	4,986	9,657	1,304	13.50	944	9.8	1.507
2060	18,204	5,606	11,905	1,523	12.79	1,048	8.8	1.652
2070	22,677	6,275	14,476	---	--	---	--	1.795

* US Bureau of the Census, Population Estimates, Series P-25 No. 359 2/20/67
** Median figures, including natural increase, derived from Census high and low
\# As shown by earlier projections to year 2000

COMPREHENSIVE STATE PLANNING AS A FRAMEWORK FOR WATER RESOURCE DEVELOPMENT

Arthur Ortiz[1/]

State planning in New Mexico has a relatively long history as an activity of state government. A State Planning Board was originally created by the legislature in 1935. It existed in one form or another until 1949, when it was replaced by an Economic Development Commission in which state planning as a meaningful process was absent. The third major legislative action in this field occurred in 1959 when the Economic Development Commission was incorporated into a newly created Department of Development, along with the Tourist Bureau and New Mexico Magazine. At the same time the State Planning Office was created as a staff agency to the governor.

For the past eight years the State Planning Office has retained the functions that it was given in 1959, except for certain changes enacted in 1961. Among other powers and duties, the Planning Office in 1959 was directed to "provide for comprehensive studies of the water resources of the state" and to "work toward the preparation of a comprehensive statewide water resource development plan relating water resource development potential and needs to population, industry, agricultural and recreational growth and development, and indicating benefits to be derived from such water development. ..." (1)

Within two years, however, the legislature decided to broaden the mandate of the Planning Office, and directed it to "work toward the preparation of comprehensive statewide resource development plans relating development potential and the needs of various resources to population, industry, agricultural and recreational growth and development, and indicating benefits to be derived from water development ... ." This fit in with the legislature's basic mandate to the Planning Office, which was given the assignment of planning "for the long range comprehensive balanced development of the state's natural, economic and human resources and public facilities." (2) By broadening areas of responsibility, the legislature acted "to correct an inbalance in the 1959 Act because of the concentration on water resources compared with other natural resources." (3)

In order to accomplish this task, a major function of the Planning Office since 1962 has been the development of a Statewide Resources Development Plan. Its first phase was conceived as an inventory of the various resources of the state and resulted in the publication of some 40 studies. These were prepared by state agencies, private consultants, and various economic experts under

1/ State Planning Officer, State Planning Office, Santa Fe, New Mexico.

the Office's supervision. Many topics of resource availability, development, and related problems were analyzed, including state water resources, water law, and agricultural land and water.

These studies have provided the framework for the current second phase of the state's Development Plan, of which three aspects are relevant to the subject of this conference. They involve new techniques for New Mexico, which, hopefully, will enable the state to anticipate more accurately and react more effectively to the multitude of problems and opportunities which are developing today and which will emerge in the future.

A major effort is the formulation of a Statement of Goals and Objectives to serve as the governor's policy statement guiding the state's overall comprehensive development. Every state should have some clear idea of what it wishes for the future and how this best should be achieved. Otherwise, it will be forced to react to events as they occur rather than be able to anticipate developments. For example, because of inadequate recognition of social and economic trends, many of the nation's largest cities are facing serious crises which are almost impossible to overcome. Effective planning might well have been able to modify or prevent many of the problems that they now face.

Similarly, in New Mexico, the rapid growth of Albuquerque has created many difficulties both within the city and also in adjacent areas. The city's internal problems include its limited economic base, some air pollution, and its declining central business district. Most of these areas of concern were perceived, but solutions have proven difficult to achieve. Although these subjects are primarily relevant to the city itself, other questions involving the region and even the state have arisen from Albuquerque's growing importance. For example, effective planning may help preserve the quality of many recreational areas in Sandoval and Torrance counties which are being utilized more intensively as Albuquerque's population increases. Similarly, such communities as Placitas, Corrales, Belen and Los Lunas are closely intertwined with Albuquerque. If their development is to be maximized qualitatively as well as economically, meaningful regional and state planning may well be required.

In comparison with many other states, New Mexico's problems seem less intractable. The rapid economic development of Colorado and Arizona provides a glimpse of what the future of New Mexico may be. For example, New Mexico's neighbors have experienced growing concentration of population within a single metropolitan area. Thus, the Denver standard metropolitan statistical area in 1965 had 55 percent of Colorado's population. Similarly, Phoenix's proportion of Arizona's total was 52 percent and Salt Lake City's was 53 percent of Utah's total. In comparison, the Albuquerque SMSA had 29 percent of New Mexico's total population in 1965. Thus one may reasonably expect that

Albuquerque's population growth will be more rapid than that of the state as a whole. This concentration of people within a limited area has meant the rural areas have lost both residents and economic influence. In addition, metropolitan area problems have become more apparent, and effective remedies more difficult.

New Mexico's effectiveness in shaping its future as it wishes will naturally depend on wise use of the powers which state government can reasonably command. For the state as a whole, and particularly for state government, it is necessary to formulate clearly articulated targets and appropriate programs for their implementation. For the state as a whole, this is the essence of policy planning.

The Planning Office is proceeding on the assumption that New Mexicans are concerned with moving ahead in each of four broad areas: economic development, personal and cultural development, natural resources development and conservation, and state and local governmental efficiency and effectiveness of operation. Thus, the crucial problems, needs and opportunities in each of these four areas of state governmental concern must be identified and state policy set forth with clarity. Only then will the various state agencies be able to work in concert with one another towards common goals.

At the first level these goals are relatively broad and general. However, they must contain enough substance to provide guidance to resolve many policy issues facing New Mexico. This should be based primarily upon identifying the basic needs and problems to be confronted. For example a broad goal in the area of economic development certainly would involve the attainment of satisfactory levels of income, employment, and production for the state's citizens and its business firms. A fundamental policy issue in this area is the proper rate of economic growth which the state desires and can achieve. Implicitly or explicitly, the state's commitment to rapid economic growth as a primary goal will be determined or modified after this and other subjective factors are analyzed and when specific objective criteria are explicitly articulated. For example, it may be desirable to set specific targets for unemployment rates or personal income in conjunction with an expected rate of population growth and its distribution. In some cases, various regional standards, possibly related to such areas as northern New Mexico, may be necessary.

In all cases, criteria for performance would relate to specific policy issues. They would be measures of intent and eventually of performance. In this manner the effectiveness of alternative policies could be anticipated and eventually compared on the basis of actual results. For example, economic growth could be assessed in terms of targets for per capita personal income

or total value of production by major industrial groups within the state. Once such criteria are formulated, the probably effectiveness of alternative policies in achieving these goals could be compared. In addition, actual performance by agencies could be measured against standards which had been accepted and understood in advance.

In the area of human resources, a broad goal might well be articulated with respect to education. It might favor the provision of an outstanding public educational system from elementary to university levels. Additional goals with respect to specific topics such as higher education, vocational education and elementary and secondary schools might also be included. These should be related, first, to economic development in terms of changes in the population's capabilities for earning a better level of income. They also should be related to goals relating to the strengthening of New Mexico's three sub-cultures and any intended assimilation between them. These goals would indicate the importance attached by the state to the educational process and expected results in human, cultural and economic terms. Thus, a broad framework of reference with respect to education could be established.

These goals should also deal with basic policy issues which confront the state with respect to the educational process. The purposes to be served by the state's public educational system need to be spelled out far more clearly than has been done before. The importance of training in the use of particular skills must be analyzed in conjunction with examination of characteristics and trends in the state's labor force and its utilization. This will help determine the role of vocational education in the state as well as the location of specific facilities.

Questions relating to higher education would certainly include possible concentration of certain graduate programs on specific campuses as well as the possible incorporation of all campuses into a single university system. The advantages and drawbacks of these approaches could be analyzed in part from the experience of other states, particularly within the Rocky Mountain area.

The educational system could also more effectively assist in the development of the state's natural resources. Exploitation of a larger proportion of its mineral wealth might be facilitated by expanded geological and related studies by the Institute of Mining and Technology.

With respect to water, the broad approach of comprehensive development planning seems particularly appropriate. The essentially stable supply of water in New Mexico will increasingly have to be apportioned among competing demands. Currently, water use is determined by which economic interest is willing to pay the highest price in a given situation. Thus mining interests have acquired water rights formerly used for agriculture and have transferred

them to their own purposes. As the demand for water grows, a new system of allocation may be required. Its form should at least be influenced by statements of goals, which will indicate the priorities which the state attaches to various alternative courses of development.

Following the enunciation of broad goals concerning these and other policy issues, specific objectives will be determined. For example, the creation of a number of vocational education institutions might be indicated. In terms of academic standards, specific targets for the proportion of high school graduates who pass specific achievement tests might be an appropriate objective.

In addition to broad statements of goals on general topics and clearly articulated objectives on specific subjects, another major task is the necessity to provide direction to the programs of state agencies in terms of goals and objectives. Such agencies should be apprised about results that are expected within a stated time period. The advantages of such an approach are obvious. Continuity of programs will be more likely even if personnel concerned with implementation are not always the same. The budgeting process will also be facilitated when requested programs can be measured against anticipated goals and eventually evaluated in terms of specific standards. The reorganization of state government can also be provided with a rationale in terms of basic functional categories which will relate to overall goals and objectives.

Thus, statements of goals and objectives can be useful on many levels. They will enunciate the state's concerns along with its approaches to the basic policy issues which are fundamental to them. In addition, narrowly-defined objectives will determine appropriate procedures for immediate action. Placing these tasks within a broad framework will also clarify interrelationships which might otherwise be obscured. Finally, the programs of state agencies will then be directed toward the accomplishment of specific objectives in the short run and broadly stated in the long run. Their efforts thus will be more rationally interrelated, which will hopefully promote greater efficiency and effective action. This will be facilitated by the preparation of plans for the major functional areas of state concern (such as education, transportation, recreation and health, to name several). Each functional area plan will identify means for achieving the relevant policy goals over a five or ten year period, or even longer. Presently, the Planning Office has prepared a Statewide Comprehensive Outdoor Recreation Plan and is in the process of preparing comprehensive plans for vocational rehabilitation, mental retardation, health, and the preservation of historic sites. Such planning involves a close working relationship with the relevant operating state agencies and private groups.

In addition to the formulation of statements of goals and objectives, a second major effort of the Planning Office involves state capital improvements programming. Although the state's capital expenditures are extensive, a recent report prepared by the Office concludes that "there is no long range comprehensive program of state capital improvements," (4) either for the state as a whole or for major functional areas. The State Planning Office is preparing a five to six year State Capital Improvements Program to be completed by January 1969. The Program will be updated annually and extended one year ahead.

This effort by the Planning Office ties in closely with the determination by the state of its basic objectives for the future. These objectives will be the basic determinants in setting up priorities for capital expenditures by the state for such expenditures constitute the state's investment program to promote economic, social, and natural development or conservation. With respect to the rest of the spending programs of state agencies, a possible method by which they can be brought into conformity with overall state objectives is a rapidly developing technique called program performance budgeting or the planning-programming-budgeting system (PPBS). This technique was first developed by the federal government in the Defense Department and relates expenditures to needs and specified levels of performance, rather than with traditional agency alignments. Plans and programs are meant to be interrelated and to be subsumed under overall objectives that have been determined for the state as a whole.

A fundamental aspect of both capital improvements programming and program budgeting is the necessity for a comprehensive statement of broad goals and operational objectives. They provide a framework by which priorities can be determined and performance may be impartially evaluated. Thus by fitting a proposed capital expenditure by the state into the overall development plan, its real significance may be revealed. Similarly, the PPBS system requires functional area planning and specific performance criteria, both of which are requisite aspects of the state's comprehensive development planning process.

A third major activity of the Planning Office related to state comprehensive development involves the division of the state into districts for planning and development purposes. New Mexico, with the fifth largest total area of all the states in the nation, is in many ways a conglomerate of disparate parts, many of which have little in common with each other. Cultural patterns and major economic activities vary widely throughout the state and present opportunities and problems which in many cases are unique to particular regions. The creation of these districts could stimulate joint activity in areas larger than individual cities or counties, but smaller than the state as a whole.

The Planning Office's districting scheme has divided the state into six such regions. Each district may establish a regional planning commission, as permitted by Chapter 239 of the New Mexico Statutes. This commission should consist of representatives of county, city and other local governmental bodies, and serve as the sponsor for all regional planning and development programs, including health, recreation, transportation and pollution control. It should serve as a review body for local plans and projects so that district-wide planning can proceed in conformity with state and regional viewpoints and through a harmonious blending of urban and rural interests.

The State Planning Office programs which have been described can be viewed most usefully as part of a planning process. Both in the short run and the long run problems sometimes arise either suddenly or gradually, often the inevitable result of the successful resolution of previous problems. The Planning Office is attempting to make state government better able to recognize and cope with problems, rather than to avoid or ignore them. The broad overview provided by a clearly articulated Statement of Goals and Objectives - both on a comprehensive and specific level - should provide a needed and useful perspective which has been lacking in the past. Capital improvements programming and program budgeting should help assure that state agencies act in consonance with these objectives. Finally, the creation of planning and development districts may provide a more effective instrument for dealing with regional problems than has heretofore existed and also help assure that regional and state goals are at least compatible if not actually identical.

In addition to the study and possible creation of new planning and administrative mechanisms, the Planning Office has been studying the present condition and probable prospects for the state as a whole, as well as its various components. Such policy planning requires reliable and accurate information. Although available data is incomplete and often inconsistent, certain patterns have become apparent and they are by no means encouraging.

One of the most prominent indicators of economic health is the rate of growth of population in a region. During the 1950's, New Mexico's average annual population increase was almost twice that of the United States as a whole. However, in the past seven years, New Mexico's population growth on an annual basis has been less than one-half as rapid as that of the nation. In fact, in the last three years New Mexico's population has remained almost completely stagnant, and one recently published report actually indicates a decline in population for the state between 1966 and 1967. (5) Similar trends with respect to income and employment are apparent. For example, in 1967, total employment in the state seems to have remained at the same level as in 1966, but most major components actually experienced decreases in employment. Agriculture, mining, construction, manufacturing and finance all seem to have fewer wage workers in 1967 than in 1966. The only major categories reporting increases

were trade, services and state and local government.

In the 1950's, New Mexico's economic boom seems to have been created, primarily, by the federal government and by certain mining activities, such as oil, gas and uranium. However, between 1960 and 1966, federal employment (both civilian and military) decreased by 1,600 or about three percent, and mining employment decreased by 4,200 or 20 percent. Thus the major sources of growth for the state in the 1950's have not contributed very much overall in the 1960's.

It is imperative that the state gain some perspective regarding strengths and weaknesses within its economy in order to improve the situation. If the state commits itself as far as possible to rising income and employment for its citizens, it must attempt to determine the best way to achieve these objectives. Additionally, human and environmental factors must always be kept in mind when decisions affecting the economy are made.

In terms of water resources development in the near future, the direction taken by the state's economy will be fundamental. For example, many of New Mexico's rivers and creeks can be used for such recreational purposes as fishing, or for certain manufacturing concerns which may to some extent pollute these streams and make them far less satisfactory for recreational purposes. In another area, measures may be taken to increase the state's effective water supply by means of phreatophyte control or irrigation ditch lining. Although such programs may in the short run benefit agriculture they might have an adverse effect on tourist activities if a by-product were the elimination of many cottonwoods in scenic areas of the state. Such seeming dilemmas can more easily be resolved if they are put in the context of an overall plan for state development in which the roles of the major economic activities have been at least anticipated if not specifically determined.

Some of the planning tools and methods being developed by the State Planning Office have previously been described in this paper. It may be useful to indicate how their implementation may be of use in solving problems related to water resources development in New Mexico.

The formulation of a broad policy statement of goals and objectives, for example, can be expected to clarify the importance the state attaches to various possible uses of water. In addition to such traditional consumptive purposes as mining and agriculture, the needs of cities and recreational activities are growing rapidly, as well as the viewpoints of conservationists. Broad indications of state goals can be significant tools for those who either administer or desire the use of water in the state. In addition, the enunciation of more specific objectives should help determine acceptable standards for water quality and depletion. The related subject of functional area planning can also be expected to illuminate relationships between seemingly dissimilar

categories. In particular, the full social benefits and costs of water projects could be more closely approximated. Moderate range planning over a five to fifteen year period could be also facilitated. Another gain would be derived from the better organization of information about the state which would be required in setting up goals and objectives.

Improvements in the performance of state government should also promote more effective water development policies. Both capital and current expenditures by the state may benefit from such techniques as capital improvements programming and program budgeting. Agencies would be aware of broad guidelines with respect to state policy and could administer their programs accordingly. A meaningful state investment plan could promote more efficient action by the state. Since program budgeting requires at least medium-range forecasts, state agencies would also be forced to plan ahead to anticipate expected requirements. Because water is an integral component of many activities in which state agencies are involved, the possible improvements in planning, coordination and administration could produce numerous benefits. As for longer-range planning, any eventual shortages in the state's water supply would be more likely to be anticipated and prevented.

The creation of planning and development districts should also yield benefits with respect to water development policies. As problems are increasingly resolved cooperatively on an area-wide basis, conflicts between rural and urban interests over water utilization may become less intense. On the interstate level, existing arrangements may also be improved through such planning-oriented groups as the Four Corners Regional Development Commission and the Federation of Rocky Mountain States, Inc.

Finally, the State Planning Office may be able to suggest improvements in regulatory activities of the state. Such areas as building and housing codes, land use zoning controls, air and water pollution standards, and taxing and licensing policies may require modifications to assure the implementation of programs implicit in statements of goals and objectives.

In addition to such planning for the immediate future, the Planning Office is also concerned with long-range trends within the state and the nation. For example, in one of the most provocative Phase I studies, Professor R. P. Lutz attempted to anticipate the effects of scientific development and technological change in the state's economy. He notes that "the state has reached a critical point in regard to the use of its available water supply," and predicts that the proportion of total consumptive use of water accounted for by agriculture will decrease in the foreseeable future. This study finds both research and development and mining to be the most promising for the state as a whole, although somewhat slower growth in agriculture and manufacturing is anticipated. (6)

In another report prepared for the Phase I Inventory, Professors H. R. Stucky and Donald C. Henderson conclude that declines in total farm employment may not only be inevitable, but may actually be desirable and necessary if agriculture is to remain viable in the state. They note that in north central New Mexico "the scientific developments and technological changes have not been as widely applied, and many rural people remain in a chronically low income position." (7) The probable structure of agricultural production and employment must be anticipated as clearly as possible if New Mexico is to share in even the present proportion in the nation's overall total.

Another study which bears on long-range analysis provides population projections for New Mexico to the year 2000. (8) Estimates of employment in basic economic activities were made and required levels of population were derived from these estimates. This analysis, along with many other studies in the Phase I aspect of the Development Plan, provide the framework, both statistical and general, for viewing New Mexico's future prospects and challenges.

When it seems clear what is likely to occur within the state as a result of fundamental technological and social forces, the state can then decide whether the future that is likely is also desirable. Within the limitations of public action and discretion, expected eventualities can be modified or possibly even obviated. In this way, the future can indeed be anticipated with some reasonable confidence that man can be the master of his destiny. Without planning, our society will be at the mercy of a rapidly accelerating revolution in science and technology and our lives will be determined by unseeing forces rather than intelligent foresight. The process of planning, at the least, provides a method for coping with and molding an environment that must and should change with the passage of time.

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RECLAMATION ACTIVITIES IN NEW MEXICO

Leon W. Hill[1/]

It is always a pleasure to appear before this gathering of water conferees. I welcome the opportunity to return to my home state and to visit my alma mater while reporting to you on Reclamation activities in New Mexico.

OPERATING PROJECTS

Results represent the best proof of the value of any program, and Reclamation is no exception. So, let's look at some of those results in New Mexico. These are best illustrated by the Bureau's finished projects in the state - the Carlsbad, Fort Sumner, Hammond, Middle Rio Grande, Rio Grande, Tucumcari, and Vermejo projects.

These projects produced crops valued at more than $44 million in 1967. About 40 percent of the cotton, 35 percent of all hay and silage, 75 percent of the commercial vegetables, 15 percent of the apples, and 100 percent of the pecans grown in New Mexico in 1966 were grown on Reclamation projects. Agriculture is a basic industry which requires many other supporting industries and one which produces new wealth so necessary for economic stability.

All of these projects are operated by water user organizations except the Middle Rio Grande and Rio Grande projects, which the Bureau operates with funds avanced by the water users.

While the completed projects are certainly successful from the irrigation standpoint, they have also provided subsidiary benefits in the way of fish and wildlife enhancement and recreation outlets. For example, more than 1,776,503 people visited Reclamation reservoirs in New Mexico last year.

LEAN YEARS

The history of Reclamation in the West is studded with success stories even though many difficulties have been encountered. Today, as it has for several years, our nation's involvement in Vietnam has necessitated a belt tightening on our domestic programs.

Yet even in these tight budget years, New Mexico has fared pretty well. We currently have three major projects under construction in the state - the San Juan-Chama, the Navajo Indian Irrigation, and the Pecos River Basin Water Salvage.

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San Juan-Chama Project

The San Juan-Chama project is designed to make possible an average annual diversion of about 110,000 acre-feet of water from the upper tributaries of the San Juan River in the Colorado River Basin, through the Continental Divide, for utilization in the Rio Grande Basin, New Mexico. The imported waters will provide municipal and industrial water for the city of Albuquerque and a supplemental supply for 121,000 acres of irrigated land.

Good progress was made on construction of features of the diversion and storage elements of the project during 1967.

El Vado Dam. All construction work was completed during 1967 on the new enlarged outlet works of El Vado Dam. We appreciate the Rio Grande Compact Commission's cooperation in permitting the use of Abiquiu Reservoir during construction of the El Vado Dam outlet works.

Azotea Tunnel. The contractor (Gibbons and Reed Company, Boyles Bros. Drilling Company, and Dugan Graham, Inc.) is excavating from both portals of the 13-mile-long Azotea Tunnel. The contractor has completed about 11.5 miles or 88 percent of tunnel excavation. Concrete lining was completed on approximately 3.2 miles of the tunnel from the outlet portal bringing the total length of tunnel lined to date to 5.2 miles or about 42 percent of the total. The concrete lining operation was shut down in October 1967 until it can be resumed from the inlet portal. All work under the contract was approximately 75 percent complete at the end of January.

Blanco Tunnel. The 9-mile-long Blanco Tunnel was holed through on March 30, 1967. The contractor (Colorado Constructors, Inc., and A. S. Horner Construction Company, Inc.) began concrete lining in August 1967; and about 1.9 miles of lining or 21 percent of the total has been completed. All work under the contract was approximately 79 percent complete at the end of January.

Oso Tunnel. Oso Tunnel was holed through on August 30, 1967. The contractor (Broyles Brothers Drilling Company) made excellent progress and excavated better than 6,000 linear feet of 10-foot 2-inch diameter tunnel per month from May through August on the 5-mile-long Oso Tunnel. Excavation through the glacial till encountered in the fall of 1966 was completed by conventional tunneling methods in April 1967. The contractor was able to return the mole to the heading April 23, 1967; and normal moling operations were resumed on May 1, 1967. The following new tunnel excavation records were set during this period: (1) monthly record - 6,851 linear feet in June; (2) 403 linear feet in a 24-hour day on June 16; and (3) 156 linear feet in an 8-hour shift on the graveyard shift June 19. Concrete lining of the tunnel was started in November,

and 3,900 feet of tunnel have been lined to date. Work on the Oso Diversion Dam was started in the fall of 1967 and was 10 percent complete by the end of December. All work under the contract was 69 percent complete at the end of January.

Channel of Azotea Creek. A $378,156 contract was awarded in August 1967 for channelization work on 4 miles of Azotea Creek below the outlet of Azotea Tunnel. The contractor (Herren-Strong, Inc.) has completed 58 percent of the work to date. Channelization work on 5 miles of Willow Creek between Azotea Creek and Heron Reservoir is scheduled to be put under contract during the summer of 1968.

Heron Dam. Universal Constructors, Inc., of Albuquerque, was awarded an $8,597,550 contract for construction of Heron Dam and relocating 8½ miles of State Highway No. 95 in September 1967. At the end of the year, the contractor had completed about 65 percent of the highway relocation, all of the open-cut excavation for the outlet works tunnel portals, and had begun tunnel excavation. Contract completion date is August 6, 1970; and work under the contract is presently 11 percent complete.

In this fiscal year of 1968 our construction budget for the San Juan-Chama project is $13,755,000, and the President's program for fiscal year 1969 includes $9,644,000 for the project.

Navajo Indian Irrigation Project

The Navajo Indian Irrigation project, a project of the Bureau of Indian Affairs, is being constructed in northwest New Mexico by the Bureau of Reclamation. This project is designed to divert water for irrigation from the existing Navajo Dam and Reservoir to 110,000 acres of land within and adjacent to the Navajo Indian Reservation, which will be developed for the Navajo Tribe.

The headwork and Tunnel No. 1 are complete; Tunnel No. 2 was holed through last july, and construction on this tunnel is about 77 percent complete. Approximately 37 percent of the construction of three siphons and two sections of open channel in the main canal has been completed.

The 1969 construction program calls for completion of Tunnel No. 2 and continuing work on two sections of the main canal. Additional contracts will be awarded as funds become available.

The project's budget for fiscal year 1968 is $6,940,180; and the amount scheduled for fiscal year 1969 is $3,548,000.

The Navajo Indian Irrigation project is approximately 15 percent complete.

Pecos River Basin Water Salvage Project

The Pecos River Basin Water Salvage project is designed as a continuing program for clearing and controlling the regrowth of salt cedars and other undesirable phreatophytes along the Pecos River south to below Pecos, Texas, which will reduce the nonbeneficial consumption of water in the basin.

The Pecos River Basin Water Salvage project is approximately 20 percent complete.

The first phreatophyte clearing contract was completed in August 1967 while the second one was completed just this month. A third contract covering clearing in the area where the Rio Hondo empties into the Pecos River was awarded in February 1968. A fourth contract covering clearing in the Lake Arthur area was awarded this month. Work is expected to be accomplished in the late spring to control growth in the area covered by the first clearing contract. To date, approximately 15,000 acres have been cleared under the above contracts.

The amount of $620,000 was appropriated for our fiscal year 1968 program. The President's budget includes $805,000 for our 1969 construction program. During fiscal year 1969, we expect to complete two phreatophyte clearing contracts. One additional major clearing contract will be started, and field data will be accumulated for future clearing work.

PROJECTS BEFORE CONGRESS

Congressional action may be forthcoming on other projects which could further alleviate the need for water in your state.

Animas-La Plata Project

The Animas-La Plata project is a multipurpose development proposed as a participating project of the Colorado River Storage project. It would be located in the San Juan River Basin in southwestern Colorado and northwestern New Mexico. The project would develop flows of the Animas-La Plate River systems for irrigation, municipal and industrial use, recreation, and fish and wildlife conservation. It would provide a full water supply for 14,700 acres and a supplemental supply for 5,500 acres in New Mexico. A much larger acreage would be irrigated in Colorado from the development.

Hooker Dam Project

The Hooker Dam project is a unit of the proposed central Arizona project for controlling and regulating erratic storm and winter season runoff, to

stabilize flows for downstream agricultural purposes, and for municipal and industrial uses in the Silver City and Tyrone areas. It would be located on the upper Gila River.

