WATER PROBLEMS AND RESEARCH NEEDS FOR NEW MEXICO

by

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July 1981

Second Printing, June 1982

ERRATA SHEET
WRRI Report # 135

The areas in the water use tables in Section II are in square miles rather than acres. In addition, there are typographical errors in the depletion figures for the Rio Grande. Below are corrected tables.

RIO GRANDE BASIN (p. 4)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
49,711	1,378,900 AF	547,000 AF	617,900 AF	348,100 AF

PECOS RIVER BASIN (p. 4)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
26,145	303,200 AF	176,000 AF	534,000 AF	329,700 AF

TEXAS GULF BASIN (p. 5)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
5,357	14,500 AF	14,500 AF	740,500 AF	408,000 AF

UPPER COLORADO BASIN (p. 7)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
9,531	326,400 AF	156,800 AF	4,900 AF	2,400 AF

LOWER COLORADO BASIN (p. 7)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
13,248	48,400 AF	33,000 AF	68,600 AF	41,400 AF

ARKANSAS-WHITE-RED RIVER BASIN (p. 8)

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
17,635	243,000 AF	143,400 AF	156,600 AF	86,600 AF

PREFACE

The New Mexico Water Resources Research Institute (WRRI) is a federal/state partnership agency established to foster research with the goal of solving important water problems of the state and region. The WRRI, located on the campus of New Mexico State University and reporting through its Board of Regents, works with all qualified institutions of higher education in New Mexico to:

1. Encourage and sponsor water resources research,
2. Provide those who manage New Mexico's water resources with the results of research, and
3. Encourage the training of young scientists.

The New Mexico WRRI is one of 54 institutes located in each of the 50 states and 4 U.S. Territories which receive annual research appropriations from the Office of Water Research and Technology (OWRT), U.S. Department of the Interior, as authorized under P.L. 95-467. The WRRI also receives state appropriations as well as funds from other state, federal and private sources.

The purpose of this document is to identify important water resources problems for New Mexico and list the high priority research topics required for the solution of the problems. It should serve as a guide to potential investigators as well as inform other state and federal agencies of what the WRRI is planning for the future.

This report has been reviewed by over 80 individuals representing most of the state and federal water-related agencies of New Mexico and by various members of the public with expressed interest in water problems and their solution. Their helpful comments are greatfully acknowledged.

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SECTION I - SUMMARY

* Surface water supplies in New Mexico are scarce and virtually fully appropriated. For practical purposes, this means that there can be no further appropriations unless existing water rights are retired.
* Fresh groundwater is being seriously depleted in the Southern High Plains section of the state and, in other areas, supplies are threatened to the point that about 90 percent of the groundwater in storage lies within "declared underground water basins."
* Mineralized groundwater is considered to be very abundant, but large scale and economically feasible schemes for its beneficial use have yet to be developed.
* The existing fresh water supplies of the state will not be adequate to meet all projected demands over the next 40 years.
* Water quality degradation by cultural and natural causes is a problem in many areas. There is also the lack of a good data base upon which to determine the sources, forms, amounts and impacts of many pollutants.
* It is not likely that, over the next few decades, New Mexico will discover new water sources or in some other way be able to significantly augment its present water supply.
* Agriculture (including irrigation, reservoir evaporation, livestock water, and stock pond evaporation) annually depletes about 90 percent of the freshwater withdrawals.
* Because of the potential for large savings, water conservation in agriculture is of paramount importance.
* The ability to substitute our abundant supplies of saline water for freshwater represents a major opportunity for the future.

SECTION II - THE WATER RESOURCE

INTRODUCTION

The water resources of New Mexico are best characterized as scarce. The climate is arid to semiarid with an average annual precipitation of 13 inches. Some southern regions receive only half that amount, while higher elevations in northern mountains receive up to 30 inches, mostly as snow. In all areas of the state, the annual open-pan evaporation exceeds precipitation, in some cases by over 100 inches. The deficit between Blaney-Criddle evapotranspiration calculated for alfalfa and precipitation often exceeds 40 inches per year.

Figure 1 displays the surface water budget for 1975, a year of high water use. Inflow of surface water amounted to 2.4 million acre-feet, while outflow was 3.4 million acre-feet. Precipitation was 85.3 million acre-feet, while evaporation was 82 million acre-feet. Losses accompanying use, such as deep percolation and irrigation ditch seepage amounted to 1.1 million acre-feet, leaving 1.2 million acre-feet for actual beneficial use. The total surface water withdrawal of 2.3 million acre-feet was slightly under one-half the total annual withdrawal of 4.4 million acre-feet. The balance was made up from groundwater.

The potentially recoverable groundwater supply of New Mexico is approximately 20 billion acre-feet. Of this, only 3 billion acre-feet is fresh, 1.4 billion acre-feet is slightly saline but usable directly for some forms of irrigation, while 15 billion acre-feet exceed salinities of 3000 mg/l TDS. In some areas, particularly along the Rio Grande, significant recharge occurs. In other areas, such as the Southern High Plains in Eastern New Mexico, there is limited recharge. In the latter example, water is being mined and large areas are experiencing heavy drawdowns.