Congress is expected to take action on the central Arizona project legislation soon, and both the Animas-La Plata and Hooker Dam are included therein.

MUNICIPAL AND INDUSTRIAL WATER FOR NAVAJO PROJECT

Authorizing legislation for the Navajo Indian Irrigation project and the San Juan-Chama project provides that no long-term contract, except contracts for the benefit of the lands of the two projects, shall be entered into for delivery of water from Navajo Reservoir or waters of the San Juan River and its tributaries until the Secretary has made a hydrologic determination that there is sufficient water to reasonably meet these demands and fulfill the Upper Colorado River Basin Compact requirements. Any such long-term municipal and industrial contract must also be approved by Congress.

The Secretary has made the determination that sufficient water is reasonably likely to be available to permit contracting up to 100,000 acre-feet annually through the year 2005. Several such long-term contracts have been negotiated, and are currently under consideration by the congress.

PROJECTS IN PLANNING STAGE

While a good deal of satisfaction may be reaped from past accomplishments and current endeavors, the task of providing water as it is needed is a never-ending job. There are several projects which could well be undertaken during the next few years.

Eastern New Mexico Water Supply Project

One such development is the Eastern New Mexico Water Supply project, which is designed to augment the present groundwater supplies of the 11 project cities with surface water from the state's Ute Reservoir located on the Canadian River near Logan.

Water will be taken from Ute Reservoir and conveyed to the 11 cities through a system containing about 347 miles of pipeline, 14 pumping plants, six regulating reservoirs, regulating tanks, and other structures. If the Eastern New Mexico Water Supply Association decides it wants the Bureau to construct the project, the report now being prepared must be submitted to congress. It will take approximately 5 years to construct the project after it is authorized and money appropriated for construction.

Brantley Project

The Brantley project is being considered by our Bureau as the principal feature of a plan to help solve some of the existing and potential water problems on the Pecos River. The reservoir site is between existing McMillan and Avalon Dams. Under present-day technology we have determined that both of these dams have inadequate spillways. Construction of Brantley Dam and Reservoir would eliminate this threat and provide needed flood control not now available. In addition, the reservoir would provide replacement storage capacity for Lake McMillan to serve irrigation water to the Carlsbad Irrigation District lands. The Brantley report is now being reviewed in our Washington office.

Other Planning Activities

Feasibility investigations have continued on the Rio Grande Water Salvage project. A field draft of Volume I on phreatophyte clearing is nearing completion. Volume II will cover other aspects of possible water salvage including channelization, drainage, and consideration of clearing between levees. The evapotranspiration tanks in the Bernardo area have remained in operation.

Reconnaissance studies of the Rio Grande tributary areas included revisions to the Costilla report, completion of a field draft on the Jemez project report, and initiation of studies on the Cuba, Canjilon, and Los Encinos projects.

In our Rio Grande Basin studies, an evaluation of channel losses in various reaches of the Rio Grande continued. The basin investigation programs for the Rio Grande and Pecos are being reoriented and combined into a statewide study called the New Mexico Basins project, in which it is intended to develop the water picture for New Mexico.

Our research work on channel evaluation consisted of work on a report of the hydraulic characteristics of the low-flow conveyance channel extending from San Acacia to the narrows of Elephant Butte Reservoir and completion of a field draft of a report on aggradation-degradation of the Rio Grande from Cochiti to the headwaters of Elephant Butte Reservoir.

Work is just starting on a safety study for the middle Rio Grande project on possible measures to reduce drownings in the irrigation and drainage system.

West Texas and Eastern New Mexico Import Project

Another aspect of our planning for the future which is a subject of increasing interest and excitement is the West Texas and Eastern New Mexico Import project. The Bureau, the Mississippi River Commission, and the Corps of Engineers are currently studying possibilities of meeting the needs of west Texas and eastern New Mexico from the lower Mississippi River.

BETTER CONSERVATION

With respect to better conservation, the Bureau of Reclamation has two programs to help distribute and conserve present water supplies. They are the rehabilitation and betterment program and the small loan program as established by the Small Reclamation Projects Act of 1956.

Tucumcari Rehabilitation and Betterment

The Bureau constructed all of the Tucumcari project's irrigation facilities below the canal headworks at Conchas Dam on the Canadian during the early 40's. Early construction did not provide for project drainage which is now being taken care of through a $1½ million rehabilitation and betterment program. This work, comprised of canal lining and drainage, was started in 1961 and will be completed in 1971. The conservancy district has contracted to perform all the work with a minimum of Bureau supervision. Specifications for the work are first approved by our office. Only one Bureau engineer is assigned to the project full time.

Carlsbad Rehabilitation and Betterment

The Carlsbad Irrigation District water users have voted to spend $4 million for a rehabilitation and betterment program similar to that at Tucumcari. The proposed work involves replacement of 97 miles of earth laterals with either concrete pipe or concrete lining. The smaller ditches will be replaced with concrete pipe and the larger ones will be concrete-lined. Tentative plans are to begin a 5-year construction program in fiscal year 1969.

The Bureau will provide engineering assistance to the district and the necessary supervision and inspection.

Small Loans Program

The Small Reclamation Projects Act of 1956 as amended June 5, 1957, and September 2, 1966, established a program under which certain types of organizations can obtain loans for small Reclamation projects and grants for those portions of the projects that are nonreimbursable as a matter of national policy. The portion of the loan attributable to the irrigation is interest-free.

The limit of federal funds that may be provided is $6,500,000 for a combination of a loan and a grant or for either. Grants may be made for flood control, recreation, and fish and wildlife purposes where these are of general public benefit. Such grants can be made up to a maximum of $6,500,000 for a single project, but the combination of a loan and grant cannot exceed this amount.

LINED CONVEYANCE CHANNELS

At some point in time consideration should be given to carrying irrigation and municipal water supplies in lined conveyance channels or closed conduits in lieu of open river channels. Possible reaches of river for study are the Rio Grande from Cochiti Dam to Elephant Butte Reservoir and Elephant Butte through El Paso.

Such an undertaking would probably have to be limited to conveying only the low flows and consumptive use requirements. Maintenance of the river channel for floodflows and periods of high runoff would have to be continued.

The value of water will increase with increased demand. When the value equals or exceeds the cost of water saved through conveyance channels, then construction of these channels will be given serious consideration.

We know that water losses, because of percolation to the underground evaporation, and transpiration by phreatophytes, are very substantial. Not only are these water losses high, but current measures for combating these losses are costly.

RECLAMATION STORY IN NEW MEXICO

This, then, is the story of Reclamation in New Mexico, past, present, and future. Much as a river carves its path through the countryside, so has Reclamation carved an important niche for itself in the history of your state.

WATER DEVELOPMENT AND PLANNING FOR NEW MEXICO

S. E. Reynolds[1/]

An orderly treatment of the subject of water development and planning in New Mexico seems to me to require at the outset some discussion of the fundamental law governing the appropriation of water in our state. While this law may not be immutable it must be the point of departure in planning and rights heretofore established under it must be protected.

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 limit of a right to the use of the public waters; and that priority of appropriation gives the better right.

Our surface water code which was enacted in substantially its present form in 1907, and our groundwater code, which was enacted in 1931, have these provisions as their cornerstones. Thus, the appropriation doctrine of water rights is the basis of New Mexico water law. In fact, the appropriation doctrine was followed first by custom and then by law in New Mexico long before the state constitution was adopted in 1912.

Under our surface water code no one may initiate construction of works for the appropriation of water without a permit from the state engineer. The state engineer may approve an application for a permit only upon a finding that there is unappropriated water available for the benefit of the applicant.

With a permit from the state engineer an appropriator of water may change the purpose for which the water was appropriated or may change the place of diversion, storage or use of his water provided that no change shall be allowed to the detriment of others having a right to the use of the public waters.

Similar provisions are applicable to our groundwaters except that the jurisdiction of the state engineer extends only to underground basins declared by him. When the state engineer finds that the waters of an underground supply have reasonably ascertainable boundaries, and when he so proclaims, he assumes jurisdiction over the appropriation of such waters. He proclaims or declares an underground water basin by the issuance of an appropriate order and publication of a description of the boundaries. Thus far, the state engineer has declared 22 such basins embracing a total of a little more than 27,000 square miles - more than a fifth of the state's area.

1/ State Engineer, State Engineer's Office, Santa Fe, New Mexico.

Groundwater outside the declared boundaries of underground water basins belongs to the public and is subject to appropriation, but anyone may develop this water and put it to beneficial use without a permit from the state engineer.

In addition to our constitution and statutes, seven interstate compacts and the Supreme Court decree in Arizona v. California, et al., govern the appropriation and use of water in New Mexico.

Our statutes authorize the creation of irrigation and conservancy districts as political subdivisions of the state. These agencies are empowered to contract with federal agencies for water projects and to levy water assessments and ad valorem taxes to pay the costs of construction and operation and maintenance for surface and underground water projects.

Since its creation by an act of the state legislature in 1935, the New Mexico Interstate Stream Commission has been deeply involved in the planning of the development of the state's water resources. The state engineer is by law a voting member and secretary of the Commission. The eight other members of the Commission are unsalaried and are appointed by the Governor to represent major irrigation districts or sections of the state.

Section 75-34-3, N.M.S.A. 1953 Comp. provides in part as follows:

> "Said Commission (the Interstate Stream Commission) is hereby authorized to negotiate compacts with other states to settle interstate controversies or looking toward an equitable distribution and division of waters in interstate stream systems, subject, in all cases, to final approval by the legislature of New Mexico; to match appropriations made by the Congress of the United States for investigations looking to the development of interstate streams originating in or flowing through the state of New Mexico; to investigate water supply; to develop, to conserve, to protect and to do any and all other things necessary to protect, conserve and develop the waters in the stream systems of this state, interstate or otherwise; . . ."

The Interstate Stream Commission has had major responsibility in the formulation of the state's position and decisions on major water projects and in the interstate and intrastate negotiations so essential to the authorization and funding of these projects. This important work of the commission has included public meetings at which the views of the various local interests were heard and carefully weighed. The Interstate Stream Commission staff has worked closely with the federal agencies in the development of water resources plans.

Most of the comprehensive water resources planning in New Mexico to date involves surface water. Many hundreds of thousands of dollars have been spent in the state's program in cooperation with U. S. Geological Survey to investigate and evaluate our groundwater resources and this work has provided a basis and a plan for the administration of those resources. But little has been spent on plans for comprehensive projects for the development and use of groundwater. This results mainly from the circumstance that groundwater is susceptible to development by private enterprise, without major federal or state projects, and that has been the course of the development of our groundwater resources.

At the present time, more than 90 percent of the 3.08 million acre-feet of water diverted annually in New Mexico is used for irrigation and, speaking generally, competition among various types of use is not intense. Such competition has not yet reached a peak because the industrialization and urbanization which the experts anticipate for New Mexico is just beginning. In 1950 our population was 681,000. In 1960 our population was 951,000. And experts predict that our population may increase to about 1.8 million by 1980. Whether or not these increases will occur depends, of course, on a number of factors, including the manner in which we manage our water resources.

Snipping the record at the limits of my own stream of consciousness of water resources planning and development in New Mexico - which begins in August 1955 - it appears that $525 million worth of water projects have been authorized or completed. And an additional $170 million worth of water projects are presently under consideration for authorization or under feasibility grade investigation.

These figures do not include water projects undertaken by private enterprise or political subdivisions of the state. Nearly all of the projects included are those of the Bureau of Reclamation or the Corps of Engineers. There is in the totals about $7.5 million spent or to be spent by the Department of Agriculture under the Public Law 566 program and about $5 million spent by the New Mexico Interstate Stream Commission on the construction of the Ute Dam and Reservoir project on the Canadian River.

To put the New Mexico program in perspective, I want to spend a few minutes outlining some of the works recently completed, recently authorized, or under active investigation.

Under the Colorado River Compact of 1922 and the Upper Colorado River Basin Compact of 1948, New Mexico may deplete the flow of the Upper Colorado River system by about 800,000 acre-feet annually. Current depletions chargeable to New Mexico amount to about 150,000 acre-feet per year - or about one-fifth of what we are entitled to under the compacts.

The Colorado River Storage Project Act of 1956 authorized a comprehensive plan for the development and use of the Upper Basin share of the Colorado River water. The Bureau of Reclamation has planned New Mexico's share in this development in close cooperation with the state.

The first major unit of the Storage Project to be completed was Navajo Dam and Reservoir on the San Juan River in New Mexico just south of the Colorado line. This unit, with a storage capacity of 1,700,000 acre-feet will store water for the authorized 110,000 acre Navajo Indian Irrigation Project which is under construction and for the recently completed small Hammond Irrigation Project. The reservoir can also furnish an estimated 200,000 acre-feet annually for diversion for municipal and industrial or other uses. It is already providing one of the best boating and fishing lakes in the Southwest.

Also authorized and presently under construction is the San Juan-Chama transmountain diversion project, which will divert an average of 110,000 acre-feet of water annually from the tributaries of the San Juan River in Colorado through 27 miles of tunnel and closed conduit for use in the water short Rio Grande Basin in New Mexico. This diversion through the Continental Divide will provide about 52,000 acre-feet of water for irrigation and 53,000 acre-feet for municipal use by the City of Albuquerque. It will furnish 5,000 acre-feet to maintain a permanent pool of 1200 acres for recreation in the Corps of Engineers Cochiti Reservoir which is under construction on the Rio Grande just above Albuquerque.

Total cost of work completed or under construction in New Mexico as a part of the Colorado River Storage Project is about $270 million.

The Central Arizona Project legislation approved by the senate in the last session of the congress would also authorize the Animas-La Plata Project in Colorado and New Mexico as a participating unit of the Colorado River Storage Project. This project would irrigate about 16,700 acres in New Mexico and would supply 13,500 acre-feet of municipal water to communities in northwestern New Mexico. Project costs allocated to New Mexico are about $26,000,000.

The Central Arizona Project bill approved by the senate would also authorize Hooker Dam and Reservoir on the Gila River in New Mexico as a unit of the project. The legislation would authorize 18,000 acre-feet of consumptive use in New Mexico in addition to the 31,000 acre-feet decreed to New Mexico for its present uses by the Supreme Court in Arizona v. California, et al.

The supply made available by the Hooker unit would probably be used principally for municipal and industrial purposes. The unit also would yield substantial recreation and fish and wildlife benefits. The Hooker unit is estimated to cost about $25,000,000.

One of the most serious water resources problems facing New Mexico among other western states is the large and increasing depletion of water supply by nonbeneficial plant growth such as salt cedar in and along our streams. Water lost in this manner in New Mexico is variously estimated at from one-half to one million acre-feet annually.

An attack on this problem was launched with the authorization of the Middle Rio Grande Project in 1948. Under this authority and subsequent authorizations of additional project units the Corps of Engineers and the Bureau of Reclamation, in a splendid example of interagency cooperation, have completed more than $75 million worth of flood and sediment control works, channelization, drainage improvement and salt cedar eradication. When works now authorized, including the Cochiti and Galisteo flood control reservoirs, are completed expenditures will total about $138 million.

This figure does not include the cost of flood and sediment control works on Rio Puerco and Rio Salado currently under feasibility investigation by the Corps of Engineers. Preliminary estimates indicate that these works will cost in the neighborhood of $23 million. With the authorized units of the Middle Rio Grande Project on the river, the Rio Puerco and Rio Salado, if uncontrolled, will contribute nearly all of the annual sediment load of about 7,000 acre-feet but only 6 percent of the water to Elephant Butte Reservoir.

It is estimated that these accomplishments by the Corps and the Bureau along with work being done by the state will ultimately salvage about 165,000 acre-feet of Rio Grande water annually. Results of the work already completed account in a large measure for the fact that New Mexico is steadily reducing its debt under the Rio Grande Compact which amounted to 382,400 acre-feet on January 1, 1968.

We are also plagued by nonbeneficial growth on the Pecos River. The Bureau of Reclamation has estimated the total amount of water that could be salvaged from such plants under present conditions on the river in New Mexico and Texas at about 150,000 acre-feet per year. A Bureau report emphasized that unless corrective action is taken nonbeneficial consumptive uses may be expected to increase markedly in the next 50 years, ultimately depleting the river by some 340,000 acre-feet annually - or almost the entire flow. In 1964 the congress passed legislation authorizing the appropriation of $2.5 million for the suppression of salt cedar on the Pecos River, and the work is now underway.

Los Esteros Reservoir was authorized for construction by the Corps of Engineers on the Pecos River about 7 miles above the town of Santa Rosa in 1954. This unit, which will have a capacity of 505,000 acre-feet, will be operated in conjunction with the existing Alamogordo Reservoir to

provide flood control on the Pecos River. The unit will also serve the purpose of extending the life of the Carlsbad Irrigation District's upstream irrigation storage capacity. Storage capacity in the District's Alamogordo Reservoir which initially had a capactiy of 156,000 acre-feet, is being lost by siltation at the rate of 1,700 acre-feet per year. The estimated cost of the Los Esteros unit is about $12 million. The congress has appropriated $100,000 for preconstruction planning in this fiscal year.

The Bureau of Reclamation has underway a feasibility investigation of the Brantley Dam and Reservoir project on the Pecos River near Carlsbad.

Brantley Reservoir would have a capacity of 520,000 acre-feet and would cost in the neighborhood of $35 million. One of the principal purposes of the Brantley project would be replacement of the existing McMillan Reservoir which provides about 33,600 acre-feet of terminal storage capacity for the Carlsbad Irrigation District. McMillan Dam has been found unsafe under the Bureau's present-day standards and subject to modification.

The Brantley unit would provide desperately needed flood protection for the city of Carlsbad. Construction and operation of the unit also would make it possible to salvage a considerable amount of water by clearing the salt cedar from the delta of the McMillan Reservoir. Clearing of this salt cedar has been deferred to avoid accelerated ensiltation of the remaining storage capacity of the McMillan Reservoir.

In 1963 the New Mexico Interstate Stream Commission completed the 110,000 acre-foot Ute Dam and Reservoir project on the Canadian River near Logan, New Mexico. The project was financed by a mineral severance tax bond issue authorized by the state legislature in 1959.

Allowing for a permanent pool of 50,000 acre-feet for recreation, it is estimated that Ute Dam and Reservoir can serve a diversion demand of 25,000 acre-feet annually. The Bureau of Reclamation has estimated that the installation of spillway gates at Ute Dam could increase this yield to nearly 50,000 acre-feet.

The Commission has set the price of water untreated in the reservoir at 3 cents per thousand gallons, but has entered only one long-term contract. This contract, with the State Parks and Recreation Commission is for 50 acre-feet annually. The Bureau of Reclamation is presently investigating a pipeline transmission system that would take water from Ute Reservoir to eleven eastern New Mexico communities which are now meeting their needs by groundwater mining. Preliminary estimates indicate that such a project will cost in the neighborhood of $68 million.

The Department of Agriculture has contributed substantially to water resources conservation and management in New Mexico. The program for the rehabilitation

of community ditch systems in New Mexico has been particularly effective. In this program the Soil Conservation Service provides technical assistance, the Association of Soil Conservation Service pays up to 70 percent of the cost of the work, the state pays up to 15 percent of the cost and will lend the water users the remaining 15 percent at 2½ percent interest. In a period of about 3 years 133 systems have been rehabilitated at a cost of about $1 million to the Department and $150,000 to the state. This program literally starts at and then nurtures the grass roots.

Considering that New Mexico has only about 2.5 million acre-feet of surface water available annually under our seven interstate compacts and the decree in Arizona v. California et al., I think I would not step out of bounds by saying that we have a pretty fair comprehensive plan for the control and use of our surface water resources. The plan makes provision for irrigation, municipal and industrial uses as well as for the growing demands for water based recreation and fish and wildlife habitat. And we are pretty well along in the construction of that plan.

Almost without exception, the federal agencies working with water resources in New Mexico have coordinated their efforts and have cooperated well with each other and with the state. These agencies have been appropriately sensitive to the wishes and objectives of the state. This desirable situation is attributable in considerable measure to the fact that the state, for many years, has been diligent in working with the federal agencies and to the fact that New Mexico's congressional delegates have very effectively represented the state's interest in water resource matters. We cannot reasonably complain that the federal government has dominated water resources work in New Mexico to the detriment of the state's interest. We would like to see the water resources activities of the federal agencies expanded.

We are withdrawing about 1.6 million acre-feet of groundwater annually for irrigation and other purposes. Most of the 1.6 million acre-feet of groundwater pumped is being "mined" - that is, in many areas, the average annual withdrawal from the aquifer exceeds the average annual recharge and water levels are declining. A large portion of the renewable surface water resources available to New Mexico within the limits of the interstate compacts and the court decree have not yet been put to beneficial use but the prospects are that this supply will have been put to such use under the projects and plans which I have outlined within a few decades.

There is some prospect that New Mexico's useable water resources can be augmented by desalting and by weather modification. Rainmaking techniques that would cause increases in runoff economically significant to our region are not yet sufficiently well established for us to rely on them in planning for the decades ahead.

Techniques for desalting are sufficiently well established to set a floor on water supply, or if you prefer, a ceiling on water cost. A supply of

fresh water adequate for all conceivable needs is available if the value of the use for which it is needed is high enough. The prospects for using desalted water for irrigation in New Mexico do not seem imminent.

Thus it appears that one of our most pressing problems is to find a water supply beyond our current entitlements to continue the economy based on groundwater mining.

The goal of developing a water supply beyond our current entitlements suggests a look beyond our state borders and participation in comprehensive regional planning. And the importance of the goal is emphasized by these points.

1. Our current irrigation economy cannot be sustained without tapping new sources.

2. At the right price, the demand for water for irrigation in New Mexico is virtually limitless and this demand cannot be met to the extent that is probably feasible without tapping new sources.

3. Projected municipal and industrial requirements cannot be met without tapping new sources or cannibalizing our existing irrigation economy. Some current requirements are being met by such cannibalization.

Recent developments in technology such as improved pumps, equipment such as "moles" for tunnelling and prospects for low-cost energy from nuclear-fired generators make it more reasonable now to consider what once seemed grandiose schemes for regional water transfers such as exportation from the Columbia River to the Colorado River, the North American Water and Power Alliance concept which would bring water from as far as Alaska to the entire western United States and the tapping of the Mississippi-Missouri River system for west Texas and eastern New Mexico - a proposition currently being studied by the Bureau of Reclamation and the Corps of Engineers.

Recent recognition of water supply as a national problem - arising in large measure out of the 1961 report of the Senate Select Committee on Water Resources - has brought about changes in political thinking which were necessary to serious consideration of regional water transfers. The report recognized a need for increased state participation in water resources planning and development and paved the way for important legislation such as:

The Water Resources Research Act of 1964

The Water Resources Planning Act of 1965

The Water Quality Act of 1965

The Land and Water Conservation Fund Act of 1965, and

The Federal Water Projects Recreation Act of 1965.

Each of these acts contains provisions to encourage and implement state participation in water resource studies, planning and development.

As most of you know, New Mexico's Senator Anderson played an outstanding role in the preparation of the Senate Select Committee report and the passage of this legislation.

The Water Resources Planning Act, which was introduced by Senator Anderson, created a federal Water Resources Council. The members of the Council are the heads of the five principal water-oriented departments of the federal government. A function of the Council is coordination of water and related land resource planning activities of federal, state and local agencies.

The Act authorized the creation of river basin planning commissions composed of representatives of the affected states and federal agencies; provision is also made for representation of interstate compact agencies and international commissions where appropriate. River basin planning commissions may be formed for a river basin or group of related river basins under conditions carefully specified in the Act.

Title III of the Act authorizes federal grants to the states to assist them in developing and participating in the development of comprehensive water and related land resources plans. Under this program, the federal government, within the limits of funds allocated, matches dollar for dollar the state money spent for comprehensive water resources planning over and above the amounts spent by the state for that purpose in fiscal year 1965.

On May 5, 1966, the Governor designated the Interstate Stream Commission as the "state agency" to administer New Mexico's program under Title III of the Planning Act. New Mexico's application for financial assistance under the provisions of Title III was dated June 3, 1966 and was the first to be submitted.

Our budget for the Title III program in this fiscal year is $80,200 - one-half state and one-half federal money.

In 1959, the New Mexico legislature created the State Planning Office. The act directed the State Planning Office to function as the governor's staff agency in planning for the long-range comprehensive, balanced development of the state's water resources, the orderly expansion of public facilities and other planning matters.

A 1961 amendment to the planning act deleted the specific reference to water resources planning and broadened the activities of the State Planning Office by providing that it "shall function as the governor's staff agency in planning for the long range, comprehensive, balanced development of the state's natural, economic and human resources and public facilities. . ."

Under its authority, dating from 1959, the State Planning Office is preparing a comprehensive resource plan for the state. This comprehensive planning is being accomplished in part with funds made available under Section 701 of the Housing Act of 1954. The Planning Office has given the Interstate Stream Commission and the state engineer responsibility in the planning of the water and related land resource aspects of the comprehensive plan and has transferred Section 701 funds to these agencies to carry out the assignments.

It is our present intention that the Interstate Stream Commission will direct the comprehensive water planning to be done under Title III independently of the Planning Office but in careful coordination with the other comprehensive resource planning activities of that office.

In very broad outline, we see the job somewhat as follows.

The first phase of the planning work requires an inventory of the natural resources of New Mexico and the current state of development and use of those resources. The State Engineer Office with the cooperation of the Interstate Stream Commission has completed an inventory of the water resources of New Mexico and the current uses of those supplies for all purposes.

The second phase of the program will include the development of projections of the distribution of population and economic activities in the state. This portion of the program is underway and is being done for the Planning Office principally by the Bureau of Business Research of the University of New Mexico.

The third step, involving water and related land resources, will be to determine the manner in which water requirements for the projected distribution of population and economic activities might be met with supplies available to the state under existing interstate agreements and the United States Supreme Court decree in Arizona v. California, et al.

This third phase of the program will include:

1. Study of alternatives for the use of water remaining available under contract with the Secretary of the Interior at Navajo Reservoir on the San Juan River;

2. Study of alternatives for the use of water potentially available from the Gila River system by exchange through the proposed Central Arizona Project;

3. Study of alternatives for the use of water available under contract with New Mexico Interstate Stream Commission from Ute Dam and Reservoir and other works on Canadian River;

4. Study of ways and means of reducing consumptive use of water by uneconomic plants and reservoir evaporation and means of improving irrigation practices;

5. Study of the potential for meeting water requirements arising from the anticipated urbanization and industrialization of the state's economy by the redistribution of water among types of use within the framework of New Mexico law; and

6. Reconnaissance grade studies of storage and transmission facilities needed to serve the projected distribution of population and economic activities.

The federal agencies and the state already have studies of varying intensity under way on several of the items of the third phase of the program and it is quite possible that conclusions on these items will be reached soon.

For example, as I have already mentioned, the Bureau of Reclamation has under way a feasibility investigation of a project that would use Ute Reservoir water that New Mexico is entitled to under the Canadian River Compact to serve 11 communities in eastern New Mexico. Also, the congress has recently authorized the Secretary of the Interior to enter contracts for water from Navajo Reservoir that will consume about one-half of the 100,000 acre-feet of consumptive use that the Secretary has found can be served from Navajo Reservoir. Water delivered under the contracts authorized will be used in industrial cooling, largely for power generation by huge coal-fired plants in San Juan County.