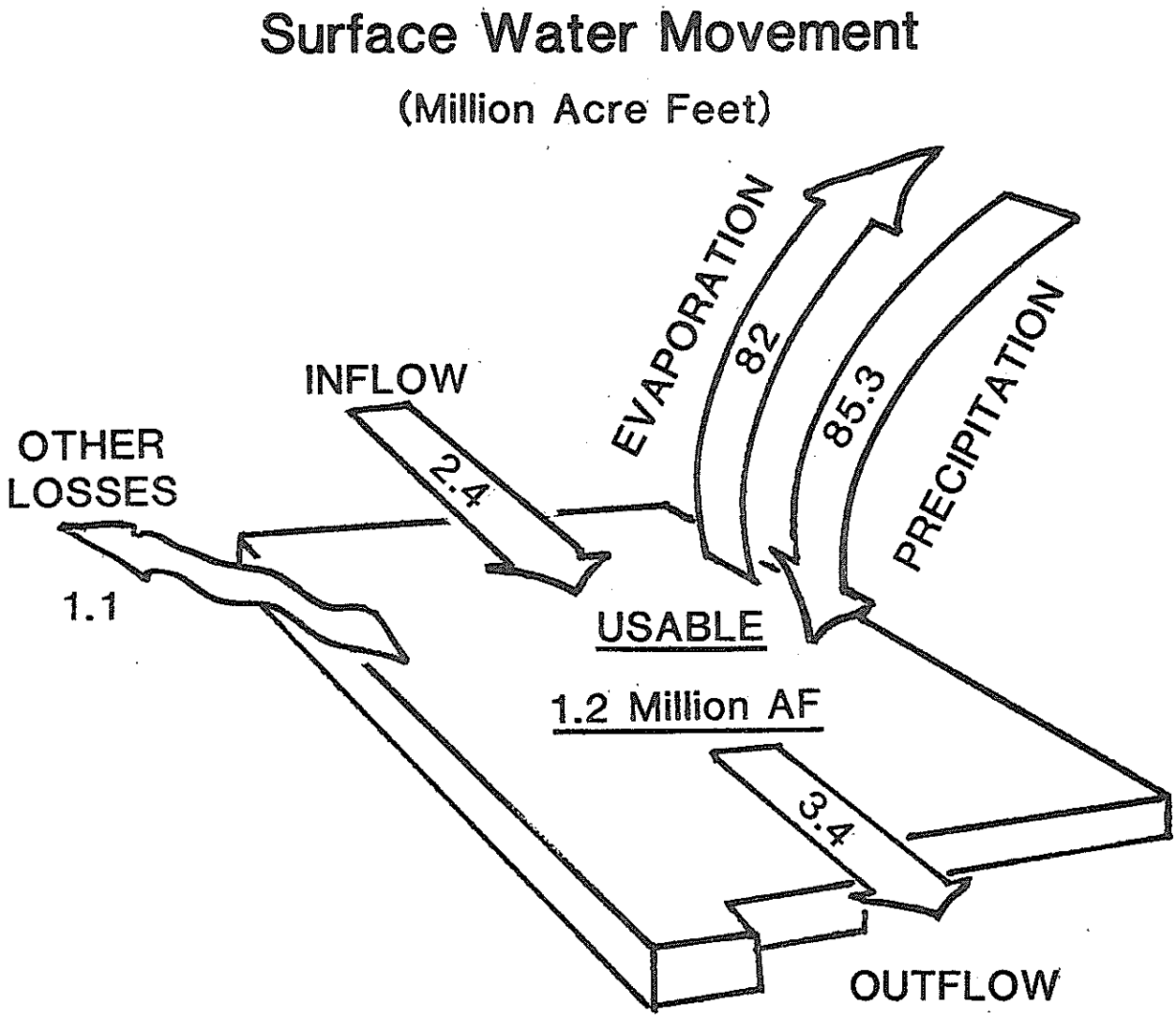


Figure 1. 1975 Surface Water Budget for New Mexico.

New Mexico can be subdivided into six drainage basins: the Rio Grande Basin, the Pecos River Basin, the Texas Gulf Basin (Southern High Plains), the Upper Colorado River Basin, the Lower Colorado River Basin, and the Arkansas-White-Red River Basin (see Figure 2). Data in the following sections are presented for 1975, a year that represented almost full use in most areas of the state.

RIO GRANDE BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
49,711	1,378,900 AF	47,000 AF	617,900 AF	348,100 AF

The Rio Grande Basin, as defined by most water agencies in the state, includes the Central and Western Closed Basins as well as portions of the Southwestern Closed Basin. It is the largest drainage basin in the state. Total dissolved solids in the surface water entering the state average about 220 mg/l. The salt concentration increases to about 825 mg/l by the time the Rio Grande enters Texas.

Groundwater aquifers along the main stem and tributaries in the Rio Grande Basin are either valley fill or bedrock. The valley fill aquifers are connected with and recharged from surface flow. Large, reliable supplies of groundwater are frequently found in this region.

PECOS RIVER BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
26,145	303,200 AF	176,000 AF	534,000 AF	329,700 AF

The Pecos River originates in New Mexico in the Sangre de Cristo Mountain range and flows southward 435 miles to Texas. It joins with the Rio Grande at the Armistad Reservoir near Del Rio on the Texas/Mexico border. Flood flows from heavy rains contribute to the

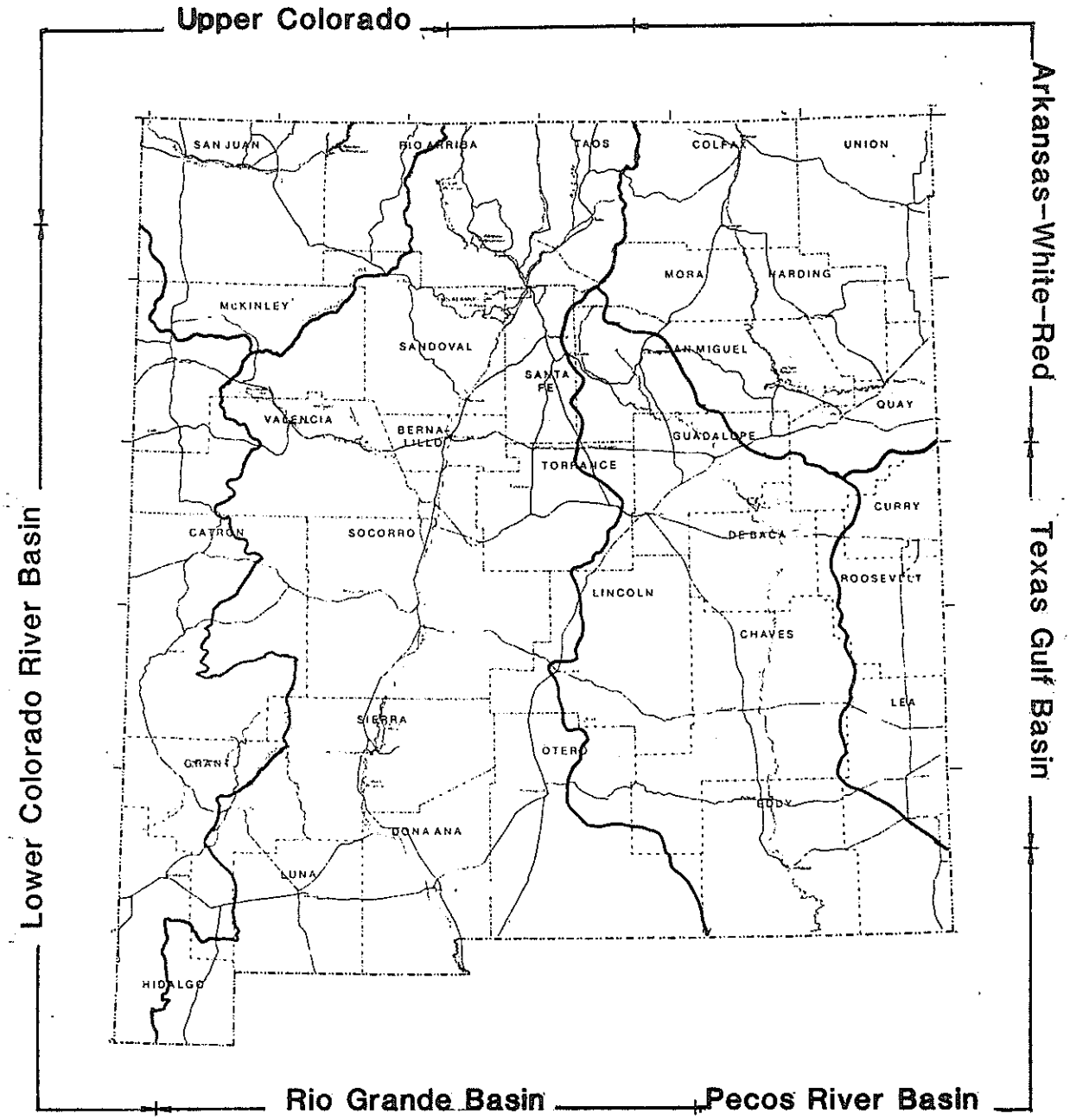


Figure 2. Surface Water Drainage Basins in New Mexico.

erratic surface flow of the river. Upstream, over 70% of the water input occurs between April and August, the heavy thunderstorm period. Flows in the lower reaches are regulated.

Surface water quality in the Pecos deteriorates significantly as it flows downstream. A portion of this increased salt burden is due to irrigation return flow; however, most of it is due to natural dissolution of rock and seepage from salt springs.