The fourth and last step in the program will be to determine the prospects for importation of water and possibly desalting of saline waters

to 1) maintain present uses and 2) furnish projected requirements that cannot be met with presently available supplies. What I have said about the prospective early commitment of all or most of our surface water entitlement and the extent of groundwater mining in New Mexico indicates the importance of this last step.

Comprehensive water resources planning for New Mexico can be - and I believe it must be - fitted into the national program being directed by the federal Water Resources Council under the Planning Act of 1965.

It is the goal of the Water Resources Council to have regional framework studies - or Type I studies - covering the entire United States completed by 1973. The Council contemplates that the product of these studies will be comprehensive plans providing projections of economic development translated into demands for water and related land resource uses, along with projection of water availability as to both quantity and quality. Using these projections, the plans would outline the characteristics of projected water and related land resources problems and the general approaches appropriate for their solution. The framework studies would provide general guides to future water resource development.

The Council contemplates that these Type I regional framework studies will be made by river basin planning commissions created pursuant to the Water Resources Planning Act, by interagency committees, such as the Pacific Southwest Inter-Agency Committee, or by other federal-state cooperative mechanisms.

No river basin planning commissions have yet been created for any of New Mexico's river basins; but five Type I studies covering New Mexico's river basins are now, or soon will be, under way. The river basins to be covered in New Mexico are:

The Upper Colorado River Basin, which includes the San Juan River system in New Mexico.

This study is being coordinated by the Pacific Southwest Inter-Agency Committee, composed of representatives of appropriate federal agencies and the seven states of the Colorado River Basin.

The Lower Colorado River Basin, which includes the Gila and Little Colorado River systems in New Mexico.

This study is also being made under the general guidance of the Pacific Southwest Inter-Agency Committee.

The Arkansas-White-Red River Basins, which include the Canadian and Dry Cimarron River systems in New Mexico.

This study probably will be coordinated by the Arkansas-White-Red River Basin Inter-Agency Committee, composed of representatives of the federal agencies and the states of New Mexico, Colorado, Missouri, Kansas, Arkansas, Oklahoma, Louisiana and Texas.

The Rio Grande Basin, which includes the Rio Grande and Pecos River systems in New Mexico.

The leadership in this study effort has been assigned to the Interior Department, which will coordinate the efforts of the federal agencies and the affected states.

The Texas-Gulf Coast Basins, which includes Running Water Draw and other minor tributaries in New Mexico.

Coordination of this study probably will be assigned to the state of Texas, since that state has already completed most of the work needed for a Type I study.

New Mexico will participate in these Type I studies, using funds available to us under Title III of the Water Resources Planning Act, along with funds appropriated for water resources investigation by the state legislature.

We have asked Region 5 of the Bureau of Reclamation to take the leadership in pulling together the product of the Type I regional framework studies into a New Mexico Basins report on a comprehensive state-wide water plan. Work on this report is now under way; it will draw on and furnish input to the Type I studies.

Region 5 undertook such planning work for the states of Kansas and Oklahoma earlier and I expect that the Bureau will undertake to prepare such reports for some of our other neighbor states.

In this New Mexico Basins project, the Bureau will use the wealth of information and ideas already available as a product of the planning efforts of the Corps of Engineers, the Soil Conservation Service and other federal and state agencies, along with the continuing output of these agencies.

It will be the responsibility of the Interstate Stream Commission, as a part of its Title III program, to coordinate the activities of the various federal and state agencies having capability to contribute to the development of a comprehensive water plan for New Mexico.

A few examples of the kind of input to a comprehensive water plan that can be arranged under the Interstate Stream Commission Title III program might be appropriate at this point. We are cooperating with the Water Resources Research Institute of New Mexico State University in its attempt to develop a mathematical decision model for design and operation of the water supply of the Pecos River system in New Mexico, with the thought that the availability of such a model could have wide and useful application in comprehensive planning.

We are also cooperating with State University in a study to determine consumptive use requirements of the major irrigated crops in various areas of the state.

The Water Research Institute, under a contract by which a part of our Title III money is transferred to the Institute, is determining the potential irrigable acreage and potential irrigation water demands in New Mexico.

A part of our Title III money is being used to finance the participation of the State Engineer in the United States Department of Agriculture Type IV River Basin Surveys in the Rio Grande and San Juan River Basins. These surveys are directed toward a study of water and related land resource problems amenable to solution by application of the programs of the Department of Agriculture.

New Mexico is currently spending about $260,000 annually in the United States Geological Survey cooperative program for water resources measurements and investigation. The information acquired in this program is essential, not only for current administration of water under our law, but also for comprehensive planning for the future. This program should be expanded, but budget restrictions are forcing us to limit the program so that we can participate in the regional planning activities generated by the Water Resources Planning Act. Since the Geological Survey cooperative program uses federal matching funds, we cannot use the matching funds available under Title III of the Planning Act to expand this program. We have reduced the amount of state money contributed to the Geological Survey program only slightly, but because of the increasing cost of doing business, there has been more of a decline in activity under the program than we like to see.

As I have already indicated, our comprehensive planning will include a look beyond our state borders for water supplies beyond our current entitlements. Obviously this is a matter of some concern to our neighbors. A state having an apparent surplus of water will - as it should - jealously guard its future. The 1965 laws which I mentioned earlier contain provisions limiting even the study of water transfers from one area to another. Nonetheless, I believe that the information being gathered and the ideas being exchanged in the preparation of the Type I regional framework studies in the western United States will show, before it is too late, that these limitations can be adjusted without jeopardy to any interests. I am convinced that inter-regional transfers, which will benefit both the area of surplus and the area of deficit in water supply, can be worked out.

WOMEN'S INTEREST IN WATER PROBLEMS

Fern Lyon[1/]

Women's interest in water problems is constant, direct, intimate, and philosophical. Because we wash clothes, dishes, and babies; because we water lawns and mop floors; and because we write the checks to pay utility bills; we are constantly, directly, and intimately reminded of the need for good water, dependable water, and economical water. We also think about water while we are doing all these things, and so we become interested in the philosophical problems connected with wise use of water in our bewildering society.

Members of my organization, the League of Women Voters, tend to be nosier than most in attempting to understand and do something about this bewilderment. One thing we have done is to put water resources on our national program agenda. For a long time we have studied water problems wherever they became apparent to us, and as a result we have come out officially in support of policies and procedures which promote comprehensive long-range planning for conservation and development of water resources and improvement of water quality.

The title suggested for this talk indicates that you want to know about women's interest in more specific water problems, particularly as they relate to a water plan for New Mexico in the next century. I hope you are prepared for the Pandora's Box you have opened.

From what we have already heard at this Conference, and at other Institute Conferences and other water meetings, we know that New Mexico is in good hands so far as imaginative planning is concerned. Good minds are at work, and we find this very reassuring. Engineers, economists, business men, politicians, agriculturists, sociologists, hydrologists - all kinds of experts who know their jobs well, are capable of working out answers for water problems including some we hadn't known about. This happy situation provides us with an opportunity to express our interest in the problems and to examine the solutions and proposals without responsibility for implementation - we'll leave all those "mere details" up to you experts. Our minds are for the most part uncluttered with specific knowledge, and so I will proceed in that state of bliss which is well known to accompany ignorance. I'll wade right into the water where you angels might fear to tread. (I'll try to forbear mention of treading water. One of the recurring problems concerning the subject of water seems to be the tempting ease with which it lends itself to bad puns.)

Earlier this year I sent a rough outline of this talk to Leaguers all over New Mexico. In return they told me about their interest in all kinds of water problems, along with comments on proposed solutions and even on the

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problems that are likely to arise out of the solution. All this was spiced with bits of gossip about what is going on in their communities and in the places where they and their families, hike, hunt, camp, fish, float or ski; and how they, their friends, and their cousins and their uncles and their aunts feel about it. Husbands were quoted at length and with respect that would warm your hearts, and I'll relay some of their more thought-provoking suggestions and comments later.

Women's interest in water problems is the same as our interest in any problems. We are interested in bringing about a satisfactory life for as many people as possible, as soon as possible, and as permanently as possible. Today I'll ignore the "possible" and talk about the problems and the solutions which interest us.

Women's interest in any problem is likely to start within their homes. We are interested in good and adequate water for our homes, and we prefer it to be soft, pleasant tasting, and economical.

We are interested in the more efficient use of water in our homes, too. We get criticized for our extravagant practices in the uses of water in our homes, and we are willing and even eager to reform. We will be happy to use appliances and plumbing designed to use less water more effectively and efficiently. Where can we get them? We welcome more information on how to manage our homes so that less water is used under existing conditions. Is there a handbook for this purpose? How do we get it?

Leaguers attending the water seminar in Portales last year were very interested in the remark of one speaker who observed that a brick in every toilet tank would save an impressive number of acre-feet of water. Some of us have tried it, but we haven't convinced any significant number of others to do so and results have been undiscernable. However, I was present at a gathering of Leaguers and their husbands (also known as the men's auxiliary) where there was talk of launching a League project using this speaker's idea. It was to be called, if I remember correctly, "A Gold Brick in Every Pot." At the time we were convinced that we had solved not only the problem of water shortage, but that of the gold drain as well. At this same symposium we finally came to the brilliant conclusion that what is basic to all water problems is over-population. A member of the League auxiliary came up with a suggestion for dissolving The Pill in the water supply. When the obvious objections were made by others present, he suggested His and Her water faucets to be used at the drinker's discretion. As you may have surmised by now, the water supply at this meeting was woefully inadequate.

Women are interested in new approaches to old problems where too much water is used and misused. Take problems of cleaning and waste disposal, for

example. How about these super-sonic devices for cleaning in our homes and elsewhere? Women are interested in any technique that will do the cleaning or waste disposal job, that will use very small amounts of water, that will be inexpensive, and that won't pollute anything. We leave the details up to you.

We are interested in having housekeeping made easier and homes cleaner and more comfortable - all without the use of water. We'd like to have our homes so free of dust and so easy to keep that by 2060 members of the League of Women Voters can concentrate on the problems of the Moon - where a good many people have indicated they wish we were already.

Women are interested in the sources of water for our homes, and in what happens to the water when it leaves our homes. We are interested in the economics involved in the ownership of the local water works, in the efficiency of the local sewage disposal plant, in the size of our water bills, in local ordinances dealing with lawn watering, and in the general attitude among both industrial and domestic users toward leaving water reasonably unpolluted when it is returned to the public domain.

Many of us live in the growing suburbs and we are interested in what sort of water and sewage systems are used there. We are interested in master plans for cities which take the problems of suburban water supply and sewage disposal into account, and which contain adequate plans for providing solutions to the problems. We are concerned about the danger that our underground water tables will be contaminated because of the increasing number of septic tanks. We are concerned that so little attention has been given to the threat of groundwater contamination. Women in the League realize that much of the problem is the result of public apathy and ignorance. Well, the official purpose of the League is to promote better government through informed and active citizen participation. Maybe we can help.

Women are interested in more than their immediate home and local water problems of course. Water problems everywhere arouse our interest and concern.

We are intensely interested in New Mexico. We are interested in preserving its priceless scenic beauty and those attractions of climate, tradition, and state of mind which brought many of us to live here in preference to our original homes. We like the space, the countryside, the traditions, the uninhibited inhabitants, and each other. We hope that by 2060 every New Mexican can choose his own most satisfactory way of living and can have an opportunity to earn enough money to afford it. We realize that water plays an infinitely important part in bringing about this happy condition.

Women are interested in legislation which deals with water problems. In every state and in Washington, Leaguers attend hearings and sessions dealing with them. We listen to testimony, try to find which other lobbyists represent who, and sometimes present statements. We are impressed with the importance of water power in politics and we have developed some appreciation of the effects of this power on the difficulties involved in solving the problems. We are interested in how legislation reflects pressures. We try to keep up with the resulting amoeba-like growth and rearrangement of all the outfits involved in coping with water problems.

Women sometimes wonder if perhaps the whole attitude toward management of water through legislation needs to be reconsidered. Let's assume that we can ignore tradition, pressure groups, and politics, and think in terms of what could be the best way to set up legislative rules for the use of our water. Couldn't there be a new and better approach to the whole business of water legislation? Somebody has mentioned doing away with county lines in such approaches - how about doing away with state lines and organizing the whole country according to the big river basins? Maybe by 2060 this will be Upper Rio Grande Basin University - how about that? The acronym URGBU has infinite possibility in college yells. Such universities might do much more to provide intelligent approaches to all kinds of related river basin problems, and they might be given more intelligent legislative support.

In short, women are interested in legislation which will result in a state (or a basin) filled with clear streams and prosperous people surrounded by lovely and unspoiled scenery, excellent roads, good schools, adequate markets for products, and happy fishermen, water skiers and yellow-rubber-boat nuts.

Women are interested in new sources of water, water now considered unuseable in our area - the brackish, the saline, and the polluted. We are told that New Mexico doesn't use nearly all the water it has available, but that much of the unused water is too brackish or saline or otherwise polluted to be useable. We are interested in the answers, and in more publicity for the answers, to such questions as these:

How is the work with salt tolerant plants going?

Is use of brackish water in the secondary recovery of oil practical?

Can saline and brackish water have the sal and brack removed economically enough so that its use is practical? Could this water be used in our homes?

Are there ways of turning waste products resulting from removing pollutants from all these unused waters into fringe benefits instead of further problems? Are they economically sound?

What is this about Kennecott Copper reusing water in its operation in Grant County? Are the processes applicable in other industries?

Is it possible to establish stringent standards for rural, municipal, and industrial withdrawals from both surface and underground sources so that careful reuse will be encouraged?

Are there techniques being used successfully elsewhere which would help solve water problems here? At the Jordan?

Women are interested in specific ways for individuals to make their livings, agriculture, for example.

We realize that New Mexico can never compete with the Imperial Valley in agricultural production, but it can certainly compete in providing satisfactory opportunities for its citizens. We are convinced that farming is the most satisfactory way of life for a good many people, and we are equally convinced that we would be more sensible to encourage such people to farm where they are most content rather than to force them to drift in desperation to large urban centers where they are miserable and where they can become involved in much greater, graver, and costlier problems than those posed by marginal farms, properly used.

Agriculture in New Mexico automatically means irrigation, of course, and irrigation automatically means water problems. We know that agriculture by irrigation is an ancient and honorable occupation in these parts - that there were thousands of miles of irrigation canals in the Southwest long before the Spanish brought in Pueblo Water Rights and casually documented royal land grants. We sometimes wonder what the pre-Columbian water rules were like.

Certainly since the days of Coronado the rules for irrigation have been proliferating and becoming increasingly complicated and confusing. Women hope that by 2060 irrigation laws will be sensible, effective, and productive. We are interested in irrigation practices which will give people who choose to farm a satisfactory life and which will take into account broader views of our over-all welfare in terms not only of gross national product, but in gross national satisfactions as well.

Women are interested in the work of such institutions as State University in development of better agricultural techniques. We occasionally visit your demonstration farms and wish there were a more ambitious program involving them. We hope that by 2060 demonstration farms will be an integral part of rural life all over New Mexico, or Rio Grande Basin, or whatever it's called then, and that they will be leading the way to improved

water management in agriculture, in better crops, and in more prosperity for everybody.

Other kinds of job opportunities interest women, too, of course. We recognize that water plays an infinitely important part in employment in New Mexico. We realize this means industry. We have noticed that a good many well publicized industries tend to bring their own workers and additional new problems with them, while others tend to exploit our natural resources in ways that do not result in beneficial use (if I may borrow a familiar phrase) so far as New Mexico's economy is concerned. We are interested in the development of industries that will use the people and the skills at hand as much as possible, with optimum benefit to New Mexico. This means special training and imaginative use of those skills and resources peculiar to New Mexico, but proof that it can be done exists in Laguna, in rare spots on the Navajo Reservation, and here and there in our larger population centers. Examples are disappointingly rare, and we hope they increase soon and regularly.

We hope that the talent of New Mexico's people for good cooking, good handcrafts, and good manners, can be used to increase the number of job opportunities in ways that will provide jobs without drastic changes in established ways of life here. Travellers are all only too familiar with the rarity of the good things New Mexico can supply in the rest of our land of the fried and home of the slip-shod. Women are interested in seeing these attributes made the most of in ways that will provide good and interesting jobs with adequate pay. The connection with this ideal and water is, of course, through wise management of water for recreation, and careful conservation of as much of our natural beauty as possible, so that the necessary consumers will be at hand.

Women spend a lot of time going with our families on camping trips, hiking trips, skiing, fishing, and floating trips. We are often the ones who act as camp cooks, cleaners of fish (or providers of substitutes for uncaught fish), and pickers-up of the family yellow-rubber-boat nuts at the end of float trips. What this amounts to is that we do spend a lot of time waiting around and staring at lakes and streams. If you stare at water enough in our recreation areas you can't help noticing signs of administration agencies. Women are interested in the administration involved in water management.

We are heartened by signs of closer cooperation among the bureaus, agencies, corps, and departments involved.

We are concerned about the disadvantages under which local populations find themselves operating when large water projects are constructed in their areas. We are concerned with the way Parkinson's Law functions in the structure of

the various types of governmental organizations involved. We have an uneasy feeling that too often unblameable tables of organization can victimize the people in those organizations as well as the local citizens. Some of us women live in conservancy districts, soil conservation districts, watershed districts, and we see first hand that not everything works out as well as could be hoped. We are pleased that most of the people involved are interested in the problems and not their own personal stake in the process. We are sorry this is not true of all of them. We hope that by 2060 all these organizations will be staffed by well paid saints, operating in an atmosphere of well informed and cooperative local citizenry and industry, and administered by geniuses with technical background and human experience that enables them to understand problems instantly, appreciate new ideas and properly reward their creators, understand the personal problems of all staff members involved, and produce flawless public relations and working arrangements with the news media and the involved local population. It goes without saying that a warm rapport will exist between these administrators and all other administrative heads on all levels of international, national, state and local organization - and even with their interplanetary counterparts which will undoubtedly exist in 2060. The Chambers of Commerce and the Sierra Clubs will love them, one and all.

Women are interested in the ideas and proposals that have come from even our present day less-than-perfect government water organizations. We are sometimes dumbfounded by the scope - but we're interested. We come away from some meetings with the feeling that by 2060 this continent will be one great swirl of water from the Great Lakes, Canada, the Mississippi, Missouri, and the Northwest, gurgling and rippling through engineering marvels throughout the Southwest and on into Mexico. Some of us have association with scientific experts in our own homes, and have discerned a charming but alarming tendency for wanting to try something big, disregarding the cost! Women are interested in costs, and we are interested in knowing if all other water sources are being adequately explored, even if they aren't so glamorous and appealing. We are interested in Mr. Dominy's report on costs and we wonder what all this will mean to our descendents when they pay their water bills and tax bills in 2060. We wonder, too, what will be happening back in Michigan, Louisiana, Saskatchewan, and Oregon?

We hear a lot about weather management - particularly in newsletters coming from the office of Senator Anderson. We know he has produced remarkable developments in Twenty-First Century type scientific industry before, and we wouldn't really be surprised to see him get this one started too. We are sure we'll be happy to have snow-on-demand on our ski slopes, rain-on-demand in our agricultural and residential areas, and sunshine-on-demand for our family picnics. We are interested in the solutions for problems arising out of weather manage-

ment, too. Even in our blissfully ignorant state we can forsee that the legal, technical, and sociological problems will be formidable. For now, we'll just leave those details up to you.

When we think of wise water management in the next hundred years, we realize that probably most important of all is flexibility in approach to the problems. Nobody can predict what we will be faced with, or in what sequence the problems will arise, and which solutions will create more problems than they solve. Women are interested in helping to create an atmosphere of well informed citizens who will accept imaginative and intelligent approaches even when they aren't dramatic and even when they are unfamiliar. Each problem deserves its own special consideration and all points of view must be respected. In order to arrive at this Utopian situation, we feel that people must become informed and active participants in the solving of the problems. Government must supply the machinery through which this participation is possible. Women in the League know from experience how difficult this can be, but we also know from experience that it is possible.

I couldn't help thinking, as I worked on this talk, what a housewife in Las Cruces in 1868 might have said if she had been asked to talk about water and what she hoped to see in its development by 1960. No matter how wild her imagination, nor how impossible her proposals might have sounded in 1868, she couldn't have come near to the realities of what has happened to water use during that time.

We hope you professionals won't underestimate your possibilities. You and your predecessors have accomplished the wildly impossible with regularity for over a hundred years now.

Women are interested to see what in the world you will be doing in the next hundred.

WATER RESOURCES PLANNING IN THE STATE OF CHIHUAHUA

Ing. Carlos Carvajal Zarazua[1/]

Before I read my simple writing about the planning and uses of water resources in the State of Chihuahua, on behalf of the Secretary of Hydraulic Resources, Mr. Jose Hernandez Teran, I want to thank the New Mexico State University and coordinator of this Thirteenth Annual New Mexico Water Conference for inviting me to be with you today.

There are, in the State of Chihuahua, vestiges of pre-hispanic works for the use of water, according to the discovery of a rudimentary system of canals in the Paquime ruins in Casas Grandes. Later, in colonial times, the water of the Conchos River was used to irrigate lands near San Francisco De Conchos. Moreover, during the same time were built several works to give water to communities, works that are still in use, like the aqueduct serving a part of Chihuahua City.

The use of water on a great scale began in 1916, when a privately owned construction company built the Boquilla Dam on the Conchos River near Camargo City, with the main purpose being electric power production, but the planned exploitation of water resources started in 1926 when the National Commission of Irrigation was created, to later be transformed into the Secretary of Hydraulic Resources.

At the beginning there were a lot of handicaps. There was no available data of any kind, the lack of Mexican technicians and, above all, the limited economic situation did not permit making reality of the big hydraulic works the country needed.

The experience obtained during forty-two years of irrigation activities, has taught us there must be two kinds of works, "big" and "small," according to the characteristics of the flows and the purposes of each project.

The best economic results are, generally, those of the so-called "big irrigation," because of the facilities in communication, credit, transportation, etc., facilities that most "small irrigation" works lack.

Considering that, the Secretary of Hydraulic Resources gave preference to "big irrigation" projects in the State of Chihuahua, building the following dams and their canal systems.

1/ General Manager of the Secretary of Hydraulic Resources, of all the works and studies in the State of Chihuahua, Chihuahua, Chihuahua, Mexico.

Boquilla System, with a capacity of 2,430,000 acre-feet to irrigate 78,000 acres in Saucillo and Delicias valleys.

"Francisco I. Madero" Dam on San Pedro River, with a capacity of 345,000 acre-feet to irrigate 61,000 acres in Meoqui Valley.

"El Tintero" Dam on Santa Maria River, with a capacity of 105,000 acre-feet, to irrigate 10,400 acres in San Buenaventura Valley.

"Abraham Gonzalez" Dam on Papigochi River, with a capacity of 57,000 acre-feet, to irrigate 13,600 acres in Guerrero Valley.

"Las Lajas" Dam on Carmen River, with a capacity of 73,000 acre-feet, to irrigate 20,000 acres in El Carmen Valley.

Under construction is "Luis L. Leon" Dam on the Conchos River with a capacity of 690,000 acre-feet to irrigate 18,500 acres in the Ojinaga Valley and to avoid floods, which, in the past years, caused disastrous losses in lives, lands and cattle.

In project is San Diego Dam on Casas Grandes River, with a capacity of 200,000 acre-feet, to irrigate 20,000 acres in Casas Grandes Valley and San Gabriel Dam on Florido River, with a capacity of 120,000 acre-feet to irrigate 17,000 acres in Jimenez Valley.

With the last three dams and systems the "big irrigation" works are finished, because there is no other flow left that can be used in great scale.

There are other rivers, of course, like the Urique, Batopilas and Chinipas that cross the Sierras, but there is little land to irrigate and it would be antieconomic, for the moment, to build any work.

The "small irrigation" projects have always had one thing in common, to give small communities better ways of living at low cost.

The "small irrigation" national plan is aimed to build several works in order to use disseminated areas all over the state, works that will be of high social value, for they represent the indispensable to a lot of rural communities, in their necessities of water for human, livestock and agricultural uses. Those works will also serve to stop the flow of impoverished farmers to cities, a cause of many urban problems.

The following are the small works in service nowadays:

"Torreoncillos" Dam on Valsequillo River, irrigating 4,000 acres in Valle de Allende.

"La Ferreña" Dam on Valle de Allende River, irrigating 3,000 acres in Valle de Allende.

"Villa Lopez" Canals on Florido River, irrigating 4,600 acres in Villa Lopez.

"Esmeralda" Canals on Conchos River, irrigating 3,700 acres in Ojinaga Valley.

"Independencia" Dam on Nuevo Madero Creek, irrigating 2,300 acres in Madera Valley.

"Laguna Colorada" Dam on Casas Grandes River, irrigating 2,500 acres in Ascencion.

"Chinatu" Tank and Canal on La Quebrada Creek, for human, agricultural and hydroelectric uses.

Under construction are the following:

"Casa de Janos" Dam and Canals on Janos River, to irrigate 2,700 acres.

"Las Chepas" Dam and Canals on Bachiniva Creek, to irrigate 1,850 acres.

The projects are as follows:

"Calabacillas" Dam on Calabacillas Creek, to irrigate 1,200 acres.

"Agua Caliente" Dam on Gandara Creek, to irrigate 1,200 acres.

"El Pajarita" Dam on Pajarito Creek, to irrigate 1,200 acres.

"Bella Vista" Dam on Sauz Creek, to irrigate 2,700 acres.

"El Vallecillo" Dam on Vallecillo Creek, to irrigate 5,000 acres.

"La Junta" Dam on Basuchil River, to irrigate 5,000 acres.

"Bufalo" Dam on Parral River, to irrigate 4,300 acres.

In project are, also, a lot of wells, small dams, drinking troughs, and everything related with water to help hundreds of poor farmers all over the state, but especially those who live in the northeastern part, where rains are scarce and soils arid.

The use of subterranean waters is important, since they permit putting into production arid zones, or as a complement of big and small irrigation works. Many studies have been done in this matter, localizing the geohydrologic zones of the following valleys:

Juarez, Casas Grandes, Delicias, Villa Ahumada, Aldama, Camargo-Jimenez, Chihuahua, El Sauz, Palomas, San Buenaventura and Cuauhtemoc.

In those zones, with the exception of Juarez, are in production 1,246 wells, irrigating 114,130 acres.

In Juarez Valley, where 383 wells at variable depths give fair to bad quality water and hardly irrigate 20,000 acres, there was found a big artesian reservoir at 1,500 feet with a 130 feet deep dynamic level and, in many cases, with 16 foot-high jets of artesian water. In that zone drilling has been started on 80 wells 24 inches in diameter, to solve definitely the lack of water in the second and third units of the system.

An inventory of the reserves in the mentioned zones is now under study, to be able to plan the exploitation in an adequate way, avoiding a strong drop in the water levels. When a zone presents such a symptom, it can be of very bad consequences, a sort of prohibition is decreed, a prohibition that in no way means there must not be any new drilling, but to ration the uses of the existing and future wells, to use the strictly indispensable water.