Aquifers in the Pecos River Basin are primarily unconsolidated sand or sedimentary rock. The alluvial aquifers are stream connected and recharged by precipitation and flood flow. Groundwater quality in the northern part of the basin is generally good (less than 200 mg/l TDS). Southern communities are pumping groundwater for municipal supplies with TDS as high as 1,800 mg/l and some with fluoride concentrations of 1.81 mg/l. Increased pumping has caused cones of depression and encroachment of saline waters into freshwater supplies.

TEXAS GULF BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
5,357	14,500 AF	14,500 AF	740,500 AF	408,000 AF

The Texas Gulf Basin contains most of the area commonly referred to as the Southern High Plains. There are no perennial streams in this region, only transient flows as a result of thunderstorms common in mid to late summer.

Most of the groundwater supplies in the Texas Gulf Basin are furnished by the Ogallala aquifer. This aquifer, containing a large but limited supply of fresh and slightly saline water consists of unconsolidated sand and gravel. Large-scale groundwater withdrawals

have taken place in this region lowering the water table. In some portions of the Portales Valley, groundwater is nearing depletion and irrigated lands are reverting back to dryland farms. It is estimated that there are over 30 million acre-feet of fresh groundwater and about 55 million acre-feet of slightly saline but usable groundwater recoverable in the basin. Groundwater quality is variable throughout the region, with the water generally becoming more saline at greater depths.

UPPER COLORADO RIVER BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
9,531	326,400 AF	156,800 AF	4,900 AF	2,400 AF

The Upper Colorado River Basin is comprised solely of the San Juan River drainage. While surface supplies have not been fully developed (326,000 acre-feet as of 1975), virtually all have been allotted. In general, surface water quality in the San Juan Basin is good, with an average TDS usually less than 700 mg/l.

Shallow groundwater is not abundant in the San Juan River Basin. Recent investigations have demonstrated significant supplies of deep groundwater. In general, the quality of shallow groundwater in the western two-thirds of the Upper Colorado Basin is poor.

LOWER COLORADO RIVER BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
13,248	48,400 AF	33,000 AF	68,600 AF	41,400 AF

The Lower Colorado River Basin covers the area south from the headwaters of the Rio Puerco near Gallup and west of the Continental Divide all the way to the southern border of the state. Major

streams in the New Mexico portion of the Lower Colorado Basin are the Rio Puerco, Zuni River, San Francisco River, and Gila River. Based on limited data, surface water quality in the Lower Colorado River Basin is generally good. Total dissolved solid concentrations rarely exceed 500 mg/l. While most of the rock formations in the Lower Colorado River Basin will yield enough water for local domestic and stock supply, few can be considered good aquifers.

ARKANSAS-WHITE-RED RIVER BASIN

Area	Surface Water		Ground Water	
Sq. Mi.	Withdrawals	Depletions	Withdrawals	Depletions
17,635	243,000 AF	143,400 AF	156,600 AF	86,600 AF

Streams in the New Mexico portion of the basin are tributaries of the Arkansas and Red Rivers; the White River drainage does not reach New Mexico. Surface water quality in the Canadian River is generally good, with average TDS concentrations less than 750 mg/l. In periods of low flow, however, concentrations may reach as high as 4,000 mg/l.

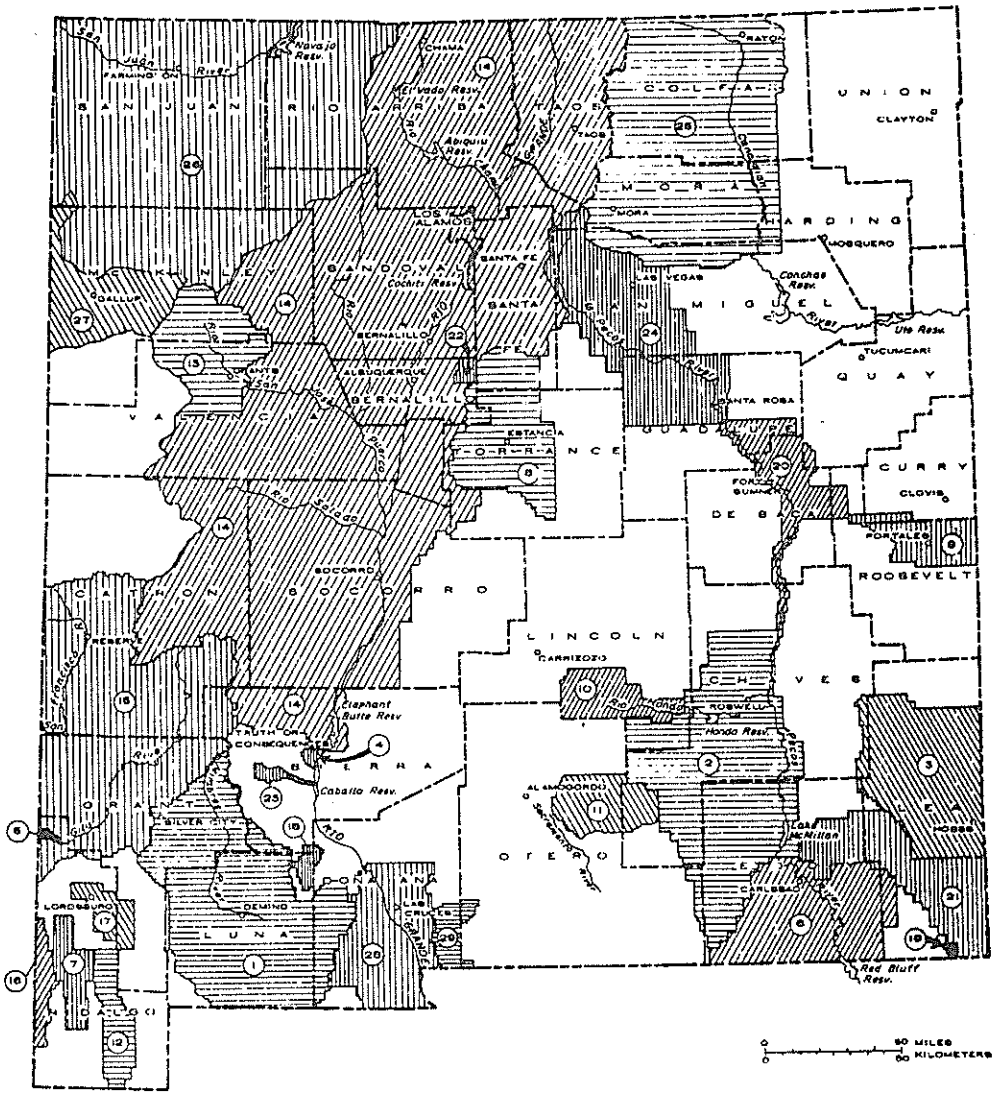
Groundwater is available in limited supplies with highly variable well yields. Groundwater is being mined in the area. Quality is highly variable from aquifer to aquifer reflecting the solubility of mineral constituents in various rock formations of the basin. In general, the basin is underlain with thin, successively more saline aquifers at increasing depths.

SECTION III - WATER USE AND PROJECTIONS

LEGAL CONSIDERATIONS

New Mexico, among all states, probably has the most clearly defined and comprehensive statutes concerning the use of its water resources. This is due to a number of factors including: the Spanish colonial heritage of water law, the foresight of the territorial and state legislatures, the judicious application of the law by the courts, and the prudent management of the State Engineer Office. Territorial legislation codified the basic tenets of New Mexico's current water law and they were subsequently incorporated into the state's constitution. The constitution provides that: "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 the law; that beneficial use is the basis, the measure, and the limit of the right to use public waters; and that priority of appropriation gives the better right."