In the field of water for domestic, industrial and recreational uses many works had been done, but, as everywhere else in the world, the necessities are always bigger than the water available.

The efforts of the federal, state and municipal governments, are coordinated to give water to 1,600,000 people. Almost half of them have no drinking water, getting it from brooks, springs, wells or car-tanks.

To solve that problem, the federal government through the Secretary of Hydraulic Resources, is doing the studies and projects, supervising the works and contributing with pipeline, pumps, and special parts. The state and municipal governments and even the people to be benefited by the works, contribute with labor and complementary funds. In that way, working united, we hope that by 1976 no town, big or small, urban or rural, will be without the most elemental of all services: drinking water.

According to the state's necessities and its economic and water disposibilities, the Secretary's activities have been basically considered following a definite plan that had permitted a reduction of waste and duplicity of works and studies, and, above all, seeking to improve the people's way of living in its social and economic demands.

To accomplish that, one of the activities developed is integral planning for the correct use of water resources, to get, with the finished works, the maximum benefits in the shortest time possible, so the state can be in a good economic situation to go on with future works and projects, all of this with a tendency to increase the water reserves and irrigating areas.

In those plans is the widening of geohydrologic studies in producing zones and the exploration to find new subterranean reservoirs, to obtain the best results in the water-soil binomium. This is very important, because in irrigating the field, it is fundamental to increase the agricultural production in proper proportion to demographic growth and the economic development of both the state and country.

OVERPOPULATION AND YOU

Dennis E. Shoemaker[1/]

It is unfortunate that the problem I am to discuss does not lend itself readily to popular expression. Though writers in the field have used terms designed to catch the public fancy, such as "population explosion," there is little concerted awareness of the overall dimensions of this problem, and even less concern about how it will affect our future existence as a nation and as a world. Part of the reason for this apathy is, of course, that we are not as yet overcome by the effects of an increased population that will soon exhaust the physical resources needed to sustain it. We have plenty to eat, room to move about, and we are used to thinking that our resources are taken from a bottomless pit. An important link in our spiritual heritage is the belief that we learned from the pioneers - that there is an inexhaustible supply of resources, and that when things get a bit crowded you need only move further west.

As an Easterner, often perplexed by the density problems of a great metropolitan area, I can understand this belief when I am in the vast open spaces of the Southwest. From the standpoint of a Philadelphian, it seems rather curious that I should be speaking of the population problem in a state that has a total population of less than one-half of the city of Philadelphia and about one-fifth of the greater Philadelphia area. But it is short-sighted to think of the problem in these terms. Your concern with water resources points up the problem much more significantly, so that it becomes stated in terms of the population a given area of land will support. Put this way, it is quite possible that New Mexico is more crowded than Philadelphia or New York City. You may even be overpopulated.

With this factor in mind, what is the evidence that there is a population problem? First, let us bear in mind certain statistical matters. In general, we may say that world population is growing at approximately twice the rate of available food resources. The population growth figure is slightly more than two percent annually. Food resources are increasing by about one percent. What this means in terms of population is that the 3.4 billion people presently alive in the world will become 7.4 billion by the end of this century. Here we must be careful to understand that when talking about percentage increase that the calculation works like compound interest in respect to one's savings account. If you take, for example, an imaginery village of a thousand people who in 1965 each had a bowl of rice per day, apply the percentage figure 2.5 (which some population experts claim is a more correct figure), there would be 1,280 people in that village by 1975. But, given a one percent food resource increase,

1/ Editor of Trends, Philadelphia, Pennsylvania.

there would only be 1,105 bowls of rice. Twenty-five years beyond that, at the year 2,000, the original 1,000 people become 2,373, and 1,000 bowls of rice become 1,417. This means that whereas at the beginning of this period each of the 1,000 people had a bowl of rice a day, thirty-five years later there would be nearly a thousand people in the same village without any rice at all. Notice that our imaginery village is not in some remote part of the world, but is in some sense a microcosm of the world itself. If we then overlay on that model actual world population, and projected increases in population and food resources to the year 2,000, we can foresee the most awesome tragedy in all history. But that tragedy is already begun. Taken on an average, there is not now a bowl of rice a day for all the world's citizens. If we also consider the noticeable fact that we are gluttons at the table, we are forced to conclude that the great wheel of world starvation has already begun to turn for a sizeable portion of the world.

We may look at the problem of a mounting world population another way in order to impress upon our minds the sheer weight this problem is. Right now world population is growing by something like a million and a quarter every week. By 1980 that figure will become a million and a half; by 1990 it will jump to two and three-tenths millions; by the year 2,000 three and three-tenths million new world citizens will join us every week of the year. This represents a staggering problem in assimilation. Cold statistics such as these begin to take on meaning when one thinks about the additional number of houses, schools, jobs and other requirements for living that will be needed. Assuming for the moment that it is possible to assimilate one million people each week - to offer everyone what is minimally required to live beyond the mere subsistence level - is it possible to undertake this project when the figure is three times what it is now?

There are other ways to describe the problem. We can, for instance, think of the land area required for over seven billion people to live. The land area of the world is 52 million square miles. Only one-tenth of that, or 5 million square miles, is presently suitable for cultivation. Taking into consideration the varying types of land used for agricultural purposes, something like one-half to one full acre of arable land is required per person to fulfill his minimum needs. On the basis of one acre per person, the present population increase each day necessitates the cultivation of 180,000 acres of new arable land. This is 281 square miles, or an area the size of Chicago. If you feed 650 pounds of food a year, the average in starvation plagued India, to each additional person now being added to the world's population, arable land area the size of the state of Colorado is required. That is according to the annual rate of increase at present - better than sixty million a year. If you look ahead to the year 2,000 when the figure projected is one hundred eighty million a year, you have to add New Mexico and Arizona to Colorado to get the additional arable land needed yearly.

Now arable land in anything like this quantity is simply not available. Land mass is limited, and it is not possible to go on adding areas the size of Colorado indefinitely. Moreover, such undeveloped farm lands as now exist will not be sufficient unless there is radical advance in agricultural technology of the kind that can turn the desert into a garden, can refurbish the topsoil in the tropical rain forests, and can bring water to vast areas of the world where the soil is now arid.

Being part of a large urban area, my own interest in population increases is partially reflected in the problem of urban density. In the greater Philadelphia area, which includes a part of New Jersey and Delaware, the present five million population is scheduled to jump well past the eight million mark in thirty years time. As is well known, the Boston-Washington, D.C., corridor is becoming one great megopolis. Now it is possible to put eight million people in the same space where there are now 5 million, provided somebody plans for this. But let me tell you about how we have thus far failed in our planning in reference to water. Both New York City and Philadelphia tap from the same Appalachian watershed. During the recent eastern drought that lasted for five years, this normally ample and productive watershed began to dry up. Now there are agreements between the two cities and others regarding how much New York can tap per day, in order to guarantee that there will be enough water still flowing down the Deleware River so that Philadelphia's needs can be met. But New York was drying up at an alarming rate and so they took their full quota rather than a reduced percentage quota. As a result, the salt line at the Delaware River mouth began to creep up the river toward the intake. It became daily news on the radio, along with the weather and traffic reports. The man on the radio would say, "The salt line has now reached the airport." The next day he would intone, "The line has moved forward to the Navy yards." I tell you, that was scary business.

If you put eight million people where there are now five, and if you can imagine a megopolis running from Boston to Washington, D.C., it is clear that something has to be done about the water requirements other than praying for rain - which incidentally is not the answer. Water requirements for the expected population in that area will be so great that if rainfall alone is depended upon, it would have to rain constantly over the whole eastern section of this country. Those who care to speculate about this problem talk mostly about desalination of the Atlantic Ocean and tapping the water resources in the upper reaches of Canada.

Problems involving density are reflected in other ways than the need for an abundant supply of water. How will people live? Buchminster Fuller has projected a mammoth pyramid city, something that looks remotely like a colossal building but which is really a complete city in itself capable of supporting 200,000 persons who would theoretically never have to step outside and breathe polluted air. The Russian Exhibit at Expo included a similar plan. Both of

them suggest a beehive or rabbit hutch approach to living. Now it is possible to live like that. Hong Kong, Tokyo, and even New York City illustrate, without any noticeable effort at planning for this, that people can adjust to a vastly increased density rate. It is not certain, however, that it can be done for long without serious consequences to the health of people. Experiments with mice suggest that higher population density reduces general health and longevity.

Overall, there were 40 people per square mile in 1930. By 1965 there were 63, and by the year 2,000 there will be 142. At present Europe has the highest density with 233 people per square mile. But by the year 2,000, Europe will have 301 and Asia will have jumped to 423. This means that by the year 2,000 there will be two acres of land arid and arable available per person where there are now three. But in largely rural and undernourished Asia there will be only 1.5 acres of land per person. We are talking here about total land. Of this total only a fraction is suitable for habitation by present standards, and even less for cultivation.

The statistical problem is expressible in still another way. It took about two million years, all the way to 1850, to get one billion people together on this planet at the same time. In the next 115 years, 2.4 billion were added. In the next 35 year period, bringing us to the year 2,000, 4 billion more will be added. In the next decade the world's population will increase by one New York City per month, 8 million people. In the final decade of this century, two such cities will be added monthly.

One of the tragic factors in this explosion is that the great masses of new population will be added to the nations of the underdeveloped part of the world. Presently two-thirds of all the world's people live in Asia, Africa and Latin America. By the end of this century four-fifths of the world's people will live there. What this means can be seen in terms of Central America, a region growing at the rate of 4.3 percent each year. In 1965 there were 56 million people there, but in less than 35 years there will be 195 million. In the year 2,000 alone just under ten million new people will be added to the Central American countries. In that same year India will add 30 million and will have a total population of one and a quarter billion. Comparatively, the United States, growing at 1.8 percent, can hardly be said to have a problem at all. We will add 6.5 million in the year 2,000, bringing the total population to 360 million. I do not mean to say that there are no serious problems for the U.S.A. Our slower rate of growth suggests the possibility of assimilation, but there will be immense social, political and human resource problems, some of which we have already indicated. There is the possibility, for instance, that our major cities will have to be torn down and rebuilt. It may be necessary to stop the urban drift and to develop totally new cities in the more sparsely settled areas of the land. This will mean colossal projects involving

the total economy of living, and, of course, overcoming our water deficit in areas where new cities will have to be located. But such problems are infinitesimal when compared with those faced by the underdeveloped nations where four-fifths of total population will be found.

It should be clear that the problem we are discussing cannot be seen in terms of a single dimension, as if the answer is to miraculously provide sufficient food and water to India which will have one-sixth of the world's population thirty years from now. That alone would be a great help, of course. But its possibility is questionable. Even if that could be done, the real needs of the stricken nations extend into every aspect of their social and economic environment. For example, half of the city dwellers of India must carry their water from ponds in heavy jars for great distances that force its limited use. Also, the increasing demand for water means that its purity cannot be guaranteed with the result that the threat of tuberculosis constantly hovers over the crowded masses. It is not, therefore, just more water that is needed in India, but a whole new system by which water can be made available for industrial use as well as individual consumption. This illustrates that a wholistic approach is required to head off the catastrophe that has already claimed thousands upon thousands of lives, that has made these nations desperately poor, and posed the likelihood of suicide revolutions.

But even here there is a curious irony. Sometimes the population explosion is misunderstood in that it is assumed the real cause is a rising birth rate. In fact, this is not the cause. Birth rates are remaining rather constant in most areas of the world, and have even dropped in a few instances. One of the real reasons for the population increase is increased longevity. New medical techniques and the availability of health services in almost all parts of the world have lowered the death rate. Infant mortality has decreased substantially and the age span has lengthened. To put it sharply, people live longer and clutter up the earth, use up its resources, and demand an increasing amount of services, and then some of them die of starvation. Now there are certain amoral types who say that the problem will be eliminated when the big bomb hits or there is a great epidemic. Of course, this perversion of Malthusian doctrine hardly rates a respectable reply. Nevertheless, it is a matter of extreme irony that the successful attempt at saving life has helped put whole continents in jeopardy.

Now we could decide that the problem is so far beyond the bounds of our own country, and, in light of the particular and peculiar problems we face in the United States, that we should forego American planned attacks on the world problem. Or we could take an intermediate step and go with the Paddock brothers who in their book, Famine - 1975, recommended the triage theory which is to concentrate aid on the salvagable nations. In their interpretation, India is a lost cause, but Pakistan isn't yet at that stage. Since we do not have

enough essential resources to go around wherever the need is, we should focus what we have where something can be salvaged and by-pass hopeless situations such as India. I must say at once that I have yet to find anyone who does not find the Paddocks' approach entirely repugnant and politically impossible. But the situation is so serious that they may, in part, be right.

Yet, how can they be? Imagine, for instance, the political consequences for a free world if India is abandoned and Pakistan is favored. Abandonment of India would automatically be interpreted to mean that we no longer care about the fate of millions of human beings, whether twelve million Indians starve or live in the coming year. What this means is that the strategies involved in solving the problem of world hunger immediately become political and economic factors of importance likened unto who has the bomb. If Mrs. Gandhi says the wrong thing President Johnson can withhold aid or cut it back. If De Gaulle gets out of hand, a change in our own aid program and policy can force him to act in a different way. In such ways a rich in resources United States can empirically decide the political course of much of the world.

In any event, it becomes clear that the feeding of the majority of the world's population must involve the entire economic, social and political structures of the nations of the world - both our own and the underdeveloped. CARE Packages, noble as their sentiment is, just will not do. Charity even becomes a questionable virtue when the whole of the economic, industrial and social structures of these lands are not taken together and seen as requiring the maximum kind of restructuring. Neither can such an effort be the result of one nation's undertaking. What is required is the resources of the total free world, and of all the nations that live in abundance. What is also required is an intensification of development within those nations that are presently victims of the dual assault - too many people and too few resources.

So great is the problem that I am now forced to say something that may evoke surprise and even anger. Since 1947 the United States has been guided in its foreign policy by the basic elements of the Marshall Plan. The plan, in its more generalized form, has eventuated in what we now call the containment policy. That is to say, what began as a humanitarian effort to rebuild a war ravaged Europe soon became a policy to stop the spread of Communism. So we undertook to rebuild Germany, for instance. And thus NATO. This policy, begun in Europe, was soon transplanted to southeast Asia and took on a military coloration in the Korean War. This was followed by SEATO and now the Vietnam war. It is not my purpose to discuss the morality or immorality of our participation in that war, but I think it is fair to say that the generally accepted ideological justification for being there is to contain the spread of Communism.

Where the surprise comes in is that I think there is a very credible argument in favor of dropping the containment policy as now interpreted because it is no

longer relevant. From my point of view, the most sensitive problem the emerging world faces is exploding population coupled with its overall "have-not" quality in Asia, Africa and Latin America. Based on the evidence, the countries of these continents - which we may call "the Third World" - either will be forced to go backwards into a primitive and jungle-like existence, or they will face a catastrophic future unlike anything recorded in the history books. It is this fact that is throwing our old East-West polarization out of kilter and rendering it obsolete. I think, in light of the evidence, that the future indicates a much closer relationship between the nations of the present free world and the Communist nations who will together become engaged in a new polarization with the "Third World."

My point is this: I think it time for the free world to address itself to the problems of the "Third World" with the kind of diligence that has up to now been given to the warding off of Communism. In that case, the Vietnam war, seen as the attempt to build a barrier beyond which Communism cannot spread, may be a mistake for two reasons. One, we are pouring fantastic resources into this war to create further ravaging, misery, death and poverty - resources that would go far to alleviate the horror the "Third World" must now endure. Two, we are fighting those whom we may imagine to be our allies in the future when the full impact of the "Third World" forces a new polarization with the presently divided East and West. In short and in particular, the United States and Russia will be forced to become allies in the struggle with the "Third World."

It is possible to discuss this particular aspect of the population explosion at length. It can be seen, for instance, that there is a growing sense of mutuality between Russia and the United States, as is indicated by the Moscow to New York City air flights that are soon to begin. We may see that in these and other more subtle manifestations of cooperative strength that the old pattern is breaking up, that our old animosity to Marxist's theories is not completely justified in political history, and that the future will demand a new perspective on the old enemy. This will not come because of a natural inclination for reconciliation, but because four-fifths of the world's population will provide us with no real choice. If that is so, then our present struggle in Vietnam must be re-evaluated, as a possible determent to the original aims of the Marshall Plan which were to provide the oppressed of the world with the resources necessary to make them self-sufficient and independent. One may imagine that this responsibility will be shared jointly by the nations of the free world and the Communist nations.

A hard look at the population problem and its possible effects usually brings forth the response that one ought not be such a pessimist, that things usually work out some way, and that good ol' American know-how will win the day in the

end. We are so used to thinking of ourselves as Mr. Clean that it is difficult for us to take any problem really seriously. Science, technology and a general spirit of uninvolved optimism has put us in a position in which we look for the relatively easy and sure answer. So we say, "All you have to do is . . ." But what a tremendous "All!" Thus I must answer the oft-repeated charge of pessimism - the kind that implies defeat, that admits to no possible and workable solutions.

I do have a solution that can be stated in the most broad and general terms. It is for the United States to radically revise its way of thinking about the way in which the world is divided. The older ideological warfare is rapidly becoming antiquarian, and we are rushing headlong for a catastrophic struggle between the "have" and "have-not" nations. The political struggle has become a moral question in proportions unlike anything we have ever known. What the rich world and the richest country in the world must decide in the very near future is that its present military and space ventures are inappropriate as we now interpret them. If we continue to contain Communism in the old way, we reduce the possibility of ally strength with those countries that will be needed to deal effectively with the "Third World." If we reach the moon and conquer that, future historians may say of us that we conquered the universe and lost our souls.

But offering that kind of a solution certainly does not qualify me as the world's leading optimist. Nevertheless, I want to shun the tag of pessimism. There are things that can be done, that must be done and quickly. The first requirement is to establish a priority system in which human want and need - in the face of mass starvation - becomes a more important problem to solve than landing on the moon, and the investment of 30 billion dollars a year in the development of human resources and possibilities becomes more important than containing Communism. We cannot be said to be involved in a vital attack on this problem if political criteria interferes with the dispersal of grain to India, as was the case in 1966. Neither can we be said to have looked at the problem and what it suggests for the future with clear-eyed horror when aid appropriations were cut back in 1967. We again show our disinterest in the matter when we pollute our own streams, erode our land, and generally waste more food than the average Indian citizen eats. We need, then first of all a change of attitude - which comes with some understanding of what the poorer two-thirds of the world is now facing, what four-fifths of the world will face, and what we must be prepared to face in the lifetime of many of us.

Secondly, we must radically revise our understanding of what it takes to feed the world now, and what it will take in a few years when the requirements will greatly exceed what they now are. This understanding begins with a stark fact:

the granaries we were worrying about a few years ago, where we were storing wheat and other surplus commodities, are now empty. The old Liberty ships tied up in the Hudson River that were filled with wheat have been scraped clean. But now a second fact: if all the ships in the world were to be loaded at once with foodstuffs for the hungry world, there would still not be enough food to go around. We get some idea of the dimensions of this problem if we examine the caloric intake factor. The United States government recommends that a 45 year old man should have 3,200 calories per day to meet normal energy demands - something on the more active side than sitting behind a desk all day. The absolute starvation level is 1,350 calories, if there is a balance of proteins, starches and fats. But since such a balance does not exist we must assume something like 1,750 calories per day as the absolute minimum, for want of proteins and fats. Given the present rate of food resources increase (1 percent) and a conservative rate of population growth (1.8 percent), there will be a mere 1,340 calories per day as a world average by the end of this century. This can mean only one thing: that our vaunted technology must go to work at once to discover the means to rapidly increase production everywhere in the world. Fact number 3: The rich nations have been regularly robbing the poor nations of vital protein foods and giving back starches in the form of grain. This fact is related not alone to a kind of international bartering system whereby protein foods are made payment for bulkier foods that have a high starch content; it is also related to our vast foreign industrial investments in which capitalistic enterprise takes on an empirical quality. A fourth fact: Attempts to establish productive possibilities in the hungry world, noble as they may be, cannot exceed the demand stemming from rapid population increases. The Aswan Dam, for example, is estimated to eventually increase Egypt's agricultural production by as much as 45 percent. But during the time the high dam is being built Egypt's population is increasing by that much.

Next, it is clear that the world's understanding of the meaning of childbearing must be revolutionized. Here we enter into a most complex subject, one to which we cannot expect to do justice in the scope of this address. We must ask at the outset what must be done to lower the birthrate. Moreover, we must ask what it means to lower the birthrate in specific cultures where the birth of a child has specific religious and psychological meanings that are not immediately clear to us. For much of the world's history, the birth of a child was considered something like legal tender, a positive and contributing asset. Children promised a labor force, an army, and offered the real possibility for the physical control of land. Sheer numbers indicated potential power. To populate the earth meant the possibility of subduing it - a Biblical injunction, by the way. In the Third Century Tertullian argued with the Roman emperor that the number of Christians had multiplied to such an extent that any policy of liquidation was bound to fail. As we know, Catholicism has made much of this ideology in the past. So has Communism. A Chinese political leader is supposed to have said that she need not fear World War III since she

could not be expected to lose more than 400 thousand of her 700 thousand people. Emerging with 300 thousand survivors she would soon be able to dominate the world.

But there are other critical aspects of this problem. An Indian peasant farmer or villager is inclined to estimate his value as a man in terms of a surviving son to carry on the family name. In order to gain this asset, to insure such a son, his family planning might include seven children, four of whom would die in infancy, two of whom might well be girls, leaving him one son to carry on for him. It takes no deep insight to understand that this man must undergo a radical change of perspective when it becomes clear that infant mortality has dropped and that he need not father as many children to achieve his goal.

In certain parts of the world fathering children is a test of manhood. A grim illustration of this is found in Latin America. A year or so ago Oscar Lewis published La Vida, an account of five Puerto Rican families in the culture of poverty. Now the word"La Vida" means "the life," which is a way of saying that one is living the life of a whore. What comes through to me in this study is that the poor women in this study related themselves to a number of men for purposes of survival, and that the price exacted by each man was giving birth to a child. I do not suggest that we can successfully by-pass this notion. In some sense, children are the test of manhood or personhood. But when this notion becomes governing - particularly within a culture that has few other opportunities to express personhood, it becomes clear at once how very difficult it is to establish a realistic program of family planning.

Nevertheless, gains are being made in this area. Japan, for example, has begun to stablize her population growth. In India, it is common to see along the roadside large billboards urging women to use the Intra-Uterine loop. Clinics and family planning agencies have sprung up in hundreds of places. But again we are tempted to an easy solution, to suggest giving out the pill in wholesale doses, and to think that five dollars worth of contraceptives are worth a hundred dollars of foreign aid. The fact is that an illiterate woman who does not even know how to read a calendar is not capable of using the pill. In addition, even if full scale use of contraceptives were to be employed as of now, it would take a number of years before the impact of a declining birth rate would be felt. The children already born, who will have to be fed, schooled, employed and housed in the next three decades have already posed the problem.

This problem, as it affects Roman Catholicism, is causing a significant change in Catholic thinking. Last summer I was part of a seminar in New Mexico in

which Father Arthur McCormack of London was a participant. Father McCormack is one of the leading population experts in the Roman Catholic Church and was responsible for some part of the thinking on this subject at the Vatican Council. It so happened that I quoted him in my magazine from a 1962 book in which he put forth the notion that contraception was against the teachings of the church, and hence God. When I talked with him, he agreed that the quote was accurate, but that he had completely changed his mind in five years, and could he please send me an up-to-date statement showing the change. I agreed to this, and the statement indicates his own position: that the church will soon find a way to advocate the use of contraceptives. Privately, he told me that is now his position, and he believed that the Bishop's Council meeting in the fall of 1967 would accept that position. As a matter of fact, it has not, but the indications are that it will eventually modify its stand considerably. In fact, in 1967 a study commission produced a majority report in which that modification was outlined. The Pope, however, found reason to accept, at that time, the minority and conservative report.

To conclude this discussion of the population explosion, we now turn to an often neglected aspect of the problem, factors involving water resources. Increased population requires more water - for personal use, for the production of the vast quantities of new food that will be needed, for industrial use, and so on. In addition, as a civilization matures and finds new outlets for productivity and recreation, the amount of water required for each individual person rises swiftly. It is estimated that the average personal use of water in the United States is something like 125 gallons per day, but when the water required to operate a modern technological society is added in the figure mounts to as much as 2,000 gallons per day. This figure, however, does not take into consideration the amount of water needed to supply agriculture, to feed livestock, to irrigate alfalfa fields such as my own organization does at a ranch in the northern part of New Mexico. For instance, if you take all the water required to produce one pound of beef, the water the steer drinks and the water required in the fields to produce grass and grain, the figure is 16 tons.

It is clear to you, as it has not been clear to many citizens of the United States, that the available water supply is limited. We cannot expect to go on forever digging deeper wells and drawing vaster amounts of water without the underground sources drying up. In Arizona, for example, the groundwater level has already fallen more than a hundred feet from its earlier regular level. The same is true for much of southern California. In this connection we may note that India, desperately short of food, irrigates more than 25 million acres by pumping from wells. This is an area almost as large as all the irrigated land in the United States. Shrinkage of groundwater in the metropolitan areas is also a factor. Around Baltimore the level has sunk 150 feet since 1916. The plain fact is that the great water bank is being used up at a rapid rate and that there are not as yet significant new deposits returned to that bank.

There are, of course, some answers. Chemically treating the great clouds in the Southwest may produce enormous quantities of water. But what if draining the water from these clouds depletes the water resources for the eastern part of the country that has an economy based on a greater consumption? Can we afford to turn the desert into a garden if it means that the lush Ohio Valley and eastern states become parched? As I mentioned earlier, the drought of the recent five years caused an enormous amount of anxiety for eastern cities.

Pipelining water seems to be another answer, but it too has limited possibilities. It is vastly expensive, but in addition there must be an adequate source. Suppose it is possible to drain billions of gallons out of the Great Lakes for use in the more arid areas, what are the consequences in light of the fact that these lakes have already become lowered in their levels. In addition, there is the problem of pollution. Cities such as Chicago must face the fact that they have chemically poisoned their waters for years with sewage and industrial waste.

In Pakistan there is an experiment involving spraying a black substance on desert areas in order to attract rain. To the degree that this works, it is also limited and expensive. Imagine spraying on a regular basis a million acres of desert!

The solution looked to with much hope is desalinization. This involves not alone water from the ocean, but also well water, as in some parts of Australia where the deep wells give forth a saline solution. Again, a vast expense would be required, involving gigantic plants and subterranean tunnels to carry the water to the place of use - subterranean in order to prevent evaporation of the costly processed water. Some thought must be given also to the salt mountains that would pile up around the desalting plants - the salt would have to be prevented from seeping into the land and groundwater sources. And there would be mountains. To garner enough water to produce a ton of milk, the desalting process would produce 35 tons of salt.

Finally, we must mention the reuse of water. Already this is being accomplished to a large degree. In the Ohio River Basin water is now being utilized ten times over. It is likely that in many parts of the world this practice will be utilized in a grand scale. This, of course, does not deal with your specific problem in New Mexico - how to locate new sources of water and how to conserve its use for the greatest effectiveness.