In a 1950 opinion, the State Supreme Court held that these constitutional provisions were applicable to the groundwater as well as the surface waters of the state. This decision gave the State Engineer the authority to regulate groundwater withdrawals by declaring underground water basins. As of September 12, 1980, there were 29 declared underground water basins covering about 60 percent of the state's area and encompassing approximately 90 percent of the state's groundwater supply (Figure 3). In a 1958 decision, and subsequently in a 1962 decision, the State Supreme Court held that the State Engineer not only had the authority but also the responsibility to coordinate the management of ground and surface waters in situations where there is a significant hydrologic relationship between the groundwater source and the stream. In both cases, the court made it clear that the coordinated management of



DECLARED UNDERGROUND WATER-BASINS IN NEW MEXICO

BASIN	AREA IN SQUARE MI.
1. MIMBRES VALLEY	4,279
2. ROSWELL	4,281
3. LEA COUNTY	2,160
4. HOT SPRINGS	36
5. VIRDEN VALLEY	19
6. CARLSBAD	1,965
7. ANIMAS	426
8. ESTANCIA	1,724
9. PORTALES	620
10. HONDO	611
11. PEÑASCO	725
12. PLAYAS VALLEY	615
13. BLUEWATER	1,319
14. RIO GRANDE	24,144
15. GILA - SAN FRANCISCO	5,659

BASIN	AREA IN SQUARE MI.
16. SAN SIMON	265
17. LORDSBURG VALLEY	529
18. NUTT - HOCKETT	135
19. JAL	15
20. FORT SUMNER	1,059
21. CAPITAN	1,550
22. BANDIA	75
23. LAS ANIMAS CREEK	76
24. UPPER PECOS	2,709
25. CANADIAN RIVER	5,825
26. SAN JUAN	9,727
27. GALLUP	1,439
28. LOWER RIO GRANDE	1,585
29. HUECO	285
TOTAL	73,546

Figure 3. Declared Underground Water Basins in New Mexico (Source - State Engineer of New Mexico Rule 2, Amendment 16, Sept. 12, 1980).

surface and groundwater is an essential responsibility of the State Engineer under New Mexico's constitution.

In 1966, the court held that the mining of groundwater was permissible. In effect, the court held that it was reasonable for the State Engineer to establish an "economic life" for the basin and to distribute the allowed withdrawals over the area of the basin to achieve a uniform time of depletion of the water supply and thus establish a time of use for the rights granted at something less than perpetuity. Had the court ruled otherwise, the first appropriator in a non-rechargable basin might have been construed to have the only right to the water and much of the state's fresh underground water would have been locked in place.

As early as 1926, the court enunciated the principles required for the appropriation of water. "The appropriation of water is accomplished by taking or diversion of it from a natural stream or other source of water supply with the intent to apply it to some beneficial use or purpose and consummated within a reasonable time by the actual application of the water to the use designed or some other useful purpose...under this doctrine it is quite as necessary to make use of the water as to divert it. In fact, no appropriation can be effected without such use. The intent, diversion, and use must coincide."

In 1980, the New Mexico legislature passed a mine dewatering act giving the State Engineer jurisdiction over waters removed as a result of mining operations. This legislation clarified a source of confusion in New Mexico water law.

As might be expected, with the doctrine of prior appropriation and New Mexico's long history of settlement, virtually the entire surface water supply of the state is appropriated for beneficial use. In addition, much of the groundwater is located in declared basins and its use is likewise apportioned. Since major interbasin transfers of water to the state are unlikely to occur in the next few decades, present and future management will have to be based on

the exchange or sale of the rights to use the presently available water.

WATER USE BY CATEGORIES

For planning purposes, water withdrawals and depletions are categorized into 13 use categories. They are: irrigated agriculture, urban/municipal, rural domestic, manufacturing, minerals, military, livestock, stock pond generation, power, fish and wildlife, recreation, reservoir evaporation, and playa lake evaporation. A tabular representation of water use distribution for 1975 is displayed in Table 1. Past, present and future water demands, based on Office of Business Economics of the Department of Commerce and the Economic Research Service of the Department of Agriculture (OBERS) projections, are presented in Figure 4.

Irrigated Agriculture

Withdrawals	Depletions
3,662,900 AF	1,765,700 AF

Irrigated agriculture is the single largest water user and accounts for over 80% of water withdrawals in the state. With the addition of reservoir evaporation, that figure increases to almost 90%. In 1975, there were 1,322,660 acres of irrigated cropland (including idle, fallow, and diverted acreage) in New Mexico (Figure 5). Irrigated acreage increased rapidly in the decades of the 1940s, 1950s, and 1960s. In 1940, there were 590,950 irrigated acres and by 1970, this acreage had more than doubled to 1,255,930 acres. Over the last decade, irrigated acreage has been increasing at about the rate of 2% per year. It is unlikely that this trend will continue in the future due to limited supplies of groundwater. In fact, acreage irrigated from groundwater sources is projected to decrease slightly in the coming years in parts of the state.

Table 1. Water Use by Categories for 1975.

Type of Use	Acre Feet of Water		Percent of State Total	
	Withdrawals	Depletions	Withdrawals	Depletions
Irrigated Agriculture	3,662,900	1,765,700		
Livestock	21,700	21,700		
Evaporation/Res. & Playa	234,100	234,100		
Evaporation/Stock Pond	32,700	32,700		
Total Agriculture	3,951,400	2,054,200	89.0%	89.8%
Manufacturing	5,300	3,200		
Minerals	95,000	39,600		
Power Generation	94,700	37,400		
Total Industrial	195,000	80,200	4.4%	3.5%
Urban/Municipal	204,400	94,400		
Rural Domestic	27,400	13,100		
Military	15,500	8,900		
Total Domestic	247,300	116,400	5.6%	5.1%
Fish and Wildlife	42,800	35,700		
Recreation	400	400		
Total Recreation	43,200	36,100	1.0%	1.6%
STATE TOTAL	4,436,900	2,286,900	100 %	100 %