It should be clear that the population and resource problem, when described in these dimensions, does not support easy and confident answers. We, in fact, do not know the means of our or the world's survival. Certainly new technology will be developed to bring new resources to millions who will live in this world during the later third of the Twentieth Century. Certainly too

there will be realignments of priorities that will provide a firmer focus on the problem we have been discussing. We may hope that the wiser political minds will see the larger dimensions of international relationships as they evolve within an exploding population. There will likely be a development of international agencies that have to do with trade, such as is suggested by the recent Kennedy round of tariff talks in Geneva. One possibility is the development of an International Protein Bank, in light of the fact that the use and distribution of protein will be as important to world survival as gold and silver and other metals have been regarded to this point. Finally, there will have to be an overall reduction in the birthrate, particularly in the "Third World."

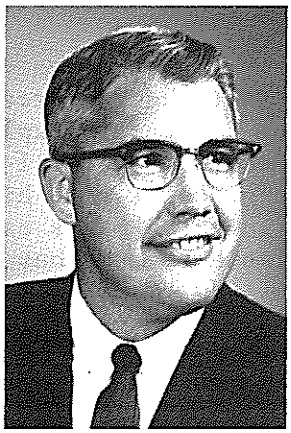
What we must do is seek to overcome the grand American delusion, and the delusion that has been held by man throughout the centuries, that the resources of the earth are inexhaustible, and that man has somehow been created to exploit the earth. The Biblical injunction was for man to have dominion over all the earth. He was to care for the earth, to cultivate it, to grace it with his presence. Let us hope that we have not passed the point in which man's exploitation of nature, of all the resources that are available to man, has created an irreparable wilderness.

Panel - Two

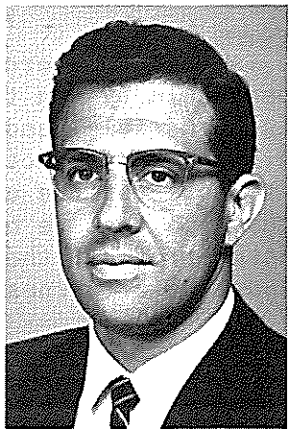
on

Water for New Mexico for the Next One Hundred Years

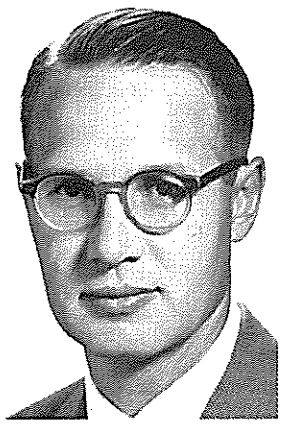
This panel considered the agricultural, municipal, industrial and recreational uses for water at various periods in the next century - to the year 2060.



Dr. George R. Dawson
Head, Department of
Agricultural Economics
presented the introduction
and summary for the panel.



Dr. John Hernandez
Professor of Civil
Engineering presented
a projection of
industrial uses.



Dr. James R. Gray
Professor of Agricultural
Economics presented a
projection of recreational
uses.

Dr. Marlin Hanson
Professor of Agricultural
Economics presented
projections of agricultural
uses.

PREFACE TO PANEL
WATER USES FOR THE NEXT HUNDRED YEARS

George R. Dawson[1/]

Charles F. Kettering once said "We should all be concerned about the future because we will spend the rest of our lives there." The aim of this conference has been one that reflects our concern about future water supplies and needs over the coming century, especially as these relate to New Mexico.

When this particular panel was first suggested, it was appropriately called an "imagineering" session. Any attempt to examine water needs one hundred years from now can be nothing more than "imagineering." In looking this far into the future, it became apparent, rather soon, to the participants in this panel that one cannot necessarily prognosticate about the future by looking at the past. To get the point of this statement, one only has to answer the question that might have been asked of a person one hundred years ago as to "What would the world be like today?" Under no sense of imagination would he or could he have visualized the events and technology of 1968.

It is therefore of utmost importance that you bear in mind that our panel members today are probably not blessed with much better predictive powers than were our ancestors of a century ago. The rate of technological change on all fronts probably makes it even more unlikely that this imagineering about the future can be very factual at this point in time. Also, any look into the future is complicated by man's political and social habits. The future in this respect is even more cloudy and uncertain--

With this dismal view as to the seemingly futile and impossible task of saying anything with precision of the next century, it may then logically be asked, "Why are we going to spend the next hour and fifteen minutes talking about water uses for the next hundred years?" The answer is really quite simple.

We do know enough about where we are today - i.e. our uses of water, availability of water, population growth, etc., to realize that planning must start now if we are to meet the future needs. Both time and the stork are working against us.

Time is required to make the necessary plans for water development, transfer, reallocation, etc. Likewise, ample evidence has been presented to support

1/ Professor and Head, Department of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, New Mexico.

the views that the world population will double by the year 2000. Man may, during this time interval, bring about a reversal of the population explosion but facts being as they are around the world today, not much change in the growth of populations will be realized in the next 30 years. Optimistically a change will have started that will in fact slow this rate of increase to a tolerable level. The concept of time then is related to the entire spectrum of problems associated with change - be it technological, social, cultural or economic.

Each panel speaker will present a synopsis of a longer and more detailed paper that will be published in the Conference Proceedings. Their assignment in their respective fifteen minute presentations is to give principally the summary and conclusions of the longer and detailed papers. It will become obvious that competition among users of water in New Mexico will without question increase in the future.

Each paper has been prepared independently of the others so as to free each speaker to devote his "imagineering" specifically to the particular topic assigned. We will therefore note variation in the basic assumptions about the future and the forces that might bring about the changes forecasted. I would hasten to underscore the fact that none of the speakers have attempted a definite forecast of the future. Instead their papers will reveal probable uses and needs under assumed and varying conditions. This is all that any prediction of the future a century away can be. Man must continue to make such efforts to look at the future so that over the shorter time span a better job of planning and execution of plans can be possible.

Some states are spending several hundred thousand dollars on studies to determine needs and uses of water in the next hundred years. Our speakers spent several frustrating hours, a few broken pencils and pads of paper. I say this not to conclude that their product is in truth of any less value than some studies costing large amounts of money. We are not reporting results of any formalized study of the magnitude mentioned.

The three papers were prepared with three common assumptions - and these were with regard to population projections, water supplies, and per capita income. We of course did not have the projections presented yesterday by Professor Edgel so may not have made projections compatible with his. In fact, our estimates are much more conservative.

Our population projections were for three levels to the year 2060. These projections were: low-2 million; medium-3.5 million; and high-5 million people for New Mexico. These projections reflect a basic assumption of

in-migration to a state experiencing a healthy economic growth and blessed with a climate and the resources to attract people and capital.

The water supply levels assumed were: (1) existing supplies and depletion of some of these supplies before the year 2060, (2) some importation to maintain current competitive positions of water users, and (3) abundant water supplies for all users through importation and/or weather modification.

NEW MEXICO MUNICIPAL, DOMESTIC AND INDUSTRIAL WATER SUPPLY DEMANDS 1968-2068

John W. Hernandez[1]/

A number of New Mexico's cities, towns, and villages have the unique charm and beauty that is a characteristic of "The Land of Enchantment," but with this there is much that is not attractive - whole communities that are ugly, shabby, and unkept. In most towns there are homes and businesses that are well maintained and that are aesthetically pleasant - homes with green lawns, shrubs, trees, and seasonal flowers. But this description does not fit all too many of our residences - a more accurate description would include tumbled down fences, overgrown yards, unpainted houses, and tangles of overhead utility lines.

Perhaps an appropriate question would be "just what does this have to do with water uses?" The charm and beauty of our communities is a manifestation of the cultural, intellectual and material wealth of the people. I hope to prove that the per capita use of water for municipal and domestic purpose, above some minimal base use, is an indirect measure of the per capita income of the people of a community. I also contend that the greater our industrial base becomes, the greater our per capita income and the greater our demands for water for municipal, domestic and industrial purposes will be in the future. I believe that the amount of water used in a community is directly indicative of its wealth and that the amount of water that will be needed 100 years from now will depend directly on the degree of prosperity of the people of our state.

THE PRESENT SITUATION - 1968

Before attempting an analysis of New Mexico's municipal, domestic and industrial (MD & I) water needs a hundred years from now, we should probably find out just where we're starting from - how much water is available for use? How much does it cost us to use this water for these purposes? What our present municipal, domestic and industrial water supply demands? What factors influence the level of these demands?

Present Municipal and Domestic Demands

New Mexico's present resident population is just over a million people with approximately three-fourths served by central water supply systems. (1) Using State Health Department estimates of an average daily use of 159 gallons per person for urban dwellers and 34 gallons per person for rural families, the yearly demand for municipal and domestic purposes can be assumed to be a

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little more than 46 billion gallons if we assume that three-fourths of the residents of the state may be classed as urban dwellers. Some of this water will be used again by virtue of having been discharged into a sewerage system but the part used for lawns and gardens and cooling (about 30 to 40 percent) is lost to evaporation and transpiration. (2, 3) Consumptive uses for these purposes will probably be higher in more arid areas and higher in areas with greater per capita incomes. Based on the previous assumptions of per capita demand, our present consumptive use of water for numicipal and domestic supply is about 18.5 billion gallons per year. The New Mexico State Engineer Office estimated the "urban" demand for water to be 110,080 acre-feet (about 36 billion gallons) diverted annually and 51,690 acre-feet (about 17 billion gallons) depleted per year during the period 1960-64. (4)

Water Costs as a Factor in Present Municipal and Domestic Demands

Municipal and domestic water demands depend in part on the cost of water, on the season, on the climate, on the culture and standard of living of the people served by a supply and on the size of the community. In general, as the standard of living increases so does the use of water increase, up to a certain upper level of per capita use which is attained when most of the homes in a particular community have multiple bathroom facilities, automatic dish-washers, garbage grinders, gardens and lawns, and home laundry facilities. I believe this upper level of use to be about 200 gallons per person per day for urban residents of northern New Mexico. (5) There is a relationship between community growth and per capita requirements: per capita use commonly increases about one-tenth percent for every percent increase in population. (6) Per capita municipal uses may be distorted by unreasonably high distribution losses or by unrealistically low water prices charged to certain classes of large water users as a form of subsidy.

The cost of water to the municipal and domestic user does affect demand, but user response to price is certainly a nonlinear, nonuniform, complex function. Table I is a summary of daily per capita demands for three groups of northern New Mexico communities : (1) villages with populations of less than 1,000, (2) towns with populations of 1,500 to 4,000 and (3) cities with 10,000 to 40,000 residents. Within each group the elevation, climate and growing seasons do not differ greatly.

The cost per 1,000 gallons for "the second" 5,000 gallons-used-per-month-per-residence is also included for comparison with the daily per capita uses. The cost of "the second" 5,000 gallons is cited for the following reasons:

1. The cost per 1,000 for "the first" 5,000 gallons-used-per-month-per-residence includes minimum billing charges that vary from

TABLE I

Water Costs and Daily/per Capita Water Demands for Northern New Mexico Communities Grouped by Similarities in Population[1/]

	Community	Daily Per Capita Municipal Diversions in Gallons	Cost per 1,000 gallons for the second 5,000 gallons used-per-month-per residence - in Dollars
GROUP I	Bloomfield	55	1.00
	Logan	50	.50
	Roy	45	.55
	Cuba	40	.90
GROUP II	Aztec	145-165	.25
	Clayton	150	.23
	Belen	125	.23
	Taos	110	.35
	Springer	90	.60
	Chama	80	.63
	Milan	90	.75
GROUP IIIA	Farmington	210	.30
	Grants	110	.30
	Santa Fe	102	.63
	Gallup	75	.75
GROUP IIIB	Los Alamos	250	.36
	Las Vegas	80	.40

1/ Data for this table was abstracted from New Mexico State Engineer Office Reports 29B and 29C, 1964 and 1966 respectively. Interpretational changes have been made in the basic data.

city to city and often does not reflect the costs the municipality must bear to produce water.

2. A family living in an incorporated community must have a supply of running water with the minimal supply for a family of four being approximately 4,000 gallons per month (4 x 34 gallons/capita/day x 30 days/month).

An example of this last point may be noted in the per capita water uses by Group I villages (Bloomfield, Logan, Roy and Cuba) in Table I. Water use in these communities is evidently not influenced by the price of water as the per capita requirements are at, or near, the minimum family requirements and the average family just does not use more than 5,000 gallons per month so that price is not a major factor in their demand pattern. The cost per 1,000 for the first 5,000 gallons per month for the villages in Group I is from $1.00 to $2.00.

In the second group of communities given in Table I, we find daily per capita demands varying from 90 to 165 gallons, far in excess of the minimum so that the amount used in these towns may indeed reflect the cost per 1,000 for "the second" 5,000 gallons used per month. As will be noted from Table I, there is a general trend of increased per capita use as the cost per 1,000 gallons decreases with this same trend observed for the cities in Group IIIA. This would indicate some sensitivity of use to price. Communities that do not have water meters may also exhibit large per capita uses. Professor Gordon Fair notes that "meterage encourages thrift and normalizes water demand" and that meter consciousness will initially depress demand when meters are first installed but that "use" does return eventually to a defensible norm. (6)

There is one other very significant factor that affects the per capita demand - the average per capita income of the residents of the community. The marked effect of income on demand may be observed by comparing the municipal uses in Los Alamos ($3,690.00 income per capita/year for Los Alamos County for 1966) with those in Las Vegas ($1,550.00 income per capita/year for San Miguel County for 1966) as shown for these Group IIIB cities in Table I. The cost of water for "the second" 5,000 gallons (about $0.40 per 1,000) is approximately the same for residents in both communities as are the growing season and elevation, but the personal wealth and standards of living in the two are far different. A family with the high per capita income is not only insensitive to the price of water, this family also has more capital goods that require water for their use and enjoyment. New Mexico's per capita income is one of the lowest in the nation and it would not be surprising to find that our per capita use of water for domestic purposes is also one of the lowest in the nation.

Present Industrial Demands

The 1958 industrial use of water in the state was estimated to be 13 billion gallons by the Department of Public Health. (1) At a previous Water Conference, Ivan Wood, in discussing MD & I uses, noted that New Mexico has the lowest industrial water demand in the nation which he estimated in 1959 to be 43,800 acre-feet per year (14 billion gallons). (7) New Mexico's industrial base is quite small in comparison with those of other states with mining and manufacturing representing only 18 percent of wages and salaries earned in New Mexico in 1964 while this figure was 27 percent for the Pacific coast states, 35 percent for the middle-Atlantic states and 40 percent for the New England area. (8) It should also be noted that the average per capita income in some of these areas exceeds that of New Mexico by almost $1,000.00 per year.

For the period 1960-64, a State Planning Office report listed the "self supplied" industrial water demand as 136,640 acre-feet (44 billion gallons) diverted annually and 74,810 acre-feet (24.4 billion gallons) depleted. (4) The United States Bureau of Mines provided the following figures for 1962 for the mineral industry in New Mexico (potash, uranium, copper, lead-zinc, sand-gravel, cement, coal, oil and gas): 168.2 billion gallons required, 152.3 billion gallons reused, 15.9 billion gallons of "new-water" added and 7.6 billion gallons consumed each year. (9) The Bureau report estimates the "new-water" needs of industries closely related to the mineral industry (petroleum refining, natural gas transmission, and gypsum wallboard manufacture) as one-half billion gallons per year. Of the 15.9 billion gallons of new water, only 9 percent was purchased with 14.5 billion gallons "self-supplied," mostly from groundwater sources (11.9 billion gallons). (10) A more recent report indicates the consumptive use for all MD & I purposes to be about 28 billion gallons per year. (11)

Price as a Factor in Present Industrial Demands

An often heard excuse for the lack of industrial development in New Mexico is that water is just too scarce and not available. I don't believe this to be true except in a very few areas of the state and in most cases water can be transported to these cities at a reasonable cost. I don't believe that the relative cost of water is a significant factor in the decision to locate an industrial plant at a given place for, as Sener has stated:

> "Water availability alone has rarely been the determining factor in attracting industry to an area. Nor has its scarcity seriously impeded industrial investment when all other economic, social and cultural conditions were available." (14)

The average cost of "self-supplied" new water for New Mexico's mineral industry in 1962 was reported to be $.08/1000 gallons or far below the price of water to municipal users given in Table I. (15) Reuse and recirculation of plant water is responsible for the low ratio of "new water" to total industrial use which is approximately 1:10 with the average cost of treatment and recirculation reported to be $0.088/1000 gallons. (15) The median price paid for "purchased water" at five New Mexico industrial plants was $0.15/1000 but the variation was from $0.02 to $2.14/1000. (15)

The cost of water to industrial users must be compared with the "value of product" per unit volume of "new water" needed with these values ranging from $4.00/1000 gallons used by the sand and gravel industry to $89 for coal and $42/1000 the average for the entire mineral industry in New Mexico in 1962. (13) The "value added" to water, when used by New Mexico industry, was given by Wollman, et al to vary from almost four to about ten dollars per thousand gallons. (16) It may be seen that the average cost of industrial water, "new" or recirculated, represents less than one percent of the "value of the product" produced. For most industries, the price of water is not a significant factor in the amount of water used. Alternatives in production methods, or in water use, will be selected when and if, the price of water exceeds some unspecified upper level for a given industry. Industries will be attracted to locations where low cost water is readily available if other location factors are also favorable. (17)

Present Total MD & I Requirements

On the surface there appears to be some difference in these estimates of municipal, domestic and industrial water uses but because of a lack of common base this is not surprising. Present average annual water diversions in New Mexico for MD & I purposes are probably in the neighborhood of 70 to 100 billion gallons with about 50 percent of this volume consumed. Municipal and domestic uses probably constitute 40 to 45 percent of this demand with the self-supplied industrial use the remaining 55 to 60 percent. If the state's population is assumed to be one million and the combined MD & I demand to be 300,000 acre-feet, then the average annual per capita diversion for these uses is 100,000 gallons and the consumptive use 50,000 gallons per capita per year. At $0.30 per 1,000 gallons this represents an expenditure of only $15.00 per capita per year for our MD & I supply.

Present Water Supply

Most of our municipal and domestic supplies and most of the self-supplied water used by industry comes from groundwater sources with only one-fourth of the MD & I water being surface supplied. (1, 4, 9, 11) A current, easily understood and candid accounting of the water resources of New Mexico is

provided by Hale, Reiland, and Beverage with their estimate of the total average annual surface supply being 888,000 acre-feet available for consumptive use and 966,000 acre-feet as the annual consumptive use of groundwater. (11) They state the following with respect to the available groundwater resources:

> "Data are not available from which to compute the portion of this water that is being mined nor to compute annual recharge to groundwater aquifiers which are not connected with surface streams in New Mexico (aquifiers from which water is being mined)."(11)

Figures in Appendix E of their report indicate that there are at least six groundwater basins in New Mexico with declining water levels. A reasonable assumption is that these declines are indicative of a progressive depletion of the groundwater reserves in these basins. To permit safe, long-term yields from these basins, pumping will have to be reduced below the present levels. In summary, the total consumptive use of both ground and surface waters is now approximately 1.85 million acre-feet per year with MD & I consumptive uses representing only six to eight percent of the present supply.

With very few exceptions there is sufficient supply of useable quality water available to New Mexico communities and in these few exceptions a supply is available although transportation costs may make the source unattractive. The adequacy of industrial supplies is similar:

> "The water supply situation at New Mexico mineral industry operations ranges from satisfactory to critical. In no large section of the state, however, are existing mineral production operations seriously affected by water shortage; the areas of serious shortage, although widely distributed, are of local extent.
>
> "One operator reported seasonal curtailment of production because of a critical water shortage. Another reported insufficient water for a desired increase in production. Quality of product is adversely affected at a few operations as a result of a limited water supply. An inadequate supply in the vicinity of many operations necessitates long-distance pumping or hauling." (18)

Industrial water needs can be met by the purchase of water rights from existing users who achieve lower "value of product" levels per unit volume consumed. This so-called "market place" system is somewhat inefficient and is subject to institutional constraints by both the state and the federal government. Municipalities may now obtain needed water rights through the exercise of the power of eminent domain.

THE FUTURE SITUATION - 2068 AND BEYOND

Future Institutional Constraints

There now exists, and there will continue to exist, competition amongst potential users for the available water supply. I believe that the following statements will characterize the nature of future competition and the nature of future institutional constraints that will function to control the amount and purpose of our water uses 100 years from now with these concepts being projections of the principal factors that now influence the present level of demand for water for MD & I purposes:

1. Because water plays such a significant role in the life of our people, there exists a compelling need to protect the public's interest in the management of the present and potential supply. In the future the Federal Government, and to a smaller extent the state government, will exercise increased control on the use, reuse, development, transportation and allocation of existing and future supplies. The social implications of use and reuse will be a dominant factor in determining the level and nature of future governmental control.

2. Domestic requirements will be given first priority in the use of the available supply with condemnation powers being used to secure the necessary rights.

3. Users offering the greatest "value added" per unit volume of water consumed will be permitted the next highest priority of use. To obtain the most efficient use of the available supply, allocations will be made and changed on the basis of the user's relative contributions to the economy. It is extremely unlikely that the present "market place" system of transfer of water rights to more economically successful users will continue to function because of the inevitable presence of government in the planning, financing and development of new sources of supply.

4. To promote the economic development of certain communities or of certain industries, the government will subsidize the use of water for these purposes just as we have subsidized irrigated agriculture in the past.

5. Requirements for increased reuse and for higher levels of treatment for waste-waters will be demanded. The reuse levels now attained by some New Mexico industries now approach the maximum practical.

The New Mexico of the Future

Economic growth is the key to New Mexico's future; this growth must and can only come about through industrial development as it is unreasonable to believe that much increase in our per capita income will be generated through agriculture unless massive water importation plans are put into effect. In the absence of these large interbasin and interstate transfer projects, New Mexico will have to rely on industry (mining, milling, manufacturing, tourists, recreational) to produce the income needed to maintain any significant increase in our population. If we maintain our present per capita industrial base we will remain a poor state with a low per capita income and a low per capita water use for MD & I purposes; uses that are lower than the national average. The present ugliness of parts of our cities and towns will continue to reflect this lack of wealth and will in fact be more pronounced. The price of water can only increase, will never be any cheaper than it is today, and if the 2068 New Mexician has a low per capita productivity and income, then the cost of water will deter his using it to maintain green lawns, trees and flowers and we will have barren desert communities. I prefer to believe that we will do the planning and develop the project necessary to make New Mexico a rich state, towns that are garden spots in the desert, beautiful tree-lined street, "breaking continually into park and garden, and with everywhere a scattering of houses - smart white gates and palings everywhere, good turf, - garden districts all set with gables and roses, holly hedges, and emerald lawns: pleasant homes---." This 1902 quote from H. G. Wells, although not characteristic of New Mexico in many respects, is a prophecy that can become a reality only if we are a wealthy state. If we are, we will enjoy high per capita incomes, we will use more water for domestic purposes as our uses will not reflect a sensitivity to the price of water, and we will use more water for industry because it will be through increased industry that we can attain higher per capita incomes.

MD & I Demands in the New Mexico of the Future

New Mexico's present water supply is sufficient, without augmentation, to meet any reasonable increase in MD & I requirements during the next 100 years because the present demands represent less than 10 percent of the available annual supply and because water rights will be transferred to MD & I uses so they generate relatively high "value of product" per unit volumes consumed compared with irrigated agriculture. The level of our future MD & I demands will depend on our productivity - high productivity, high per capita income and high per capita water demands; low productivity, low per capita incomes and low per capita water needs.

I recommend the following actions and programs be undertaken at once to insure

a prosperous New Mexico in 2068:

1. Provide funds for an accurate and complete inventory of the natural resources of our state.

2. Make funds available for definite and specific steps toward the realization of presently proposed massive water importation projects.

3. Provide funds (or forego taxes) to encourage and attract industrial capital to New Mexico. The magnitude of these expenditures should be comparable to those provided for agricultural subsidies by the state and federal governments.

4. Support research and development projects at our state universities to find and perfect products, production techniques and markets for New Mexico's natural resources.

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RECREATIONAL WATER NEEDS IN NEW MEXICO FOR THE NEXT HUNDRED YEARS

James R. Gray[1/]

INTRODUCTION

The probability of either accuracy or precision of projections to 2060 is remote. It is particularly remote when the subject is recreation because the relationships between recreational use and the factors affecting use are imperfectly understood. Consider for a moment the problems of a New Mexico recreational planner in 1860 attempting to project recreational needs in New Mexico to 1960.

According to Clawson and Knetsch the major factors affecting the future demand for recreation are population, leisure, transportation, and income (1, pp. 93-110). Since the impact of these factors on the supply side of recreation are even more imperfectly understood than on the demand side, and especially because mathematical projections for even 10 years rather than 100 are extremely risky, the procedures used in the projections to the year 2060 will be more of an imagineering technique than a scientific one.

Again according to Clawson and Knetsch there are five major methods for projecting the recreational demand for resources (1, p. 117). These are (1) Simple trend extensions of past uses, (2) Extensions of trends of the basic causal factors as mentioned in the preceding paragraph, (3) Applications of the satiety principle to place a ceiling on projected uses, (4) Projections of other authorities, and finally, (5) Judgement using a number of factors in an informal way. Obviously, imagineering lies mainly in the last mentioned technique.

In this paper the three factors of population, leisure and income will be imagineered to the year 2060. Since imagineering may not be completely trustworthy, pessimistic, average and optimistic attitudes will be used to project the effects of these demand factors on the recreational water supply needs in New Mexico. Some current research on consumptive uses of water by recreationists will be applied after they are checked against recent studies.

THE PRESENT SITUATION

Presently the population in New Mexico is about 1,000,000 persons. Leisure time per 56-hour work week in the United States (and presumably New Mexico) is about 20-25 hours, while per capita personal income in New Mexico is about $2,160. With these statistics in mind, a portion of the present recreational situation in New Mexico can be shown in the following.

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The population distribution in New Mexico is pictured in Figure 1 (2, p. 18). Note the radii indicating population concentrations in southeastern New Mexico and in northcentral New Mexico. The figure is partially incomplete in that El Paso is not included.