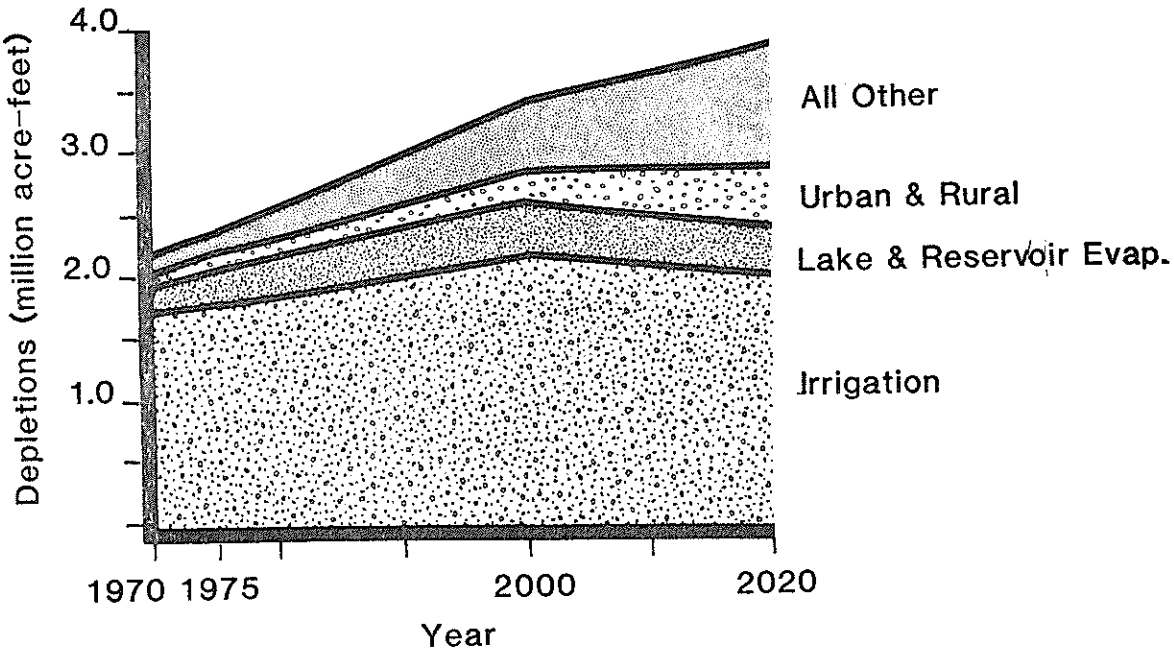


Figure 4. Past and Future Water Depletions in New Mexico (1970 Data from New Mexico Water Resources: Assessment For Planning Purposes; 1975 Data from NM State Engineer Technical Report No. 41; 2000 and 2020 Figures Based on OBERS Projections in New Mexico Water Resources: Assessment For Planning Purposes).

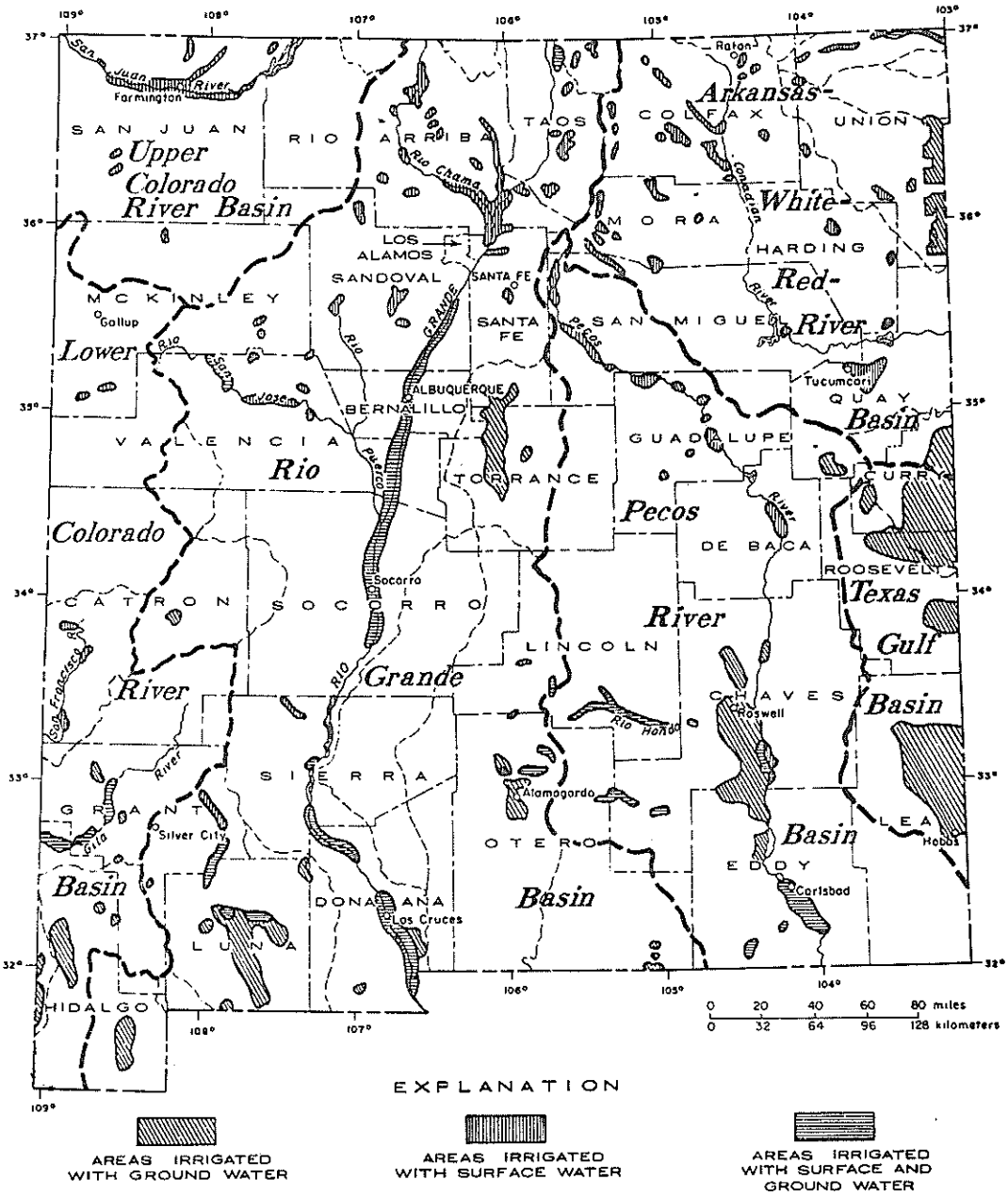


Figure 5. Irrigated Land In New Mexico, 1975 (Source, NM State Engineer Technical Report No. 41).

Assuming no changes in water-use patterns, irrigation water demands are expected to stay relatively constant in the Rio Grande, Pecos, and Lower Colorado River Basins. The Upper Colorado, and Arkansas-White-Red River Basins have the potential for increased development, especially with the Navajo irrigation project. Irrigation is expected to decline in the Texas Gulf Basin.

Urban/Municipal

Withdrawals	Depletions
204,400 AF	94,400 AF

Urban uses cover all water supplied by a public or municipal water system in areas of 2,500 or more people, even if unincorporated. Urban uses include domestic water for household use as well as the watering of lawns and gardens, and filling of privately-owned swimming pools. Public use is incorporated in this category and includes water used for public offices, street cleaning, fire fighting, city-based recreation, and other public services. Commercial use for small business establishments, as well as city-based manufacturing drawing from public supply systems, are included as urban. The light industry served through urban water systems probably includes over 80% of the manufacturing water requirements in New Mexico.

Most of the water for urban use is obtained by pumping from groundwater sources. Municipal water use has been increasing and will likely continue to do so because both the population and per capita use are increasing.

Rural Domestic

Withdrawals	Depletions
27,400 AF	13,100 AF

Rural domestic water requirements are those needs of communities with less than 2,500 inhabitants. Domestic, public, commercial, and

industrial uses are included in this category; however, water used in operation of ranches or other agronomic activities are not. Over 90% of the withdrawals were from groundwater sources. Per capita depletions for rural domestic use have been increasing and are projected to continue to do so, increasing the rural water demand in spite of the relatively stable projected rural population.

Manufacturing

Withdrawals	Depletions
5,300 AF	3,200 AF

For the purposes of reporting, manufacturing water requirements are those which are self supplied. This represents only a small portion of the water in New Mexico actually used for manufacturing, the bulk of which is included in urban water-use figures. Virtually all of this water comes from groundwater sources. Manufacturing water requirements are projected to increase.

Minerals

Withdrawals	Depletions
95,000 AF	39,600 AF

Water for mineral development includes that water needed for the mining, milling, and smelting of minerals; oil and gas well drilling; secondary recovery of petroleum; natural gas transmission; and processing of fossil fuels including coal gasification and coal liquefaction. Water needs in fossil fuel power production are considered in the power production category. Future demands are based on past and present mineral production in New Mexico, national demand figures, and known mineral reserves. By the year 2000 withdrawals are expected to reach 300,000 acre-feet with depletions of approximately 200,000 acre-feet. These projections are based on maximum development of the resource and the ability to purchase water rights from other uses.

Military

Withdrawals	Depletions
15,500 AF	8,900 AF

Military water use includes all water requirements attendant to the operation of military bases. Virtually all water used for military purposes is currently drawn from groundwater. Use figures are not projected to change through the year 2020.

Livestock

Withdrawals	Depletions
21,700 AF	21,700 AF

Beef production generates the highest cash receipts of any agricultural activity in New Mexico. Dairying is a significant activity as well. Modest growth is expected in the livestock industry, particularly in poultry raising. Small increases in water utilization are projected. Stock pond evaporation in 1975 was 32,700 acre-feet. These figures are also expected to increase moderately by the year 2000.

Power Generation

Withdrawals	Depletions
94,700 AF	37,400 AF

Only a small portion of New Mexico's power is produced directly by water through hydropower generation. Most water use is for cooling in fossil fuel fired plants. Depletion of water for the year 2000 is projected to be 109,000 acre-feet. It is certain that the use of water for power production will increase; however, the extent of that increase will be dependent on the nature of the fuel supplies developed and the ability of the developers to obtain water rights.

Fish and Wildlife

Withdrawals	Depletions
42,800 AF	35,700 AF

The majority of surface water acreage used for sport fishing is found in multipurpose reservoirs and most of the fish harvested by sport fishermen are taken from these reservoirs. On the other hand, the highest fish yield per acre surface area is found in smaller impoundments specifically developed as sport fisheries. The majority of fish taken are stocked, having been hatched in fish production units. The New Mexico Game and Fish Department has been developing small lakes for fishing purposes as funding has become available. The Bureau of Indian Affairs has also developed fishing lakes on Indian lands for Indians as well as the general public. Assuming maximum development, total water depletions for fisheries and wildlife in the year 2000 will be about 118,000 acre-feet.

Recreation

Withdrawals	Depletions
400 AF	400 AF

Future water-based recreation will be provided primarily by multipurpose reservoir development or by water development for fish and wildlife purposes. Water development specifically for water-based recreation is unlikely. Land-based recreation, such as camping, hiking, and picnicking, is not a water intensive activity. Future use projections range from 1,100 acre-feet to 2,400 acre-feet for the year 2000.

Evaporation from Reservoirs and Playa Lakes

Withdrawals	Depletions
234,100 AF	234,100 AF

Playa lake evaporation has remained constant and is expected to continue at current levels. There are currently about 51,200 acres of multipurpose reservoirs. Evaporation varies considerably depending on on the water level of the reservoirs. Acreage of multipurpose reservoirs is projected to increase to almost 100,000 acres by the year 2000 with a subsequent increase in evaporative water loss to 400,000 acre-feet.

SECTION IV - PROGRAMS OF STATE AND FEDERAL WATER AGENCIES

While water is scarce in New Mexico, communication on water problems is not. The WRRI is in frequent contact with the principal state and federal agencies concerned with water. Many agency personnel are members of both the Institute's Program Development and Review Board and its Statewide Advisory Committee.

STATE AGENCIES

In addition to the WRRI, there are five state agencies with significant interest in water management and research: (1) New Mexico State Engineer Office; (2) New Mexico Interstate Stream Commission; (3) New Mexico Environmental Improvement Division; (4) New Mexico Bureau of Mines and Mineral Resources; and (5) New Mexico Game and Fish Department. All carry out research or monitoring activities often in cooperation with the Institute, each other, or with federal agencies.

New Mexico State Engineer Office

The principal state water management agency is the State Engineer Office. It is the state regulatory agency charged with supervising water withdrawals, transfer of rights, issuance of drilling permits, and similar administrative functions. The research and monitoring activities carried out by this agency are principally in support of its regulatory role. The State Engineer Office has a large stream flow, groundwater quantity, and groundwater withdrawal monitoring program. The program is carried out both by its own personnel and in cooperation with the U.S. Geological Survey.

New Mexico Interstate Stream Commission (ISC)

The ISC is the state agency responsible for all of New Mexico's interstate water compacts. It is also responsible for investigating the state's water supply and taking actions to conserve, protect and augment it. The ISC maintains a technical staff for these purposes. It also works closely with the State Engineer Office and USGS. As one of its functions, the ISC administers the State Water Research, Conservation, and Development Fund with the goal of developing information, techniques, or devices that will result in water conservation or which will improve the quality or quantity of the water supply. In addition, this body administers the Water Resources Council Title III funds in New Mexico.

New Mexico Environmental Improvement Division

The New Mexico Environmental Improvement Division (EID) is the principal state water quality agency. It serves as the enforcement arm of the state Water Quality Control Commission. It has an in-house data collection and research effort to support its regulatory mission. It also supervises an extensive program of data collection from industries. The EID has prepared a five year plan for the period 1980 to 1985.

New Mexico Bureau of Mines and Mineral Resources

The New Mexico Bureau of Mines and Mineral Resources is the state agency responsible for investigating and reporting on the geology and mineral resources of the state. The New Mexico Bureau of Mines carries out a water research and data collection effort, frequently in cooperation with other state and federal agencies. Its water-related studies are a significant part of its overall activities and include published comprehensive water resources reports.

New Mexico Department of Game and Fish

The New Mexico Department of Game and Fish collects water quality data related to fisheries requirements for much of the state's surface waters. It also collects and makes available fish species data for these waters. In addition, it carries out and sponsors research in fisheries management and other water-related subjects in cooperation with other agencies.

FEDERAL AGENCIES

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation has plans to initiate programs which will include projects with a high potential for development, low environmental impact, and high local support. These projects will fall within a scheme of federal priorities including energy development, Indian and other federal reserved water rights, conservation, nonstructural alternatives, and others. The only significant development in irrigated agriculture will be the completion of the Navajo irrigation project. The completion of this project will increase the total irrigated acreage in the state in the near future; however, the Bureau of Reclamation anticipates decline in total irrigated agriculture in the future due to retirement of agricultural water rights for municipal and industrial water use.

The U.S. Bureau of Reclamation sees the need for research in a number of areas including agricultural water conservation, desalinization and saline water use, water reuse, phreatophyte management, Indian water rights, and, particularly, energy-related questions. It will be reevaluating the hydroelectric potential of existing structures in New Mexico and considering the adaptability for pump back options to aid in peak load energy generation. It also intends to look at solar and wind energy production and the integration of these energy outputs into the energy grid. It

anticipates planning activities in playa lake utilization and saline water use. In cooperation with state and other federal agencies, it has initiated a study for saline water utilization in the Tularosa Basin of New Mexico.

U.S. Army Corps of Engineers

The District Engineer for the Albuquerque District U.S. Army Corps of Engineers, states that today's problems require more and better information than we have and that many of these problems are likely to persist through 1985. He believes that the Corps' major federal mandate is in the broad area of conservation. The Corps will continue its activities in stream surveillance and gaging as well as other activities which will improve the Corps' predictive capabilities for stream flow and flood warning. The other major area of research will be in reservoir management, both the hydraulic parameters as well as legal aspects. The Corps expects that more effective reservoir management should increase the amount of water available to downstream users without impairing the flood control functions for which many of its projects were originally designed.