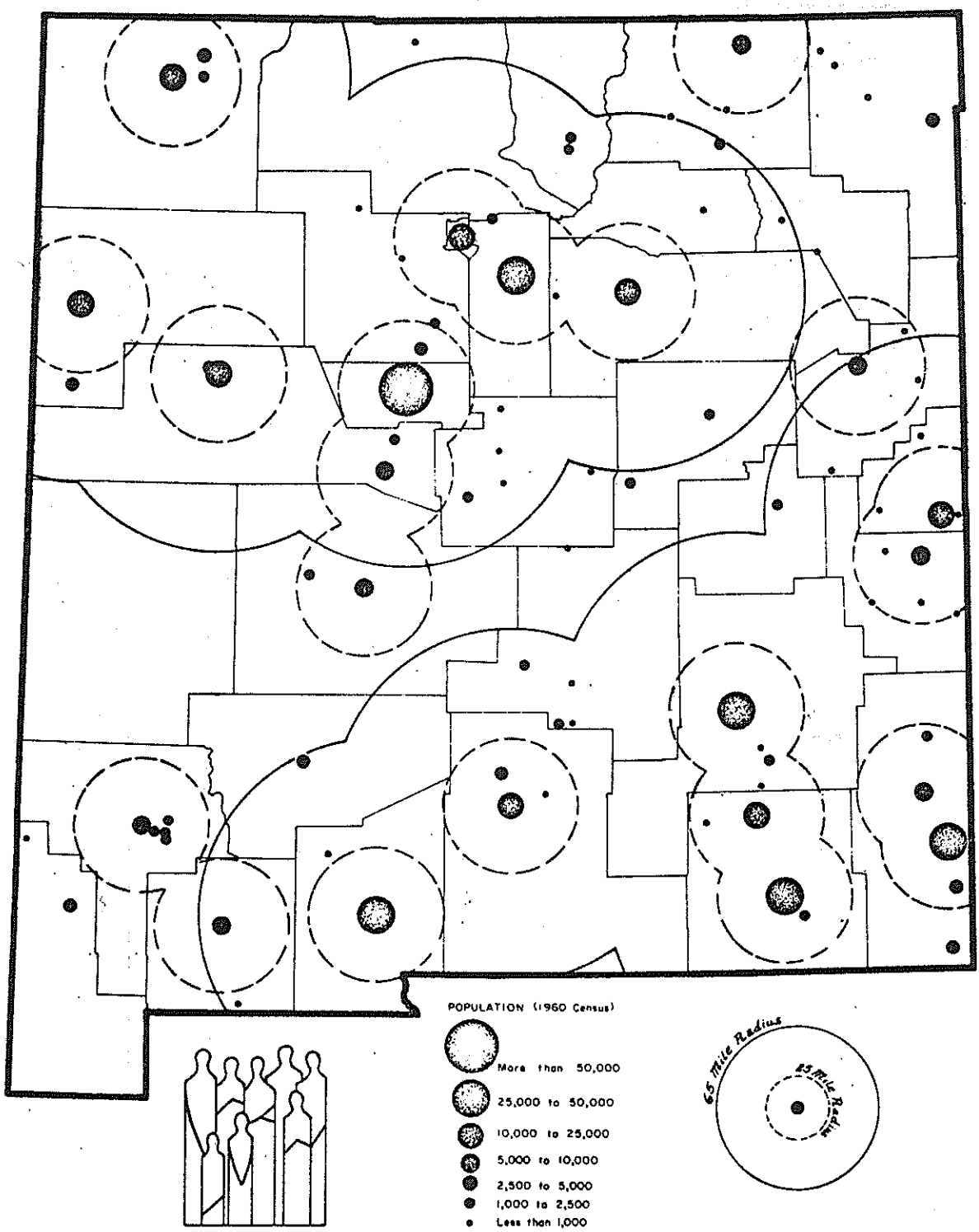
The geographical distribution of recreational waters in the state is shown in Figures 2 (showing fishing streams of the state) and 3 (representing motor-boat and water skiing locations) (2, pp. 40 and 43, respectively). A special use of water for recreation, skiing sites, are shown in Figure 4 (2, p. 26).

Generally the northern population center is well-served by all three types of water sport areas although they lie generally further north of the center. In the southern area, all three types of activities are deficient with the possible exception of warm-water fishing.

A summary of the quantities of the three major recreational resources in New Mexico indicates the state now has about 0.08 acre of lakes per capita and 10 feet of fishing streams on public land (Table 1) (2, p. 52).

The present situation regarding water use by out-of-state recreationists can be partially demonstrated by Figure 5 (2, p. 30). The major routes of I-10 in southern New Mexico and I-40 in central New Mexico miss almost all of the major recreational water areas. The value of the tourist industry in New Mexico in 1963 has been estimated at about $200 million per year, about equally divided for food, lodging, automobile costs, and other costs (3, p. 10). A 1965 tabulation at Elephant Butte and Navajo Reservoirs indicated 25 percent of the sample of visitors at Elephant Butte were from in-state and the remaining 75 percent from out-of-state (4, p. 39). Almost the reverse proportions were recorded at Navajo Reservoir. Many estimates are available regarding number of visitors to various kinds of facilities, number of license holders, etc. The water use of recreationists is more difficult to determine. Carruthers estimated the quantity of water used by businesses serving recreationists in the Reserve Area in 1963 (5,p. 99). According to his estimates using the input-output model and projecting to the year 2000, an increase in the study area of 150,000 recreationists would require 155 additional acre-feet of water, or about .001 acre-foot of water per recreationist to supply the businesses serving recreationists. On the other hand, Coppedge estimated the quantity of water lost in the two above mentioned reservoirs because water was held in them for recreational purposes (4, pp. 72 and 76). The losses were seepage and evaporation from the proportions of the reservoirs considered to be their minimum recreational pools. Water use for 854,000 recreationists in 1966 at Elephant Butte Reservoir was 38,240 acre-feet, or .045 acre-foot per recreationist. At Navajo Reservoir the loss was 9,700 acre-feet for 237,000 recreationists, or a rate of .041 acre-foot. If the

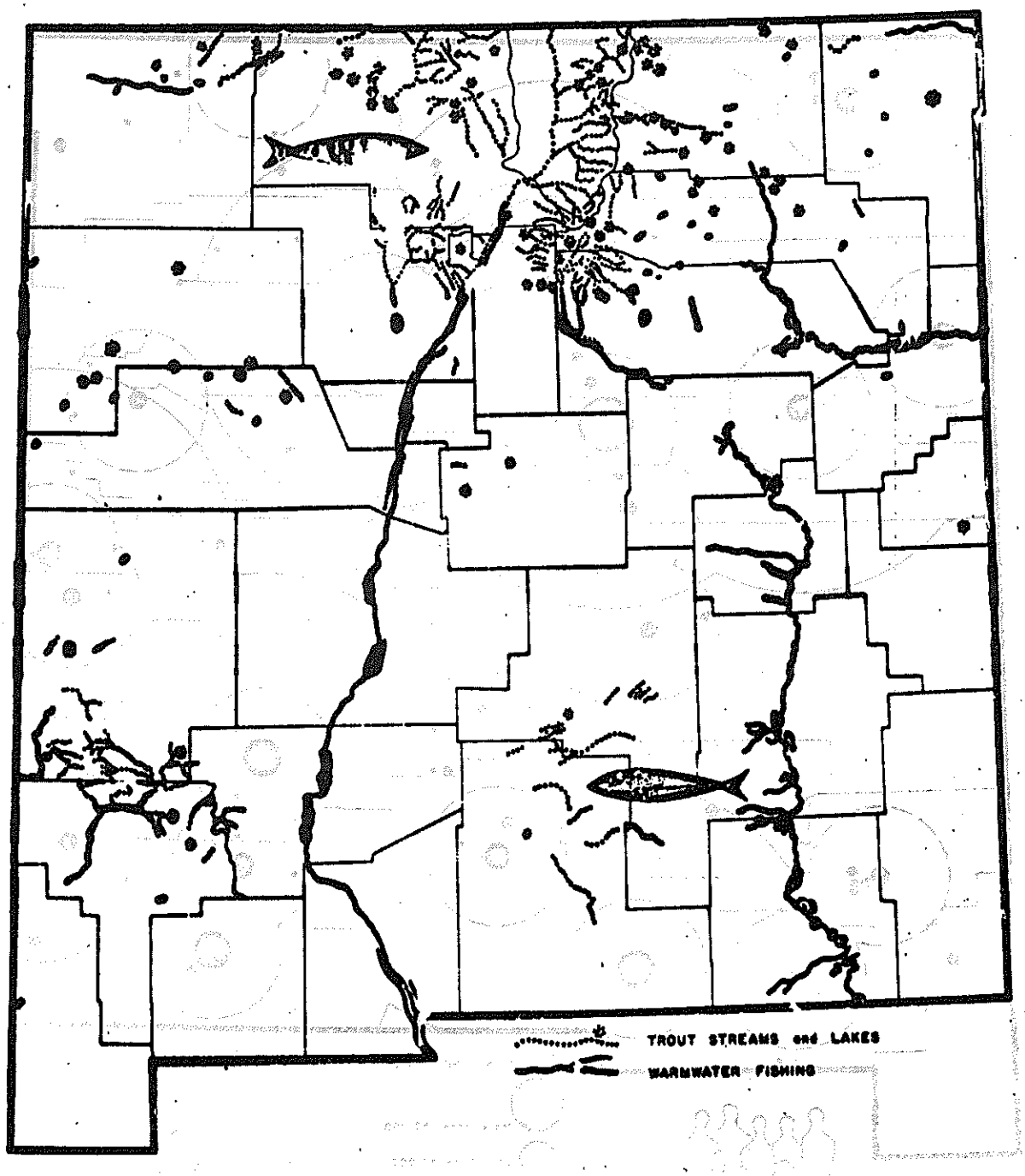
FIGURE 1



C E N T E R S O F P O P U L A T I O N

PLATE III

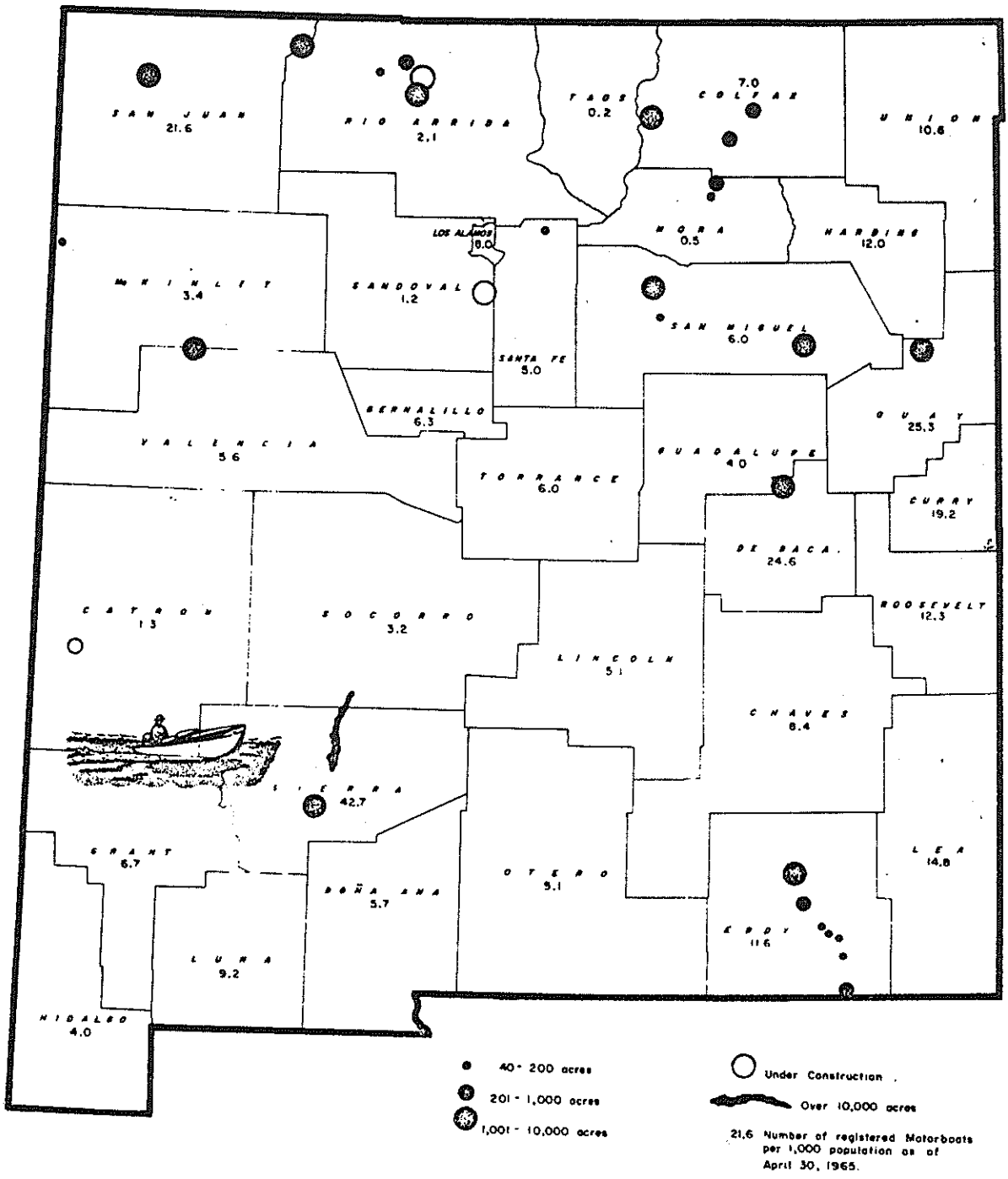
FIGURE 2



F I S H I N G W A T E R S

PLATE XII

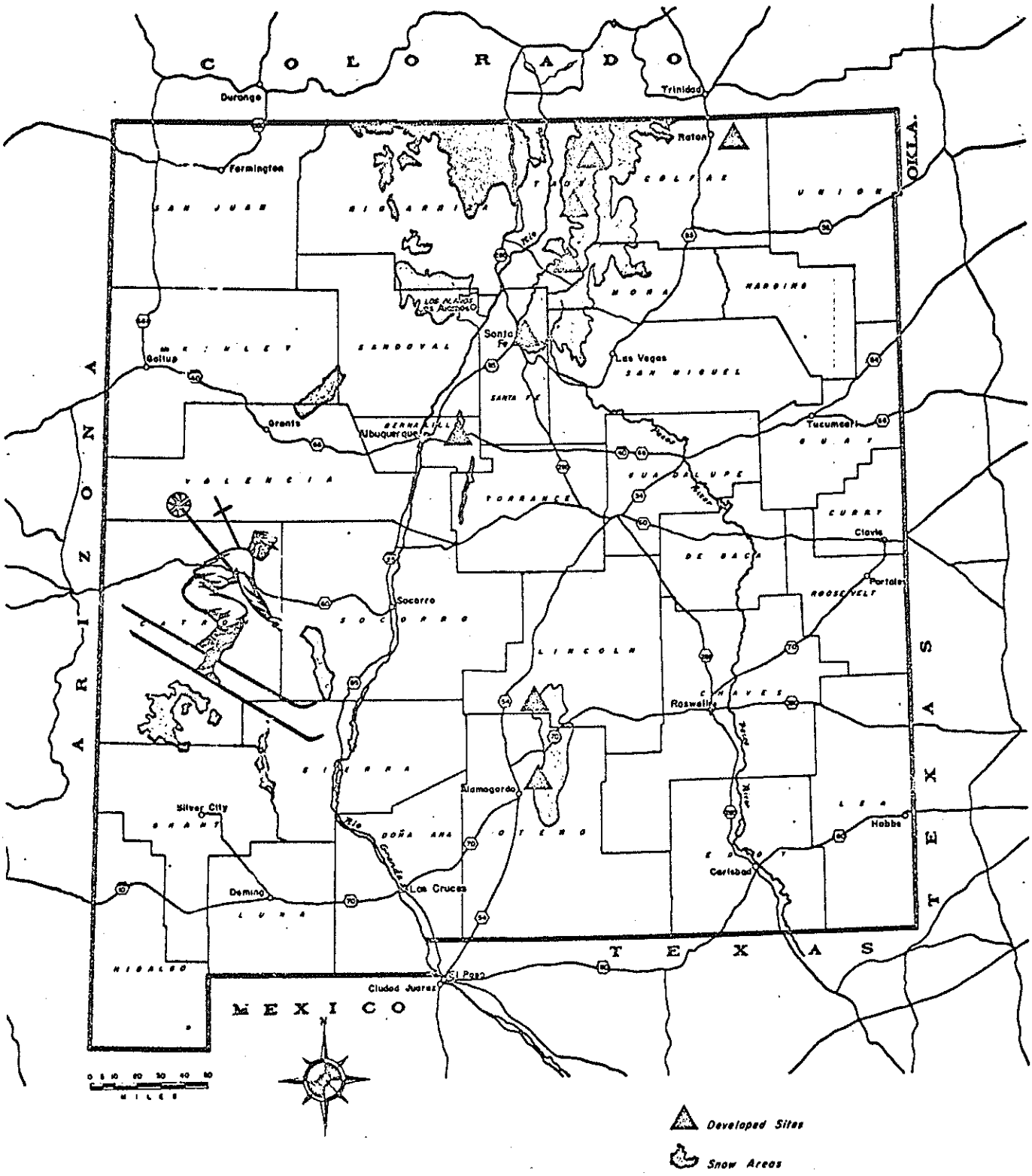
FIGURE 3



WATERS FOR MOTORBOATING AND SKIING

PLATE XIII

FIGURE 4



WINTER SPORTS

PLATE V

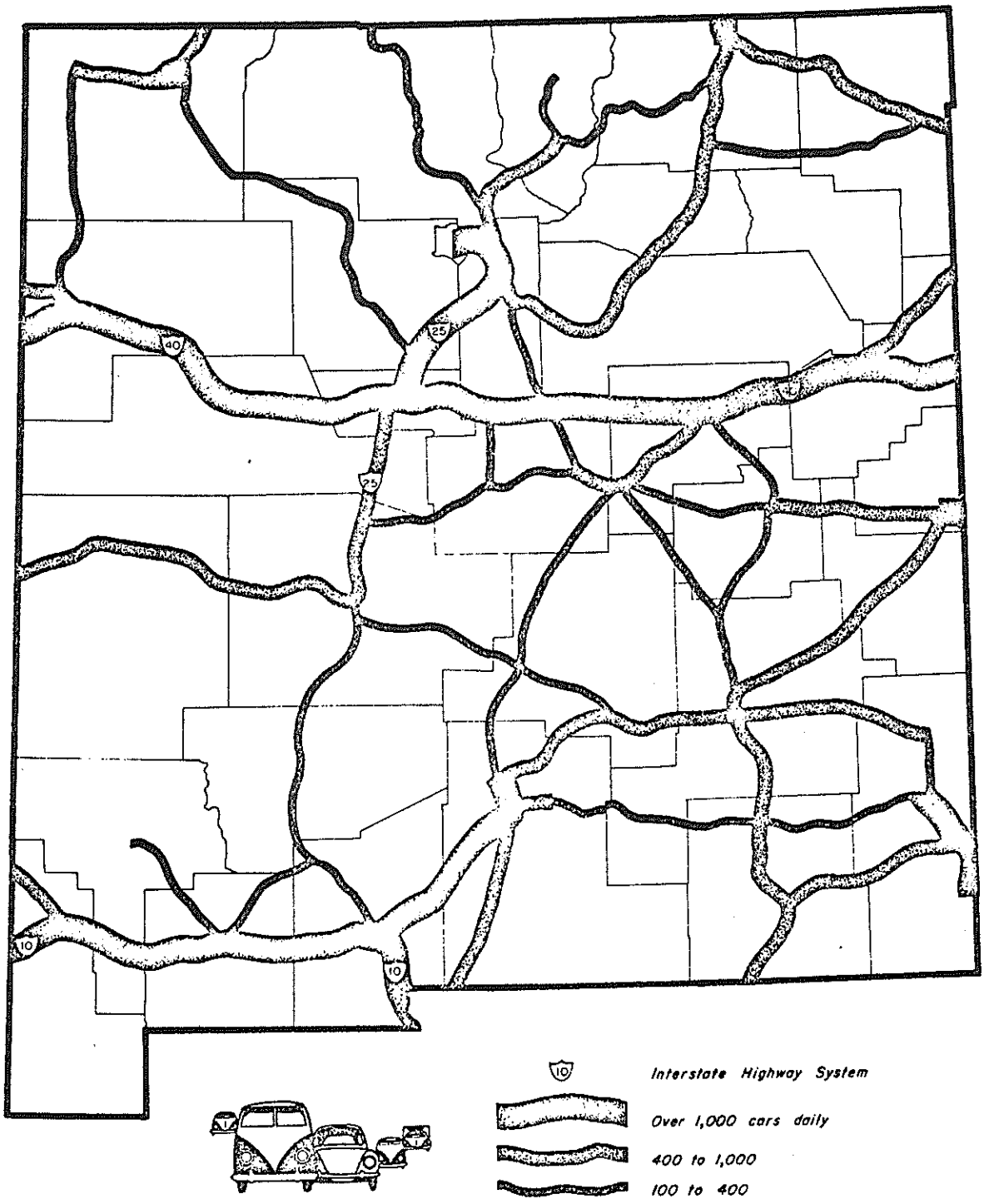
Table 1. Water-Based Recreational Facilities in New Mexico, 1965

Agency and Ownership Class	Total Area of Lakes[1/]	Length of Fishing Streams	Ski Areas
	Acres	Miles	No.
PUBLIC:			
Forest Service	315	1,550	6
National Parks	0	16	0
Park and Recreation Commission	59,575	0	0
Dept. of Game and Fish	2,409	127	0
Municipalities	747	0	0
Public Unclassified	11,880	201	0
Total	74,926	1,890	6
INDIAN	5,498	---	2
PRIVATE	1,597	---	8
State Total	82,021		16

1/ In public areas includes lakes and reservoirs publicly owned or controlled for public use. In Indian areas includes all fishing waters. In private areas all fishing areas.

Source: State Planning Office, "New Mexico Comprehensive Plan for Outdoor Recreation," Santa Fe. October 1965, pp. 52-58. Based partially on the inventory prepared by New Mexico Soil and Water Conservation Districts.

FIGURE 5



OUT-OF-STATE PASSENGER CARS
AVERAGE ANNUAL DAILY TRAFFIC 1963

PLATE VII

average of these accumulated rates, .046 acre-foot at Elephant Butte and .042 at Navajo, or .044 acre-foot is applied to population estimates, then 44,000 acre-feet of water represents the present recreational depletion of water in New Mexico.1/ This estimate is in general agreement with the 49,790 acre-feet estimate made in the State Resource Development Plan, particularly when the Plan excluded evaporation as a charge to recreational uses (6, p. 90).

The relationship that will be used to project uses to 2060 will be based on the above per capita estimate of recreational water use multiplied by the three factors of population, leisure and income changes, as direct variables. Transportation per capita is believed to be a function of leisure and income. Including the transportation factor directly would be at least partially a double counting of this factor. The procedure assumes that out-of-state tourists will increase in proportion to the in-state population. Also judgement was used to reduce the population, leisure, and income projections below that expected from current linear trends.

The formula for the water needs for recreation in New Mexico becomes:

Water quantity = (Rate of use per capita) X (Population of New Mexico) X (Index of leisure) X (Index of New Mexico per capita personal income)

In 1965-66, the solution would be:

Water quantity = (.044) X (1,000,000) X (1.00) X (1.00)

= 44,000 acre-feet

THE PROJECTION FACTORS

The projection factors, using a linear trend extension adjusted to the satiety principle in the leisure area, and judgement regarding projections past 2000, are given in Table 2.

FUTURE SITUATION - LOW LEVEL

The low level of recreational use of water in New Mexico in 2060 is a pessimistic projection in which national and international populations are pressing on the food supply, the growth rate has been zero for many decades (no increase in the per capita income), leisure time has not increased from the present, and water is not being imported into New Mexico.

1/ Actually, the ten major lakes in New Mexico reported 2.7 million recreational visits in 1966 (7,p.59). Many recreationists in New Mexico visit these lakes numerous times during the year, particularly motor boatists and fishermen. They are counted in the 2.7 million estimate for each visit. If the assumption is made that each recreationist visits the reservoir 2.7 times, then the population value can be applied directly.

Table 2. Projections to the Year 2060 for Recreational Water Needs in New Mexico

Factor	Units	1965-66 Level	Projections to 2060		
			Low Level	Medium Level	High Level
Population, N. M.	Mil.	1.0	2.0	4.0	5.0
Per Capita Income in New Mexico	Dol.	2,160	2,160	6,000	13,000
Index	--	100	100	277	602
Leisure in Hours Per 56-Hour Week	Hours	22	22	30	38
Index	--	100	100	136	173

The gross recreational water need, using the formula would be:

$$\text{Water quantity} = (.044) \times (2{,}000{,}000) \times (1.00) \times (1.00)$$

$$= 88{,}000 \text{ acre-feet}$$

In this situation it is probable that (1) Water evaporation will be eliminated from most major water impoundment bodies, (2) Seepage reduced in these bodies, and (3) Pollution will be rigorously controlled. Maximum controls will be exerted to store water efficiently, distribution systems will be developed to reduce waste to a minimum, and recreational uses, both quantity and location-wise, will be secondary to food production and urban uses. As a consequence of these actions, water use for recreation will shift from the partially-competitive category to the completely-supplementary category. That is, if water is needed for food or urban uses, recreational uses of water may well fall below the 88,000 acre-foot requirement, and indeed possibly below the present 44,000 acre-foot use.

Recreational characteristics in this severe water shortage condition will consist of a carefully controlled, restricted use situation in which recreationists will be required to purchase daily entrance permits for water bodies. These water bodies will be designed for most efficient water storage rather than for beauty or other recreational values. The entrance permit demand is expected to exceed the supply, perhaps requiring random drawings in the same way that hunting is restricted for some game species in New Mexico. Motor boating and water skiing will be restricted in favor of fishing. Snow skiing will be encouraged as a relatively light consumptive use of water. Private recreational developments will be permitted if the water quality or quantity remains relatively unaffected by recreational users. If water is allocated to recreational uses, it will be for user-oriented developments near and in metropolitan areas, rather than the combinations now available (resource-oriented and combination user and resource oriented).

FUTURE SITUATION - MEDIUM LEVEL

The medium level of recreational use assumes that population will increase moderately, the per capita income and leisure time will increase at about a half of the projected rate, water will be imported into the Southwest but not at a rate that will change the present competitive positions of the various industries using water, and the state and regional nationalism presently experienced will be relaxed to permit a freer flow of resources and trade.

Gross recreational water needs in this situation will be:

Water Quantity = (.044) X (4,000,000) X (1.36) X (2.77)

= 663,000 acre-feet

This large quantity of water will meet the needs of a population in New Mexico plus accompanying increases in out-of-state tourists that is four times that of the present, the recreationists will have at the minimum almost three times as much income as at present to spend on recreation, and he will have a third more leisure time in which to do it. The present trend regarding income allocation indicates that as incomes increase the proportion spent on recreation also increases. Therefore, insofar as the income variable is concerned, the above estimate is conservative.

The major restriction at the medium level projection will be leisure time and this factor may well determine the characteristics of the recreational development in New Mexico. Readily available water bodies will become prime requisites to the population of recreationists. It is probable that a continuous series of reservoirs may be constructed along the major waterways, particularly in the Rio Grande Valley, to permit easy access to a series of metropolitan areas extending from Taos intermittently to El Paso. To take advantage of the traffic flows in New Mexico, private water-based recreational developments can be expected along routes I-40 and I-10.

FUTURE SITUATION - HIGH LEVEL

Perhaps the most important of the assumptions for the high level of recreational use of water in New Mexico is concerned with water importation. It is assumed that water will be freely imported into New Mexico and/or weather modification will be effective enough to permit an adequate supply of water for all needs. Additionally, leisure time and income will advance at the projected rate while population will stabilize at about the 5,000,000 level. Legal boundaries will cease to be a factor affecting the New Mexico economy and the population center of the continental United States will lie slightly to the East.