U.S. Geological Survey - Water Resources Division

The Water Resources Division of the USGS (Albuquerque Office) maintains a very large data collection program both nationally and in the state of New Mexico. It anticipates that there will be major financial constraints on its activities in the future, and has as a goal to increase the efficiency of data collection and equipment to allow real time data collection that is not manpower intensive. Another area of future research activity will deal with groundwater quality, especially groundwater chemistry. Water use (demand) is an area of current and future study.

In addition to its research and data collection activities, the USGS operates a major water data depository system, WATSTORE. This system contains not only federally-gathered information for New Mexico but also those data generated by the State Engineer Office

and the Environmental Improvement Division. In addition, the USGS maintains the NAWDEX system to help identify whether specific data has been collected and where it is located.

Other Federal Agencies

Two federal agencies, the Bureau of Land Management and the U.S. Forest Service, are responsible for the administration of 22 million acres of land in New Mexico. The enhancement of water quality and water yields are included as activities with these agencies. Both maintain water data collection programs and conduct studies in-house and in cooperation with other agencies.

SECTION V - SUMMARY OF STATE PLANNING ACTIVITIES

WATER SUPPLY PLANS

A major water-resources planning effort for New Mexico was recently carried out by the Bureau of Reclamation in cooperation with the New Mexico Interstate Stream Commission. The project was initiated in 1967 and completed in 1976 with the publication of New Mexico Water Resources: Assessment for Planning Purposes. The study presents an appraisal of present and future water requirements for the state of New Mexico. Water requirements were estimated for the year 1980, 2000, and 2020 based on three different projected population levels. The study presents no specific plan of development but does present a number of management and development alternatives.

WATER QUALITY PLANS

Other water-related planning activities in New Mexico involve satisfying the requirements of the Federal Clean Water Act (P.L. 92-500, as amended by P.L. 95-217). Planning under the act includes: facilities plans (Section 201), river basin water-quality management plans (Section 303(c)), and the statewide water quality management plan (Section 208).

Each community that receives federal construction grant funds for planning and construction of wastewater treatment facilities must complete a facility plan. The facility plan examines community needs for collection and treatment of sewage, the service area, and design alternatives. Based upon an analysis of cost-effectiveness, the plan recommends a design alternative and analyzes the environmental impact of the selected design over alternative designs.

River basin water quality management plans have been prepared for all eleven water quality basins in New Mexico. Each basin plan summarizes existing water quality and water quality problems in the basin, reviews water quality management activities, and makes

recommendations addressing significant problems. The focus is on point sources of pollution.

THE NATIONAL ASSESSMENT

The Water Resources Council Second National Assessment investigated New Mexico's water problems. This assessment was complicated by the fact that New Mexico falls within five planning regions (11, 12, 13, 14, and 15) and thirteen subregions. Implementation of recommendations made in this assessment will be further complicated by the fact that 12 of the 13 subregions found in New Mexico overlap one or more additional states.

The assessment identified at least one problem area in each of the five regions. Despite the regional heterogeneity, there are common problems identified for the entire state. Foremost among these is the lack of sufficient water supply. The water supply problems involve both water quantity and water quality. Of particular concern in this area is the mining or overdraft of groundwater supplies. In addition to the actual physical problems of an adequate water supply, the assessment identified potential socioeconomic problems which will accompany water depletion in the future.

In contrast to water scarcity problems, the assessment identified regions of the state where flooding has caused significant difficulties. An additional complication, addressed in the assessment, is the current unresolved state of Indian reserved water rights and their potential impact on both Indian and non-Indian users in the state.

SECTION VI - PROBLEM CATEGORIZATION

This section presents a breakdown of New Mexico's water problems and forms the basis for the research needs identified in the next section. Input for this section has come from many sources beginning as early as 1971 when the WRRI sponsored a series of eight regional meetings for this purpose. Follow-up inquiries in the form of mail questionnaires and personal interviews have been conducted on a periodic basis since that time culminating with a recent series of interviews conducted during the spring of 1980.

The following is a list of 6 general problem areas that we have developed from approximately 100 individual problems brought to our attention.

1. The foremost water problem in New Mexico is our declining groundwater table and inadequate surface water supply to meet projected needs. Virtually all of New Mexico's problems are consequences of this inadequate supply. There are already critical shortages of water for agricultural, municipal, industrial and recreational uses in many areas of the state.

2. There is a continuing need for improved irrigation systems and water use management in irrigated agriculture. This is an acute problem, since in some areas of the state only 20 to 30% of water diverted is actually delivered to the crop to be irrigated. On-farm management of water through better delivery systems, scheduling of irrigation, or development of stress resistant crops represent a potential means of saving large amounts of water.

3. Poor water quality in many areas of the state is perceived as a significant problem. Included are salinity increases in irrigation return flows, contamination of fresh groundwater through salt encroachment and sediment loading of surface water. Less well documented, but of great concern are potential threats to both surface and groundwater from the mining industry (uranium and coal), energy development, municipal and rural non-point source runoff, septic tanks, and others. A closely associated problem is the protection of water rights when coupled with enforcement of water quality statutes.

4. A problem perceived by many is the lack of an adequate knowledge base on present and projected water supplies and demands. While enough is known to conclude that New Mexico will probably have no new major finds of additional groundwater, there is often a lack of site specific information upon which to base local management and development decisions. This is especially true of those areas where the relationship of surface and groundwater is not well understood. Coupled with the lack of detailed information is a need for a more efficient information dissemination system for knowledge that has already been obtained.

5. Another concern expressed by many deals with water rights; however, many of the concerns cannot be resolved through research alone. Federal reserved water rights and Indian reserved water rights will take many years to resolve. Resolution of these rights and other claims to New Mexico's water in the Courts may at some time require an understanding of the potential impacts of various decisions. Prior knowledge of the range of potential impacts will be useful in developing management strategies

that could minimize disruption of the affected portion of society when these issues are settled.

6. A final problem area deals with inadequate local planning, zoning and subsequent haphazard development. There is a need to more accurately determine the long-term consequences of different development alternatives so that water quality and quantity problems can be anticipated and controlled before they become critical. This includes not only water shortages, but flooding problems which are of particular concern in metropolitan areas.

SECTION VII - RESEARCH NEEDS

The WRRI recently completed a Water Data Management study for the New Mexico Legislature, a portion of which was designed to obtain user perceptions of water data needs and water research priorities. A stratified random sample of 88 individuals and agency representatives was selected for personal interviews. Interest groups represented included: agriculture, state and federal government, industry, research scientists, and municipal officials. The stated research priorities tended to reflect the interviewees' interests and experience and in nearly every case addressed an important water problem in the state. The following is a breakdown of these research needs grouped by general problem area.

I. PROBLEM AREA -- WATER CONSERVATION

Research Priorities:

A. Develop more water efficient agricultural planting and cropping schemes, irrigation scheduling, and more energy efficient water delivery systems.

B. Develop drought resistant and/or salt tolerant crops to enable savings of freshwater and development of brackish water supplies. This includes modification of existing crops and adaptation of native species to agriculture.