With the above assumptions, gross recreational water needs in New Mexico will be as follows:

Water quantity = (.044) X (5,000,000) X (1.73) X (6.02)

= 2,291,000 acre-feet

The immediate reaction to this computation is that it is impossible as we view it from the mid-1960's. Reflect for a moment on our planner in 1860.

Picture his amazement at seeing the San Juan-Chama Diversion, or even at seeing a water skier at Elephant Butte Reservoir. The recreational situation in 2060 may well be equally amazing to any of us surviving to 2060.

One question that might be raised is that of the competitive position of water for recreation with those of other uses. The research by Wollman and others in the 1950's indicated recreational uses can compete with agricultural uses but not with some of the urban uses (8, pp. XVII-XIX). His result was partially supported by those of Coppedge in his study of Elephant Butte and Navajo reservoirs, where the recreational values of water were in the $400-$600 per acre-foot range (4, pp. 72 and 76).

If the above amount of water is to be used for recreation, it is probable that the Rio Grande will become a series of reservoirs to provide adequate supplies of water for recreational, domestic and agricultural uses. With abundant supplies of water and large populations, large-scale private developments are expected in the northcentral area comparable to those presently in some eastern coastal and Pacific areas. Land presently used in and adjacent to small farm enterprises may well be diverted to fish ponds, stream developments, and ski areas. Other developments are expected along the heavy travelled routes in the Albuquerque, Grants and Farmington areas, although water supplies may be limited in the Gallup area. Perhaps the largest relatively undeveloped recreational area in New Mexico is the Gila Area in southwestern New Mexico. If water is imported to Arizona and southwestern New Mexico, present supplies in this area will be retained in the area for broad-scale developments. The area is particularly favorably located, being at the center of the El Paso-Albuquerque-Phoenix triangle, as well as adjacent to the heavy traffic flows along I-10.

CONCLUSIONS

Recreation will be and is being restricted in New Mexico by a paucity of water resources. In the next hundred years, population, leisure and income increases will place heavy burdens on the water resource unless sharply increased quantities of water are allocated to this use. With water importations, an imagineering estimate indicates about 2.3 million acre-feet of water will be needed if the present 1965-66 rate of use is maintained: Water-based recreational developments of public lands will be concentrated in northcentral and southwestern New Mexico. Concentrations will occur on private lands in northcentral New Mexico, along the Rio Grande and Pecos River, but especially along the major transcontinental travel routes.

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IRRIGATION WATER NEEDS IN NEW MEXICO FOR THE NEXT HUNDRED YEARS

Marlin L. Hanson[1/]

What will irrigation farming be like a hundred years from now, or even in the year 2000? Almost certainly irrigation technology will preclude the crude practice of running water down furrows. Probably most crops will be solid planted and watered by sub-irrigation systems or sprinklers. In more humid areas the farmer may simply order a rain instead of relying on supplemental irrigation. Certainly developments at least this startling will have occurred by the turn of the century.

Perhaps irrigation, or even agriculture as we know it, will be obsolete by the year 2060. Our food may be drawn from the oceans or chemically synthesized. Our farmers may be producing for markets increasingly eroded by cheap manufactured substitutes. This prospect seems more likely than one of United States agricultural capacity under constant strain to feed a world population increasing at an exponential rate.

Water problems are high on the list of public concerns at present. Water supply and pollution problems have spread to the eastern states and become more critical in the West. The problems are of a scope and nature requiring state, interstate and federal planning and large public investments in water development programs.

Much interest has been directed to plans for importing water into southwestern states and communities. Importations appear to offer the only means for maintaining present levels of irrigation in pump irrigated areas. Other plans would permit continued irrigation development. The uncertain future of irrigation should cause us to consider carefully alternative plans for developing water resources and should tend to favor programs which develop water resources more gradually, in accordance with market demands, and commit public investments for shorter periods of time.

FACTORS AFFECTING FUTURE IRRIGATION IN NEW MEXICO

Projections of future irrigation water requirements must be based on a set of assumptions which concern those factors thought to be relevant or determining. A projection is not identical with but is related to a prediction. It is a prediction of what would occur at some future time

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if all the assumptions upon which the projection is based came about.

Among the factors that will determine future irrigation water needs in New Mexico are: (1) World population changes relative to food supply potentials and their implications for United States agricultural production, (2) Technological developments in food production and water developments, (3) Public policies as they relate to local areas and not necessarily related to the above, (4) Population growth and shifts in New Mexico and the United States.

World Population and Food Supplies

Population in the under-developed countries is increasing at the rate of 2.5 percent annually (1). The extent to which United States agriculture will be called upon to supply food deficits of under-developed countries has been the subject of speculation. Recent studies have indicated that United States agriculture has an abundance of land resources that could be rather readily converted to crop production (2). The 1958 Conservation Needs Inventory of land resources in the United States showed 422 million acres used for crops. Class I to IV land in this inventory is regarded as suitable for crop production and over 75 percent of the 806 million acres in these classes could be made available by corrective practices to control erosion and improve drainage.

The potential is considerably greater than this. The CNI is entirely inadequate as a basis for projecting the potential increase in irrigable acreage in the western states since climatic factors largely distinguish class I to IV land from that in higher classes. In New Mexico with a land area of nearly 77.8 million acres only about 5.8 million acres of class I to IV land was listed in the inventory of which 2.1 million acres was cropland (most of the remainder is range) (3). In most of New Mexico only the irrigated land is included in the arable classes due to the climatic variable of limited rainfall. Land in higher classes would be classed I to IV if irrigated. For example, in Dona Ana County 99,500 acres are included in classes I to IV of which 95,900 acres are irrigated. All but 2300 acres of the remaining 532,100 acres is class VII land. Another 1.8 million acres in Dona Ana county is in federal ownership and omitted from the inventory.

No irrigability classification of soils exists in New Mexico except for an initial effort by Dregne and Anderson for Curry County (4). They placed 94 percent of the land area of Curry County in irrigable classes I to IV and the remaining 6 percent in class V, non-irrigable. The Agricultural Economics Department of New Mexico State University is engaged in a study to evaluate the economic irrigability of land in New Mexico based on economic and climatic as well as soil variables.

Table I indicates the performance required by United States agriculture to supply world food needs in 2000 and 2060 assuming an extreme imbalance between population growth and food production in the under-developed countries. World population would increase from 3.4 billion in 1965 to 7.5 billion in the year 2000 and reach 30.4 billion by 2060. If the United States were to make up all the food deficits of the world, grain production would have to increase four times by the year 2000 and 24 times by 2060. This would require an annual rate of increase of 4 percent to the year 2000 declining to 3.4 percent in 2060. During the period 1955-65, agricultural production in the United States increased at a rate of nearly 2 percent, all as a result of increased yields or shifts in existing land use. Acreage declined slightly. The projections would require that yields continue to increase at least two percent each year and that crop land increase at the same rate until 2000 and somewhat less thereafter.

Public Policies

Decisions arrived at through the political process are often dictated by local desires and conditions and may be only remotely related to national and world conditions and pressures. Pavelis took account of this variable in projecting the long term growth of irrigation acreage in the 22 major water regions of the United States (5). He applied a complex statistical projection of historical rates of irrigation development that allowed irrigated acreage in each region to approach a maximum by the year 2000. The maximum in each region was the proportion of potentially irrigable land that the postulated irrigation policies would allow to be developed.

The potentially irrigable acreage was set by economic limitations. However, his study was limited by the lack of an irrigability classification of land that hampers other efforts. Moreover, the political limits were only assumed and had no analytical basis.

PRESENT IRRIGATION IN NEW MEXICO

The most recently published estimates of the acreages irrigated in New Mexico were prepared by the State Engineer Office and are reported by drainage basin in Table 2 (6). The most recent revision puts the 1965 irrigated acreage at 1,046,600.

In this paper the Rio Grande Basin was divided into north and south portions at the northern border of Sierra County. The western closed basins were combined with the Lower Colorado River Basin. The location of the drainage basins is shown in Figure 1.

Table 1. United States and world population and grain production, 1965 and projections to 2000 and 2060

	World Population						
	1965[a]			2000		2060	
	Total	Percent of total	Percent Annual Increase	Total	Percent of total	Total	Percent of total
	(millions)			(millions)		(millions)	
Less Developed Countries	2,600	70.0	2.5	6,170	82.0	27,130	89.2
Developed Countries except United States	610	24.4	1.5	1,030	13.7	2,510	8.2
United States	190	5.6	1.5	320	4.3	780	2.6
World Total	3,400	100.0	---	7,520	100.0	30,420	100.0

	World Grain Production (tons)											
	Per Capita Consumption	Percent Annual Increase	1965[a]			2000			2060			
			Total	Percent of total	Imports	Total	Percent of total	Imports	Total	Percent of total	Imports
	(tons)		(millions)		(millions)			(millions)	(millions)		(millions)
Less Developed Countries	.171	1.0	424.5	43.8	20.5	599.9	31.0	455.2	1,092.1	16.1	3,547.1
Developed Countries except United States	.636	1.5	368.4	38.0	19.7	620.5	32.1	33.6	1,516.9	22.4	79.5
United States	.705	B*	176.0	18.2	-42.1	714.4	36.9	-488.8	4,176.5	61.5	-3,626.6
World Total			968.9	100.0	- 1.9	1,934.8	100.0	0	6,785.5	100.0	0

*B is percentage annual rate of increase of United States production to satisfy world food needs and is 4.1 percent in the year 2000 decreasing to 3.4 percent in the year 2060.

a/ Source of figures: Heady, E. O., Mayer, Leo V., and Ball, A. Gordon. "Trends and Capacity of U. S. Agriculture", paper given at conference sponsored by the Center for Agricultural and Economic Development, Iowa State University, Oct. 2-4, 1967.

Table 2. Acreage Irrigated and Source of Water Used in New Mexico by Drainage Basins, 1960-64.[1/]

	Acres Irrigated			
	Surface Water	Ground Water	Surface and Groundwater Combined	Total
Arkansas River	95,130	4,530	-	99,660
Southern High Plains	-	288,200	-	288,200
Pecos River	39,520	124,405	32,935	196,860
Central Closed Basins	3,070	28,440	1,000	32,510
Rio Grande	132,590	18,825	105,030	256,445
Western Closed Basins	-	160	-	160
San Juan River	51,000	-	-	51,000
Lower Colorado River	12,280	3,930	5,450	21,660
Southwestern Closed Basins	215	53,220	1,000	54,435
TOTALS	333,805	521,710	145,415	1,000,930

1/ Source: New Mexico State Engineer Office, "Water Resources of New Mexico," State Planning Office, Santa Fe, 1967.

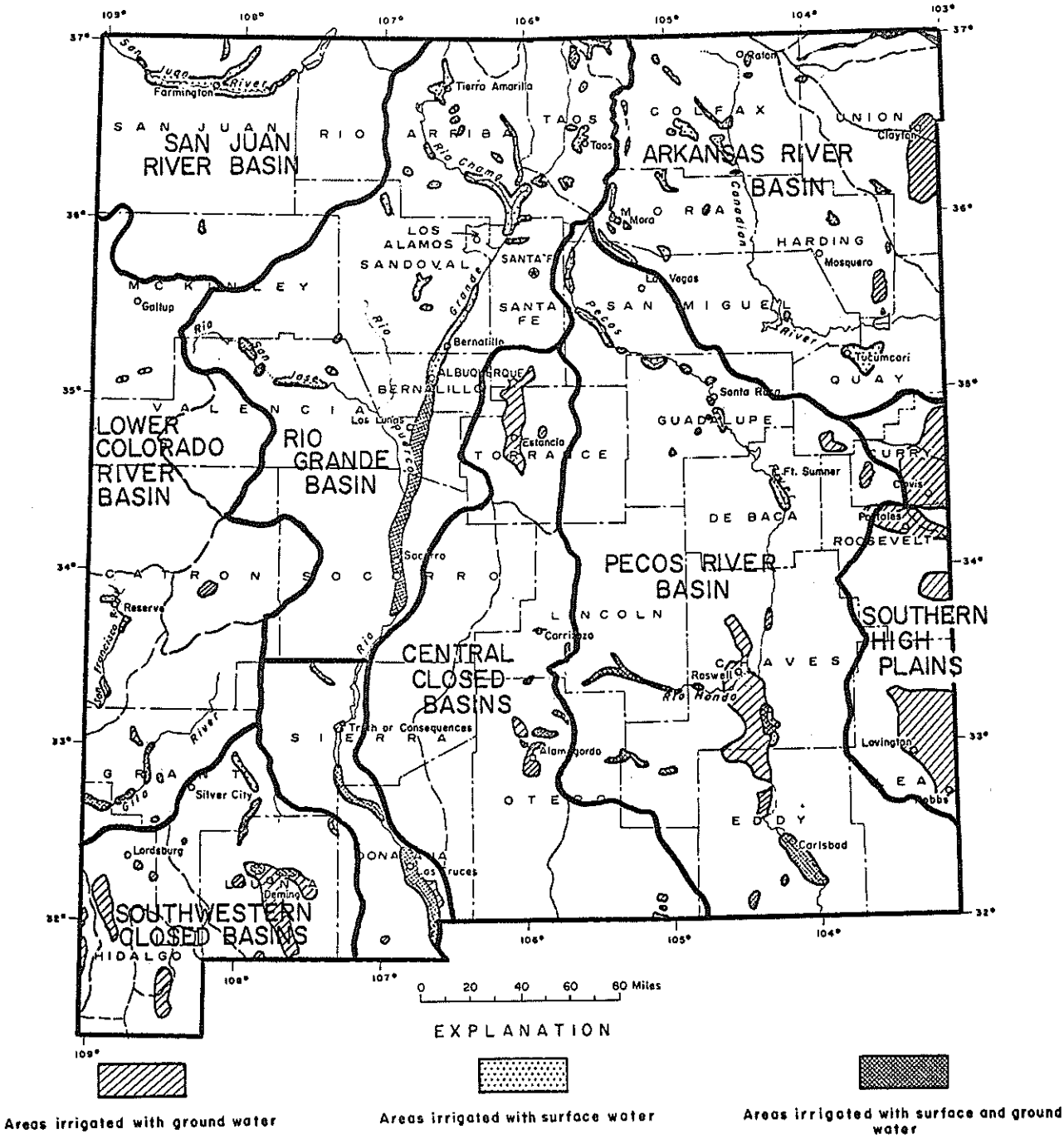

Figure 1. Drainage Basins in New Mexico and Irrigated Areas by Source of Supply, 1965.

Irrigation development in recent years has increased most rapidly in the southern High Plains Basin, particularly in Curry County (Table 4). Pump irrigation development is continuing in the southwest closed basin, especially in southern Hidalgo County. Significant irrigation development is underway in the Arkansas River Basin. In contrast, development in the Pecos River Basin and Rio Grande Basin is relatively static.

The Navajo Indian Irrigation Project will make 250,000 acre-feet available for irrigation in the San Juan Basin. At present rates of diversion, irrigated acreage could more than double. The San Juan-Chama project, also under construction will provide 29,900 acre-feet for irrigation in the Rio Grande Basin in northern New Mexico and 22,600 acre-feet for supplemental irrigation in the Middle Rio Grande Conservancy District (6).

Table 3 shows the irrigated acreages of principal crops in each drainage basin in 1966 as reported by the Crop Reporting Service. Gross value of crop production per acre was calculated for each basin.

PROJECTED WATER USE FOR IRRIGATION

High, low and medium projections of irrigated acreage and water requirements for irrigation were made to the years 2000 and 2060. The temptation to make any of these projections - particularly the medium projection - a prediction was scrupulously avoided.

High Level of Irrigation Use

The assumptions which result in the high projection of irrigation in New Mexico are not those likely to be responsible should the projection actually occur. It is more probable that irrigation in the magnitude of nearly eight million acres projected for 2060 would come about rather soon, say within 30 years, or not at all, and would be the result of political pressures that put through large water developments such as those being presently proposed. However, the assumptions used here merely remove any political or legal obstacle to increase irrigation development resulting from the forces described below.

Assumptions for the high projection. The high projection is consistent with the following assumptions: (1) World population will continue to increase at the present high rate of 2.3 percent annually. (2) United States agricultural production will increase at a rate to supply world food deficits. Transportation and distribution facilities will make the demand effective. Production increases in New Mexico will keep pace with or exceed the United States rate. (3) Water is available for importation into New Mexico or transfer within New Mexico at approximately the same relative costs (including land preparation and diversion systems) as at present.

Table 3. Acreage and Gross Value Per Acre of Principal Irrigated Crops by Drainage Basin, New Mexico, 1966.

Drainage Basin	Irrigated Crop Acres, 1966									Gross Value per Acre (Dollars)
	Cotton	Small Grain	Corn and Sorghum[1]	All Hay	Vegetables	Dry Beans	Peanuts	Pecans and Apples[2]	Total	
Arkansas River	1,190	6,400	18,170	50,100	0	20	60	65	76,005	44
Southern High Plains	25,170	69,690	120,310	18,100	970	340	8,140	-	242,720	98
Pecos River	43,425	7,680	7,860	88,100	95	160	0	1,225	148,545	153
Central Closed	1,280	1,070	1,400	6,600	1,760	1,100	0	-	13,210	155
South Rio Grande	46,085	2,800	2,700	16,200	7,710	20	0	6,005	81,520	285
Southwestern Closed	13,810	2,350	26,550	5,100	275	1,510	0	105	49,700	151
Lower Colorado River and Western Closed	25	700	850	5,500	0	0	0	180	7,255	66
San Juan	0	650	3,000	14,400	0	250	0	800	19,100	88
North Rio Grande	1,285	5,660	4,960	59,900	1,490	300	0	1,785	75,380	90
STATE TOTAL	132,270	97,000	185,800	264,000	12,300	3,700	8,200	10,165	713,435	
Gross Value Per Acre (Dollars)	226	80	78	85	889	73	258	377		128

1/ Includes broomcorn

2/ Additional Source: New Mexico Crop and Livestock Reporting Service, "New Mexico Apples and Pecans", New Mexico Department of Agriculture, New Mexico State University, October, 1963.

Source: New Mexico Agricultural Statistics, Vol. VI, Las Cruces, New Mexico, June, 1967.

Computations were made assuming that irrigated acreage will continue to increase at the same annual rate as in the 1955-65 period. The rate was weighted toward the most recent five-year period by averaging the annual increase from 1955-65 and from 1960-65. Separate rates were calculated for each drainage basin and are presented in Table 4. However, the rate of increase for the entire state of 2.14 percent per year, was applied to the 1965 irrigated acreage of each basin.

Irrigated acreage more than doubled between 1965 and 2000 and increased 7.4 times by 2060. The increase in acreage calculated for each basin was adjusted by the ratio of the 1966 gross value of crops per irrigated acre in the basin divided by the same figure calculated for the state. Thus the projected 2000 and 2060 irrigated acreages in each region reflected the 1955-65 rate of increase in the state and the value or productivity of water in each region. The latter assumes that gross value is related to the net return per acre and to the marginal value product of water.

Location of production. Projected irrigated acreage in each basin is shown in Table 4. The areas of lowest value irrigation received the smallest increase, notably the Arkansas River Basin and Colorado River Basin. Irrigated acreage was projected to increase three times and four times, respectively. The largest increase was in the southern portion of the Rio Grande Basin where irrigated acreage would increase from about 100,000 in 1965 to over 1.5 million in 2060. Rather large increases of about nine times the present acreage would occur in other southern regions.

Radically different values would have resulted if the rate of change within a basin had been the basis for projecting irrigation development. Development in the Rio Grande and Pecos basins would have been nearly stationary. Since irrigable land appears to be abundant in all areas, the assumptions of plentiful and reasonably priced water supplies should allow for irrigation development in each basin, to the extent that it is profitable.

Water uses. Water diversions were assumed to increase at the same rate as irrigated acreage, but depletions increased per acre and as a percent of diversions. This reflected increased consumptive requirements for rapidly increasing crop yields and greater irrigation efficiency which allowed per acre diversions to remain constant.

The projections reflect the increase in irrigated land and water requirements to allow New Mexico agriculture to maintain its share of United States production. The projected water requirements are presented in Table 5. Depletions for irrigation in New Mexico were 1.7 million acre-feet in 1965 and diversions were nearly 3.2 million acre-feet. Under the high projected

Table 4. Acres Irrigated by drainage Basin in New Mexico 1955-65 and Projections to 2000 and 2060: High Level of Water Use.

Drainage Basin	Acres Irrigated[1]			Annual[2] Rate of Increase	Projected Acres Irrigated[3]	
	1955	1960	1965		2000	2060
	(000)	(000)	(000)	(Percent)	(000)	(000)
Arkansas River	77.5	87.0	98.7	2.46	135	319
Southern High Plains	209.0	244.0	326.0	5.26	601	1,949
Pecos River	192.5	196.3	195.9	0.08	454	1,718
Central Closed	26.0	29.3	31.5	1.75	74	279
South Rio Grande	95.6	97.8	99.1	0.31	342	1,534
Southwestern Closed	50.7	58.2	68.8	3.25	158	596
Lower Colorado River and Western Closed	15.1	12.2	18.1	4.50	28	79
San Juan	42.5	47.6	50.5	1.50	109	381
North Rio Grande	168.0	151.0	158.0	-0.40	280	880
STATE TOTAL	876.9	923.7	1,046.6	2.14	2,181	7,735

1/ Estimates still under revision by the State Engineer Office, State Soil Conservation Service, New Mexico Agricultural Experiment Station, and United States Bureau of Reclamation.

2/ Calculated as the average of the 1955-65 and 1960-65 annual rates of increase.

3/ Acreage irrigated in each basin in 1965 was increased at the annual rate of increase in New Mexico of 2.14 percent and projected to the years 2000 and 2060. The increase in acreage for a basin was adjusted by the ratio of gross value per acre irrigated in the basin to the average gross value per acre irrigated in the state. Crop values for 1966 were from New Mexico Agricultural Statistics, June 1967.

Table 5. Water Diversions and Depletions for Irrigation by Drainage Basin, 1965 and High Projections to 2000 and 2060.

Drainage Basin	1965 Water Depletions[1] (1000 Acre-feet)	1965 Water Diversions[1] (1000 Acre-feet)	Water Depletions[2] (1000 Acre-feet)		Water Diversions[3] (1000 Acre-feet)	
			2000	2060	2000	2060
Arkansas River	132.8	232.8	194	565	318	753
Southern High Plains	406.7	637.2	716	2,858	1,174	3,810
Pecos River	370.9	662.9	937	4,359	1,536	5,812
Central Closed	52.2	79.1	112	524	184	698
South Rio Grande	230.1	483.8	1,017	5,610	1,668	7,483
Southwestern Closed	132.4	220.8	309	1,432	506	1,909
Lower Colorado River and Western Closed	32.3	55.4	53	181	87	241
San Juan	94.0	179.2	237	1,016	388	1,354
North Rio Grande	284.5	615.8	667	2,574	1,093	3,432
STATE TOTAL	1,735.9	3,167.9	4,242	19,119	6,954	25,492

1/ Source: New Mexico State Engineer Office, "Water Resources in New Mexico: Occurrence, Development and Use," State Planning Office, Santa Fe, 1967.

2/ It is assumed that water depletions, which averaged 54 percent of water diversions in 1965, will have increased to 61 percent by 2000 and 75 percent by 2060 due to increased efficiency of diversion and irrigation and due also to greater consumptive use per acre as the result of an assumed 2 percent annual increase in crop yields.

3/ Water diversions are assumed to remain at the 1965 per acre level. Water requirements per acre have increased due to increased per acre yields, but increased efficiency of diversion and application balances this.

use irrigation depletions would increase to over 4.2 million acre-feet in 2000 and 19 million acre-feet by 2060. Diversions would increase 1000 percent as an average for the state compared to a 670 percent increase in acreage. Nearly the entire increase in depletions above present levels would have to come from importations to the state.

We might compare the magnitude of these high projected water requirements with development projects such as NAWAPA and the west Texas plans. The former proposed to provide 10 million acre-feet to New Mexico annually, mainly to the Arkansas River, Pecos River, Rio Grande below Caballo Reservoir and the southwestern closed basins. The west Texas plans would provide water to the southern High Plains Basin of New Mexico where irrigable land area has been estimated at about 10 million acres.

Low Level of Irrigation Use

The factors which combine to cause large water requirements for recreation and municipal-industrial uses may result in low requirements and/or availability of water for irrigation. Rapid population growth that augmented the demand for New Mexico (United States) agricultural products, if accompanied by continued prosperity in this country, would increase all demands for water. If water rights were freely marketable, water would be purchased from agriculture for these other uses. If population grew more rapidly than our ability to feed ourselves and the world, the value of water for irrigation would increase relative to other uses.

Rising per capita incomes increase the demand for recreation and most industrial products more rapidly than for agricultural products.

Assumptions for the low projections. The low projected use of irrigation water might be the result of technological obsolescence or lack of demand for agricultural products as described earlier. This possibility is ignored and the following assumed: (1) Population in New Mexico will grow at a rapid rate compared to the moderate rate of increase in the United States. (2) Water supplies are limited to presently known and economically available quantities. (3) Legal institutions (water laws and public policies) prevent importations or transfers from the area of origin. (4) Recreation and municipal-industrial uses, being of higher value, can and will purchase from agriculture the amounts of water desired.

The assumptions are not entirely compatible. Economic activity in many New Mexico communities is directly related to the growth or decline of agriculture. Prosperity and rapid population growth would be difficult to maintain if diminishing water supplies caused irrigation to decline rapidly. Neither are the assumptions the most extreme that could be postulated.

New Mexico population was not a consideration in the high projection. Edgel's population projection for New Mexico counties to the year 2000 was the basis for projecting irrigated acreage in each drainage basin in the low projection (8). According to this projection, New Mexico's population would increase from 951,000 in 1960 to 2,778,000 in the year 2000, an annual rate of increase of about 2.7 percent.

For the purposes of this study, the rate of population growth after 2000 was assumed to decline so that New Mexico population reached 6 million by the year 2060.

All available surface and groundwater in New Mexico is assumed to be fully appropriated and no additional irrigation development is permitted. Irrigation is the residual user after all other uses are satisfied. Possible reductions in nonbeneficial uses are not considered. Groundwater mining will continue until physical or economic limitations reduce depletions to a balance with recharge. Where surface and groundwater sources are commingled water depletions are maintained at a level that balances the basin. The results are given in Table 6.

Location and amounts of irrigation. The low projection indicated a decline in irrigated acreage of 40 percent by the year 2000. Irrigated acreage and water depletions would decline to a third the 1965 level by 2060. Both areas of high and low value crop production experienced equally sharp declines. This was a consequence of the assumptions for the low projection.

The complicated hydrology of New Mexico water basins prevented reliable estimates of groundwater recharge. Some information is available for bold estimates. The remaining saturated depth of acquifer was compared to the rate of decline in water level in projecting the irrigated acreage remaining in 2000 and 2060. The rate of mining was assumed to decrease over time as wells went out of production and pumping quantities decreased. The effect was to prolong the life of the acquifer.

Pump irrigation on the southern High Plains would virtually cease by 2000. Pumping from the extremely deep acquifers of Luna and Hidalgo counties might be prolonged for a longer period.

Nonirrigation uses were responsible for the decline of irrigation in the northern Rio Grande Valley. Population was projected to multiply ten times throughout the Rio Grande Basin by 2060.

Medium Level of Irrigation Use

The medium level of water use assumes that conditions remain much as at present. This will require a moderate amount of development of water supplies

Table 6. Acres Irrigated, Water Depletions and Water Diversions for Irrigation by Drainage Basin, 1965, and Projections to 2000 and 2060: Low Level of Water Use.

Drainage Basin	Acres Irrigated			Water Depletions (1000 Acre-feet)			Water Diversions (1000 Acre-feet)		
	1965 (1000)	2000 (1000)	2060 (1000)	1965	2000	2060	1965	2000	2060
Arkansas River	98.7	99	99	132.8	133	133	232.8	233	233
Southern High Plains	326.0	50	0	406.7	62	0	637.2	98	0
Pecos River	195.9	118	62	370.9	221	117	662.9	395	209
Central Closed	31.5	21	16	52.2	30	22	79.1	48	37
South Rio Grande	99.1	82	47	230.1	190	108	483.8	440	250
Southwestern Closed	68.8	30	2	132.4	58	4	220.8	111	7
Lower Colorado River and Western Closed	18.1	18	18	32.3	32	32	55.4	55	55
San Juan	50.5	50	50	94.0	94	94	179.2	179	179
North Rio Grande	158.0	147	16	284.5	264	9	615.8	570	194
STATE TOTALS	1,046.6	615	310	1,735.9	1,084	519	3,167.9	2,129	1,164

to recharge groundwater tables in pump irrigated areas. The Navajo Indian Irrigation Project and irrigation under the San Juan-Chama Diversion are included in projections of irrigated acreage. This was the only expansion of irrigated acreage included in the projection.

Assumptions for the medium projection. The medium projection is based on the following assumptions: (1) The population-food supply balance in the world does not become critical. As a result there is a moderate increase in demands for irrigation water and agricultural products. Agricultural production in the United States will continue to increase without an increase in acreage. (2) Presently unappropriated water will be developed and water importations will permit irrigation to continue at present levels or increase sufficiently to allow New Mexico agricultural production to keep pace with the moderate world population growth. (3) There are no institutional restrictions on water transfers.

A medium projection based on these assumptions takes advantage of data developed for the high and low projections of irrigation water needs. It provides a rough estimate of the magnitudes of water importations needed to maintain present irrigation developments in each basin and still permit population and other water uses to increase rather rapidly. Increased water requirements for nonagricultural uses are those developed for the low projection and based on Edgel's population projections for New Mexico.

Water requirements of the medium projection. The results of the medium projection are in Table 7. Irrigated acreage and water depletions were assumed to remain at 1965 levels for the next hundred years. No shifts were projected between regions. The exception was in the San Juan and Rio Grande Basins. The Navajo Indian Project and San Juan-Chama Diversion were assumed to be completed and water allocated as proposed. A rather slow rate of development was assumed that did not immediately or fully utilize the large water supplies. Some of this water, in addition to the maximum 235,000 acre-feet scheduled to be diverted to the Rio Grande Basin, was used to alleviate the pressing water problems of that region.

The medium projection indicated that given the present uses of water in New Mexico an additional 590,000 acre-feet would be needed in 1965 to maintain groundwater levels with the largest requirements in the southeastern High Plains, Pecos River and southwestern closed basins. The projected increase in other uses, associated with the growth in population, would require supplemental supplies of water in the Rio Grande Basin before the year 2000.

By the year 2060 other uses would far outweigh agriculture as important users of water. Included in the total depletion figures of Table 7 are nonbeneficial depletions and evaporation from reservoirs which distort the magnitudes of

Table 7. Water Depletions and Importations Needed to Maintain Irrigation in New Mexico and Satisfy Nonirrigation Use: Projection of Medium Water Use to 2000 and 2060.

Drainage Basin	Projected Irrigation (1000 Acres)	Irrigation Depletions (1000 Acre-feet)	Total Depletions (1000 Acre-feet)[1/]			Water Importations (1000 Acre-feet)		
			1965	2000	2060	1965	2000	2060
Arkansas River	99	133	250	270	300	0	0	0
Southern High Plains	326	407	450	480	550	310	340	410
Pecos River	196	371	650	710	810	90	150	250
Central Closed	32	52	110	120	140	60	70	90
South Rio Grande	99	230	650	690	830	0	(40)	(190)
Southwestern Closed	69	132	150	170	210	130	150	190
Lower Colorado River and Western Closed	18	32	50	60	60	0	0	0
San Juan[2/]								
(1) Present (1965) Irrigation	50	94	250	460	490	0	(-190)	(-390)
(2) San Juan and Navajo Projects	100	191						
North Rio Grande	158	284	760	910	1,250	0	(150)	(490)
STATE TOTAL	1,147	1,926	3,320	3,870	4,640	590	710	1,230

1/ Total depletions for each basin are estimates found in "Water Resources of New Mexico," op.cit., and were adjusted to the 1965 acreages in Table 4 of this manuscript.

2/ The San Juan Basin is projected to be a net exporter to the Rio Grande Basin, nearly to the extent of its needs. Since the San Juan and Navajo Indian projects are currently under construction, the water supplies are included in the projections to 2000 and 2060.

nonagricultural uses. However, these two types of depletion were assumed to remain at the same level over time so that comparisons for other uses may be made.

CONCLUDING REMARKS

The projections have very little analytical content and employ the simplest types of projection techniques. Projections of 50 or a hundred years, especially in such an unpredictable area as this, is an exercise in futility. However, planning is essential in any undertaking involving investments. An unavoidable first step in planning the development of water resources is making projections of the future. There would appear to be merit in attempting to develop water resources piece-meal rather than on a grandiose scale. A major obstacle has been the inability or unwillingness to consider alternatives.

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WATER USES FOR THE NEXT HUNDRED YEARS
A Summary Statement

George R. Dawson[1/]

I would first like to compliment each of the three speakers for their papers and their attempts at making some projections into a time period that defies the imagination. Each paper develops a line of reasoning that brings at least into a "fuzzy" focus an idea of the magnitude of potential water uses and needs a hundred years from now.

As we stated in the preface remarks for this panel discussion, the objective here was to attempt an estimate of the future under a series of stated assumptions as to the direction of change in the future. Quite obviously none of us here today will be here in 2060 (although I am not absolutely sure even about that) to check on the accuracy of these projections. Others - many others, will continue to examine the changes as they occur and restructure projections based on new knowledge.

It would be possible at this point to start my summary statement by listing a number of uncertainties about the shape of world affairs - present and future - but our crystal ball is even less clear on these matters. I also have the problem of how to approach the task of summarizing uncertainties. Suffice it to say, however, that -

1. Population will continue to increase at breakneck speed at least to the year 2000. Only hopefully can we say progress of science and man will slow birth rates to a level commensurate with our ability to feed ourselves. Estimates of arable land in the world on a per capita basis in 1960 were 1.2 acres and by 2000 this will have been reduced to .48 with a population of 7.4 billion people. A generalized projection at these rates would mean less than 0.1 acre per capita by 2060. Only about five percent of the earth's surface is suitable for agricultural production.

2. The United States will be forced to make major contributions to starving populations around the globe where at present the fertility of the people is outstripping the fertility of the soil. These contributions will be in the form of actual food aid and technological assistance. FAO reports a yearly decline in per capita world food production. It is estimated that 10,000 people starve to death daily in a world where two of every three persons are undernourished even at the minimum nutritional levels. We now have food deficits of gigantic proportions. World grain needs of 770 million tons even in 1980 exceeds current production by more than 300 million tons. This problem simply will not

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just go away and the United States cannot fill the food gap from its own production. Increased per capita food production is an absolute necessity. By 2000, we will have three billion malnourished and starving people instead of 1.5 billion as we have today, unless per capita food production is increased. The social pressures created under such circumstances are inconceivable. The race is on! A race that cannot be won at current production rates - be it of people or food. We are on a collision course!

3. Food aid requirements plus meeting food demands at home will require vast increases in food production. We will not be able to ignore world population - food imbalances.

I have set this general stage with the backdrop of a picture of population and food balance problems because it seems to me that it is highly important that any projection about the future of New Mexico be made at least with some attention given to how New Mexico might be affected from such external forces.

THREE COURSES

We have heard projections for New Mexico that would indicate a population of six to twenty-two times present numbers, and employed so as to achieve higher incomes creating demands for vast increases in water for MD & I, recreation, and in agriculture. If I have been able to assemble these estimates properly, we will require no less than seven times as much water in 2060 as we now have in New Mexico. MD & I uses are projected to increase to a depletion requirement of about one million acre-feet, and recreation uses for seepage and evaporation losses alone without considering impounding requirements will require about 2.3 million acre-feet. As a bench mark these two uses alone total 3.3 million acre-feet which is almost identical with the current total depletions under all uses in the state of 3.25 million acre-feet. A dismal view then would be that if the state moves as Hernandez and Gray "imagineered" it, irrigated agriculture will have passed into the history books unless additional water supplies are provided or significantly greater accomplishments are made in efficiency of water use - in all use categories. Technology will solve part of the problem but certainly not all of it.

Now before someone concludes that this will be the situation in 2068, let me hasten to develop my second course of action that would reverse the above. Since all we can do is put some rather broad parameters around what the future may hold, we are obligated to present the view that agriculture could well be the highest bidder for the majority of total water supplies regardless of

their sources due to pressing population-food problems. Many varying views are available today as to the likelihood of such a situation but it is still one of the possibilities, like it or not - believe it or not.

A third possibility that should get consideration would be that New Mexico use its water resources for industrial and recreational development if it can be reasonably determined that agricultural production will in fact shift to areas with greater comparative advantage. This assumes an affluent population and food technological developments that reduce farming to a nonessential in New Mexico.

Needless to say, I am only speculating from points made in the three papers and taking a few liberties at that. Yet it is obvious that if developments occur as outlined by the three speakers for 2060 that competition for available supplies of water will be more than keen. It would further seem obvious that if supplies of water are to be adequate to permit maximum development in all use categories, additional water supplies will have to be provided. All speakers at this Conference appear to have been in agreement on this point. It would be also concluded that we will need to give much consideration to the need for and basis of establishing priorities on our uses of water.

We are facing a challenging dilemma. To achieve higher per capita income, industrial development on a greatly increased scale must be stimulated. People with higher incomes have increased demand for water for both municipal and recreational uses. Increased population gives rise to greatly increased demand for food and thus increased demand for water in farming.

Assuming existing or decreasing supplies of water in the future, New Mexico has some decisions to make. Will the need for food force us to use our water for production on farms or will comparative advantage push New Mexico toward industrialization at the expense of farming? Under varying sets of assumptions, answers will reveal the direction of change. We must be prepared to take some hard looks at alternative future prospects and attempt to bring about the changes that make for a better New Mexico. That planning must start now.

If we plan for an abundant supply of water, New Mexico can be a major industrial state, a recreationist's paradise and have a farming industry irrigating at least eight times as many acres as today. This you may conclude is also an optimist's view but it need not be.

On the other hand, if we fail to plan by taking into account projections of the future, we can be a poor state with little expansion or economic growth.

New Mexico is not about to dry up and blow away even without an increase in water supplies from new sources. But, as it or if it becomes a more "thirsty"

state, we have some major decisions to make as to how the available water should be used. These decisions will without doubt force changes in current political, institutional, and personal barriers to change. Domestic uses of course will have priority but what about watering lawns, washing cars, using water on hobby horse pastures, etc., where economic benefits are questionable? Every decision we make will affect our future. Historical or traditional uses may not be considered as basis for a future use.

People will, I believe, continue to move water if it is needed to where they want it and will produce the products needed and wanted, whatever these products be. Production areas have changed in the past and will change in the future. I disagree with the theories claiming that areas with surplus water have an unquestioned right to hold that water for some "potential" use in the indefinite future. We must determine national priorities that may well disregard existing political boundaries. Projections of the next hundred years are imperfect - and some will say impractical - yet, if we are to readjust to changes that are inevitable as well as to adjust those things that can be adjusted, long range projections and plans must be made. This is a continuous responsibility. Such imagineering projections force us to take stock of our resources, our policies, laws institutions, etc., and to modify them so as to provide a means to a better life for all people rather than taking whatever the consequences might hand out as a result of our short-sightedness in planning. Long range planning helps focus on the needs for and kinds of shorter range planning. By focusing down from long range to short range problems and development of alternative solutions, we do have opportunity to guide that change - at least in part - and in directions beneficial to all of society.

We prefaced this "emagineering" session with remarks about the futility of attempting projections as to the state of the world in 2068 by comparing the question today to a similar request of a man back in 1860 to describe 1968 conditions. Obviously conditions at both times are similar in that we just are not capable of seeing that far ahead. Yet, I propose to you today that unless we work diligently in the coming years, there may in fact be another disturbing similarity between 1868 and 2068. Namely, that in 1868 water was critical for survival, especially to the traveler of the desert Southwest and it may be equally as critical for survival in 2068 if we do not take the necessary action to assure an adequate water supply to meet the needs of that time, whatever they be.

I would summarize the job ahead in five points. We must (1) observe the facts and define the problem, (2) analyze these facts and all alternatives, (3) make decisions, (4) take the necessary action to implement the decision, and (5) accept the economic and social responsibilities for those actions.

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MEETING FUTURE WATER NEEDS

Roland R. Renne[1/]

As the last speaker at this Annual Conference, I would like very much to be able to select just the right words that would enable each of us to leave the Conference on a high note of enthusiasm and optimism for the future.

This has been an excellent conference. Up to now I have enjoyed it very much. The program has not been too crowded and there has been opportunity for ample discussion by those attending the Conference, as well as the panel members.

The fact that we have been discussing ways of assuring adequate supplies of water for New Mexico to the year 2000 and to the year 2060 appears to have broadened our horizons, and enabled us to speak more freely about things as they may be one hundred years from now than we would have spoken were we saying what will be done or what will be the situation a year or two, or five from now. I am sure each of us has learned a great deal from this Conference and has been stimulated to apply his talents a little bit more effectively to improve our water development and management programs to permit continued growth of the New Mexico economy.

The title assigned to me is: "How Can New Mexico and the Southwest Organize to Meet Its Future Water Needs?" The use of the word "its" indicates to me that perhaps it was desired to convey the thought that New Mexico and the Southwest are one and the same in terms of water needs, or at least their water problems are very similar. The word "their" may be better English but the word "its" is a realistic point of view concerning how to get the overall job done.

New Mexico certainly cannot completely solve its water problems alone and apart from the region and even the two working closely together and in harmony would not be adequate to solve some of the water problems we face, particularly those that may face us 50 or 100 years from now, when our population may be much larger.

How Far Ahead Can or Should We Plan?

I think we would all agree that we cannot leave such important things as our water supplies to chance. I am sure a great majority, if not all of us, agree that effective planning is highly desirable and we must plan ahead.

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There is considerable disagreement on how far ahead we can plan. I remember a major professor of mine in graduate school, years ago, suggested that this topic would make a good doctoral thesis. There is much evidence to show that most of us do not think farther ahead than two generations - our own and that of our children. As we approach our later years perhaps we think ahead for our children and their children; that is, our grandchildren. Probably most of us do not think ahead more than 40 or 50 years. Perhaps because the times and technology are changing faster than ever, a century is not too far to contemplate our problems ahead and try to prepare to meet them satisfactorily.

Recently a serious attempt was made to do some long-range forecasting. Olaf Helmer, of the Rand Corporation, and T. J. Gordon, of Douglas Aircraft Corporation, studied this matter and found a near vacuum as far as tested techniques are concerned. They set up an experiment using 82 top experts who had outstanding records in various fields and divided them into six panels: (1) scientific breakthroughs, (2) automation, (3) space, (4) weapons, (5) population, and (6) war prevention.

This group considered 136 potential futures open to man. After carefully examining these each of the experts or "wise men" indicated a date in which he believed a breakthrough could be achieved. From these dates a median date for each breakthrough was determined.

I will take only the major <u>scientific</u> breakthroughs that were suggested and mention four that may be of particular interest to us. The group came up with 31 scientific breakthroughs out of the 136 potential futures which they examined. Four of these 31 major scientific breakthroughs include:

First, "regional weather control" - predicted for the year 1990. The word "regional" in this case is a general term and does influence one's view as to when such a breakthrough may be accomplished. From what Commissioner Floyd Dominy told us yeaterday we may be able to make a scientific breakthrough before 1990, which will enable us to influence precipitation in a given region significantly. The use of the word "control," however, would go farther than what Commissioner Dominy was emphasizing. Control of the weather of a region would imply more than merely increasing precipitation ten, twenty, or thirty percent by activity in a part of the year in which cloud conditions were favorable for such results. The year 1990 is not far off and the fact that these "wise men" felt that regional weather control was a distinct possibility by that time indicates that we may be closer to outstanding achievements in this field than we think.

The second breakthrough I have selected is "hereditary defects controlled by altering genes." The median date for this breakthrough is suggested as the

year 2000. This kind of breakthrough could be of tremendous significance and I am sure I do not need to explain its ramifications.

The third scientific breakthrough selected is "biochemicals to aid growth of new organs and limbs." The median date for this breakthrough is suggested as the year 2010. Maybe this development will replace the need of heart transfers.

The fourth major breakthrough I have selected from the group is "control of the aging process" permitting extension of life fifty years. The predicted median date for this breakthrough is 2050. Unfortunately, it will be too late for many of us, but I think we can all see what it would mean to our total population numbers. It might even make Ralph Edgel's figures, which he showed us yesterday, on New Mexico's predicted population for the year 2060 look quite conservative and certainly would have a significant effect on water demands.

We all agree that probably the best basis for judging the future is the experience of the past. America has experienced tremendous change and progress through science. Not all change is progress. I like to define progress as "change in the right direction" and the right direction, I submit, is elimination of disease, poverty, ignorance, fear, and other similar human troubles.

I suggest that probably the most important single contributing factor to our great progress has been our nationwide system of "free" public schools - from kindergarten through college. I put the word free in quotes because I realize that education is not completely free, but the bulk of the costs is provided through public tax funds and we have followed the principle of emphasizing quality and merit but have supplemented this with a geographical distribution of schools and colleges to make education more readily available to all our youth and adults. We have defended the position that we would provide this type of education for all up to the limit of each individual's capacity to make effective use of such knowledge, education, and/or training.

The effectiveness of this system is well demonstrated through our land-grant universities with their schools of agriculture and mechanical arts, the agricultural experiment stations, and the Cooperative Extension Service. This campus is a good example of the kind of effective service which these institutions have been rendering the state.

Through the leadership of your Great Senior Senator from New Mexico, Clinton P. Anderson, we have applied some of the same research and informational services that have been applied to agriculture to water. We now have 51 water resources research institutes or centers (one in each of the 50 states and Puerto Rico).

However, the Water Resources Research Act of 1964 improved upon several of the provisions of the Land-Grant College legislation of 1862. In addition to these 51 Institute universities we have other universities affiliated with these 51 so that now more than 100 universities and colleges are affiliated together working on water resources research problems. In New Mexico all three of the major institutions, the University at Albuquerque, New Mexico Institute of Mining and Technology at Socorro, and New Mexico State University, where the Water Resources Research Institute is located, are working together effectively to help solve some of New Mexico's difficult water problems.

I do not mean to imply that no water research was done by universities and colleges prior to the passage of the 1964 Act, but there was no systematic, continuing, cooperative federal-state research effort corresponding to our agricultural experiment station system which has now been operating more than eighty years. But, prior to passage of the 1964 Water Resources Research Act, research in water and resources which affect water was small, spotty, sporadic, and completely inadequate to solve the tremendous water problems that beset us.

This dual approach of emphasizing quality and geographical distribution as criteria for support will continue to help us achieve major breakthroughs in solving our water problems in the years ahead - just as education and research through land-grant and state university system has helped advance scientific discovery and develop technology which have helped to make our country strong and productive.

What are Most Effective Means of Dealing with Water Problems in Water-Short Areas?

The awareness and concern of land-grant universities like New Mexico State for the state's progress, working effectively with sister institutions in the state, is evidenced in many ways. One of these is this Annual Water Resources Conference under the able leadership of Dr. Ralph Stucky and with support which he has had from the staff and administration of this institution. This Annual Conference is one of the most effective means of dealing with water problems intelligently. Adequate support for strong research and educational programs in the water resources field are a major means of dealing effectively with our water problems. I doubt if dollars can be spent more effectively in any other way for bringing about satisfactory solutions to our water problems than through this channel.

There are eight principal ways of solving water shortages in an area such as the Southwest and New Mexico. These are: (1) purification or treatment of wastes to make water usable; (2) reuse, that is, treatment after each major use, to permit a further reuse; (3) restricted or curtailed use through metering or a system of charges to discourage wastes and uneconomic use; (4) use classifications of water with a quality grade or standard consistent with the

quality required for a given use; (5) improved management of watersheds to catch and hold water to increase water recharge; (6) desalination; (7) weather modification through cloud seeding and other techniques; (8) importation from areas nearby or from a greater distance.

The organized effort most likely to achieve the desired goals of adequate usable water to meet New Mexico needs for the next 100 years will be determined largely by which ones of these eight approaches are chosen for major emphasis. For example, the first approach, "purification or treatment of wastes to make water usable" could be carried out in each local community and financed by a combination of state and local government effort, or by local (district and county) or statewide group action.

So could the next three methods, and in a limited way, both items (5) and (6), "improved management of watersheds" and "desalination," but for maximum results the last four approaches, "watershed management," "desalination," "weather modification," and "importation" will require organized effort involving more than local, district, county, or state action, or a combination of these. They will require a regional (interstate) effort and in the case of the last two (weather modification and importation), which perhaps hold greatest promise of almost unlimited quantities of usable water at minimum costs to meet the needs 100 years from now, national and/or international effort may be required.

Obviously the place to begin is at home - within the state. New Mexico has already done a great deal to put its own water house in order. It has developed a strong water resources research program which combines the competence of its three major training and research institutions at Albuquerque, Las Cruces, and Socorro. It has an effective State Planning Office and a State Engineer's Office with a state administration concerned and informed on the water needs and water problems of New Mexico. It has strong community and district groups or organizations and good working relationships with federal and interstate agencies concerned with water resources research, planning and development, and management.

During the next few years, say to 1980, New Mexico may be able to meet its most vital water needs through local, district, county, and state action, together with current federal and regional programs in water research, planning and development, and management. Beyond 1980, however, it appears that unless research can come up with new answers for old problems and the resulting technology enables us to utilize lower cost methods, we will have to look beyond the state for water supplies to meet increasing needs. Research and planning will need to be increased and more effective interstate, national, and international programs developed to meet growing needs in our most critical areas, of which the Southwest ranks at the top.

The economics or costs involved in water development programs will have an important influence on how much and where the various possible approaches will be applied. If New Mexico does have 2-3/4 million people by the year 2000, or 12 million by the year 2060, it will certainly need a lot more usable water than now. It would need at least three times as much as now in the year 2000 and perhaps fifteen times as much in the year 2060. Perhaps a desirable study would be to try to determine how much additional water for New Mexico can be secured through the use of each of the first five of the eight general methods mentioned earlier. The remaining three methods, namely, desalination, weather modification, and importation, could potentially supply almost limitless quantities of water. As yet, however, economic feasibility and/or technical feasibility place definite limits on the extent of their use. In the case of importation, interstate basin transfers would be involved and/or international importation, in which case political feasibility is an added problem. In such cases federal legislation or federal action would be essential to facilitate interstate and international agreements, compacts, contracts, or other arrangements involving both surface transportation of water and possible modified precipitation techniques.

A Program to Meet Future Needs

Any program developed to meet prospective water needs will involve at least three major areas: (1) research, (2) planning and development, and (3) management.

Research. An adequate, sound, systematic, continuing research program is the fundamental underpinning of satisfactorily meeting our future needs. Not only is research vital but lead time is needed in research if results are to be available in developing and applying new technology when such new technology is needed to solve perplexing water problems. Currently the federal government is putting about two percent of its total research budget on water resources research. The Office of Science and Technology's Committee on Water Resources Research has developed a ten-year plan for federal water research and indicated budget needs for the first five years of this ten-year period (1966-1975). Because of current heavy demands on the federal budget for other purposes, the fiscal year 1969 budget for water research is below that suggested in the ten-year plan. Federal expenditures for water research for fiscal year 1968 total $134 million, and the 1969 budget calls for $140 million. The suggested budget for 1971 is $199 million, or nearly $60 million more than the 1969 figure. At current rates of increase the 1971 goal will not be met and there will be a sizeable shortfall.

Currently the New Mexico Water Resources Research Institute, here at Las Cruces, with its affiliated institutions, University of New Mexico and New Mexico

Institute of Mining and Technology, has fourteen water resources research projects underway in cooperation with the federal government's water resources research program. Dr. Stucky and his group have developed a strong research program dealing with some of New Mexico's most acute water problems.

Perhaps the best first step New Mexico could take in preparing to meet its future water needs in the year 2000 and the year 2060 is to make additional state funds available for the water resources research effort. In many cases the money will do double duty since it will be matched with federal funds appropriated for the cooperative effort under the Water Resources Research Act of 1964, as amended in 1966.

Planning and Development. Federal water resources planning funds are now available through the Water Resources Council and average around $40 or $50 thousand per state for developing more adequate water resources plans. New Mexico has an effective State Planning Office and the second step should be a vigorous, concerted, continuing effort to develop the best possible water resources development plans for the state. Adequate state funds, along with available federal funds would make possible more adequate development plans and especially more adequate consideration of alternative plans which are essential for sound decision making by the Executive and Legislative Branches of the Government.

In addition to the development of plans and alternatives for water development should go a strong review function by the State Planning Agency to analyze thoroughly all development proposals so that sound devisions on development priorities, as well as types of construction and development projects can be made.

Under the Water Resources Planning Act of 1965 four regional planning agencies with basin commissions have already been established, namely, the Pacific Northwest River Basin Commission, the Souri-Red-Rainey River Basin Commission (North Dakota-Minnesota), the Great Lakes Basin Commission, and the New England River Basins Commission. There are some 300 or more major river basins in the United States but present thinking is to have perhaps twenty or so river basin planning commissions, one of which would include the Southwest. These regional planning agencies can be very helpful in assisting member states of their region with developing sound plans to solve their water problems. They also can perform a strong review function.

When sound plans are developed at both state and regional levels we are then in a much stronger position to proceed with adequate water development programs. Some of the larger projects will undoubtedly require federal action and possibly international action.

Management. We all know how important good water management on the land and in water project operations is, and we all know we can improve our management. This is a continuing problem but we should not forget that relatively minor improvements in the aggregate can achieve meaningful results. Good management can be advanced significantly by effective water information programs and conferences such as this, which bring together various water users, government officals, and citizens who, together, can help achieve the types of research, planning, development, and management programs vital to most efficient use of New Mexico's limited water supplies.

It has been a privilege to be with you these past two days and I am sure this Annual Conference has been beneficial to all of us. It certainly has helped me to get a better understanding of New Mexico's water problems. The grass roots interest and response evidenced in this Conference will help secure more adequate and meaningful solutions to New Mexico's water problems.