C. Studies designed to more accurately determine actual water depletions for various water use categories.

D. Develop more accurate weather predictions.

E. Develop better techniques to suppress or minimize evaporation and evapotranspiration. This category also includes assessments on alternative water storage and release schemes and the associated institutional constraints.

F. Studies of a socioeconomic nature to develop greater incentives for water conservation at the home or farm level, assessments of pricing and subsidy policies, institutional arrangements to permit more efficient water use, and impacts on preferred modes of life.

II. PROBLEM AREA -- WATER QUALITY

Research Priorities:

A. Develop improved schemes for water quality monitoring and more sensitive techniques to measure biological and chemical constituents of water, especially drinking water. Particular attention needs to be given to developing a better background data base for toxic substances.

B. Develop a better basic understanding of the physical, chemical and biological relationships between water quality and quantity.

C. Studies designed to assess the social, legal, and economic impacts of enforcement of water quality regulations.

D. Better determinations of the environmental, economic and health impacts of natural and culturally induced water quality degradation.

E. Develop better wastewater treatment and/or wastewater recycling systems for municipalities, industry, and livestock operations.

F. Studies to develop additional scientific background for management to protect and enhance lake, stream, and wetlands habitat for fish and wildlife.

G. Develop water management alternatives that better match the water quality with its intended ultimate use. Of particular importance is finding innovative ways to reduce depletions of drinking quality water for those uses that can tolerate a lower quality.

III. PROBLEM AREA -- SURFACE AND GROUNDWATER RELATIONSHIPS

Research Priorities:

A. Continued refinement of hydrological surface/groundwater models and further model verification with field data.

B. Development of realistic simulations that are understandable to decision makers.

IV. PROBLEM AREA -- WATER RIGHTS, PLANNING, AND COMPETING USES

Research Priorities:

A. Studies designed to assess the long-term impacts of alternative water reallocation.

B. Studies to identify innovative methods for optimizing the long-term economic, social, and environmental benefits that can be realized from a scarce and finite water supply.

V. PROBLEM AREA -- URBAN AND INDUSTRIAL DEVELOPMENT

Research Priorities:

A. Assessment of the long-term consequences of energy and mineral development on future water supplies and water quality.

B. Studies to identify future water problems under different development scenarios in urbanizing areas.

C. Studies to better determine the impacts of urbanization on stormwater runoff.

D. Studies to find environmentally acceptable and economically feasible methods for alleviating the adverse impacts of floods.

VI. PROBLEM AREA -- BASIC RESEARCH

Research Priorities:

It is inappropriate to develop a set of priority topics in this category.

These studies would generally deal with developing a fundamental understanding of basic processes that often transcend the limitations imposed by empirical knowledge. They would also deal with developing unconventional solutions to water problems. Basic research could also represent areas of inquiry characterized as "high risk" in terms of potential payoff. The highest priority topics would be those proposals with the following characteristics: an identifiable link to an important water problem; topics proposed by scientists with an established reputation of excellence in their disciplines; and projects, as judged by peers, to be of solid scientific merit.

SECTION VIII - CURRENT AND PAST RESEARCH

The WRRI has a current research budget of about $1.2 million from both Federal and State sources. It is distributed among projects covering most of the problem areas identified in the previous section. There has been a heavier emphasis on agriculturally related water studies than on certain aspects of water quality and socioeconomic problems. This reflects the perceived urgency of the problem, the high percentage of water used in agriculture, the availability of funds in the problem area, and the quality of research proposals submitted by investigators.

Unlike some research agencies with "in-house" scientists and predictable budgets the WRRI cannot direct a particular investigator to spend the next two to five years on an assigned topic. We identify important research areas, bring them to the attention of the scientific community, and then review proposals with the help of our state-wide Program Development and Review Board. If there is a lack of interest or scientific manpower in a priority area it is not likely to receive attention. This system has the potential for missing some research problems of importance to the state. On the whole, however, the system has worked successfully. Research supported by the Institute over the last five years reflects activity in each of the six major problem areas, and most of the identified subproblems. The following is a selected list of research topics receiving WRRI funding during the five-year period from 1975 to 1980. They are listed to give potential investigators more specific examples of the types of projects that compete well for the available funds.

Problem Area I - Water Conservation

Water Stress Conditioning of Cotton to Improve Water Use Efficiency and Conserve Irrigation Water

Sodium Sealed Watersheds to Harvest Water for Crop Production with Limited Rainfall

Utilization of Brackish Water for Irrigation of Salt Grass, A Potential Forage Crop

Crambe Species as Alternate Biological Source of Oil and Protein for Arid Lands

A Selective Breeding Program to Improve the Water Efficiency and Nutrient Acceptability of Kochia as a Forage Crop

Breeding to Improve Alfalfa for Production Under Low Moisture Conditions

Effects of Decreased Watering on Wheat Yields in the High Plains

Predicting Plant Water Use with Climatological Data

Irrigated Agricultural Decision Strategies for Variable Weather Conditions

Analysis of New Mexico Residents' Attitudes Toward Water Use and Costs

Case Studies of the Development of New Mexico Water Resource Institutions

Problem Area II - Water Quality

Evaluation of Sediments in Caballo & Elephant Butte Reservoirs as a Potential Source of Toxic Materials

A Study of Nutrient Sources in Snow and Quemado Lakes

The Clean Water Act and Alternative Treatments of Wastewater Effluents in Albuquerque

The Impact of Grazing on the Quality of Water in a Recreational Stream

Role of Nitrogen and Phosphorous in Algal Blooms in Abiquiu and Cochiti Reservoirs

Environmental Impact of Septic Tanks in New Mexico

Disinfection of Wastewater

Selection of an Alga for Concentrating Trace Elements from Uranium Mine Waste Water

Water Treatment for Small Public Supplies

A Model for Optimizing Sport Fisheries in the Rio Grande of New Mexico

Assessment of Selected Agricultural Management Practices for Reducing Non-Point Pollution of Surface Waters

Problem Area III - Surface and Groundwater Relationships

Determination of Hydraulic Conductivity in the Unsaturated Subsoil

Recharge in Semi-Arid Mountain Environments

A Systematic Investigation of Watershed Runoff

A Geochemical and Hydrologic Investigation of Groundwater Recharge in the Roswell Basin

Aquifer Characterization Using Chemical Tracer Techniques

Problem Area IV - Water Rights, Planning and Competing Uses

Inventory of New Mexico's Water Resource Data

Economic Impact of Alternative Resolutions of Pueblo Indian Reserved Rights in the Rio Grande Basin

Pueblo Water Rights on the Upper Rio Grande

Forecasting Future Market Values for Water Rights in New Mexico

Institutional Alternatives for the Management of Groundwater Shared by New Mexico and Mexico

Problem Area V - Urban and Industrial Development

Problems of Water Supply Contamination Due to Underground Coal Gasification

Potential Effects on Water of Increased Demand for Nuclear Energy

Adaptability of Manufacturing Industries' Water Needs to Semi-Arid Regions

A Study of the Feasibility of Establishing an Energy-Water Complex in the Tularosa Basin

Problem Area VI - Basic Research

A Comparison of Structure and Function in Salt Tolerant and Non-Tolerant Grasses

The Nature of Virus Interaction with Soil in the Groundwater Environment

Biological Community Structure in Northern New Mexico Lakes

Calcium Carbonate Equilibria in Soils and Irrigation Waters

Rates of Water Loss in Selected Phreatophyte Species

ACKNOWLEDGMENTS

This report has made extensive use of data from two primary sources. They are:

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