AN ANALYTICAL INTERDISCIPLINARY EVALUATION OF THE UTILIZATION OF THE WATER RESOURCES OF THE RIO GRANDE IN NEW MEXICO:
SOCORRO REGION

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This study was part of an interdisciplinary-interuniversity research project entitled "An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico."

The principal investigators were Robert R. Lansford, Agricultural Economist, New Mexico State University; Shaul Ben-David, Economist, University of New Mexico; Thomas G. Gebhard, Jr., Civil Engineer, New Mexico State University; Willem Brutsaert, Groundwater Hydrologist, New Mexico Institute of Mining and Technology; and Bobby J. Creel, Agricultural Economist, New Mexico State University. Other investigators included John W. Hernandez, Civil Engineer, New Mexico State University; Clyde Eastman, Development Sociologist, New Mexico State University; John Borrego, Landscape Architect, University of New Mexico; William C. Arnwine, Industrial Engineer, New Mexico State University; and Walter Parr, Attorney, Las Cruces, New Mexico.

These consultants were included in the research effort and made contributions both in advice to the study group and in data development. The architectural consultant provided information on landscape architecture and aesthetic functions of the environment as related to alternative settlement patterns. Sociological and population problems in the Rio Grande region were considered by the Development Sociologist and included in the interregional models. The law consultant served on legal phases which developed as the investigations proceeded, and his advice was considered in the final analysis of the study. The Industrial Engineer helped in the development

of industrial water-use coefficients. Robert R. Lansford served as the coordinator for all phases of the project.

Although the research team is solely and totally responsible for statements and conclusions in this report, many people helped in the work: Fred Roach, Graduate Assistant at the University of New Mexico, helped with the development of the socio-economic model. One of the key elements of this study was the use of a Technical Advisory Committee composed of representatives from state and federal agencies. The willingness of this advisory committee to work with the study group was outstanding. Many of the changes in the study reflected the advice offered by members of the Technical Advisory Committee. Membership of the Technical Advisory Committee was:

Mr. Robert F. Stephens	U.S. Bureau of Sport Fisheries and Wildlife
Mr. T. A. Garrity	U.S. Bureau of Indian Affairs
Mr. William E. Hale	U.S. Geological Survey
Mr. W. J. Anderson	U.S. Bureau of Land Management
Mr. James Kirby	U.S. Bureau of Reclamation
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Mr. Wayne Cunningham	Elephant Butte Irrigation District
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Mr. Phil Mutz	New Mexico Interstate Stream Commission
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ABSTRACT

An Interdisciplinary approach to the solution of the water resource problems of the Socorro Region in New Mexico was centered around a socio-economic model, developed to represent the New Mexico economy, with special emphasis placed upon the Rio Grande region. Inputs into the socio-economic model were obtained from separate studies covering the hydrological, agricultural, municipal, and industrial areas.

Three sets of alternatives were considered: 1) growth without a water constraint; 2) growth, with a surface-water constraint; 3) growth, with both surface- and ground-water constraints.

Without a water constraint, in the Rio Grande region, both production and depletions are expected to exhibit the largest increase (59.7 percent and 47.4 percent, respectively). When a surface-water constraint is imposed, the value of production is reduced by $18.1 million in 2020 and water depletions are expected to decrease about 18.1 percent by 2020. When a total water constraint is imposed, the value of production is decreased $4.1 million below that expected when using only a surface-water constraint, and water depletions are reduced about 8.4 percent.

The Socorro Region is expected to follow the general trend of the total Rio Grande region but at a lower growth rate. The expected increase in total value of production from 1970 to 2020 is 46.8 percent, employment about 21 percent.

When a surface-water constraint is imposed, production is expected to be reduced $0.6 million in 2020, employment by 49 employees, and water depletions by 8,918 acre-feet. When an additional constraint is imposed on ground water in the Socorro Region, production would be decreased $1.0 million in 2020, employment by an additional 107 employees, and water depletions by 533 acre-feet.

*KEYWORDS: *New Mexico, *Rio Grande Basin, *Water resources, *Socio-economic model, Interdisciplinary, Ground water appropriation, Water law, Compacts, Treaties, Litigation, Adjudication of water rights, Water quality, Water utilization, Population, Employment, Industrial, Recreation, Water management, Input-output coefficients, Linear programming model, Surface-ground-water conjunctive-use model, Economic land classification, Irrigation diversions and depletions.*

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INTRODUCTION

This report represents an in-depth look at the water and related resources in the Socorro Region of New Mexico (Figure 1). Other reports have been prepared for the Upper Rio Grande Region (WRRI Report No. 021), the Middle Rio Grande Region (WRRI Report No. 022), and the Lower Rio Grande Region (WRRI Report No. 024). These reports are viewed as basic data reports to supplement the overall report (WRRI Report No. 020, *An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico*, March 1973).

The Upper Rio Grande Region extends from the New Mexico-Colorado state line to Otowi Bridge and includes the counties of Rio Arriba, Taos, and Santa Fe; the Middle Rio Grande Region from Otowi Bridge to the Socorro-Valencia county line includes the counties of Sandoval, Bernalillo, and Valencia; the Socorro Region, which includes Socorro County; and the Lower Rio Grande Region from the Socorro-Sierra county line to the New Mexico-Texas state line. This differs from other previous divisions in that the Middle Rio Grande Basin generally includes the designated Socorro Region. A distinction was made primarily because the Socorro Region, even though served by the Middle Rio Grande Conservancy District, is essentially a separate area in relation to the type of agriculture, hydrology, geology, and the influence of the Albuquerque metropolitan area.

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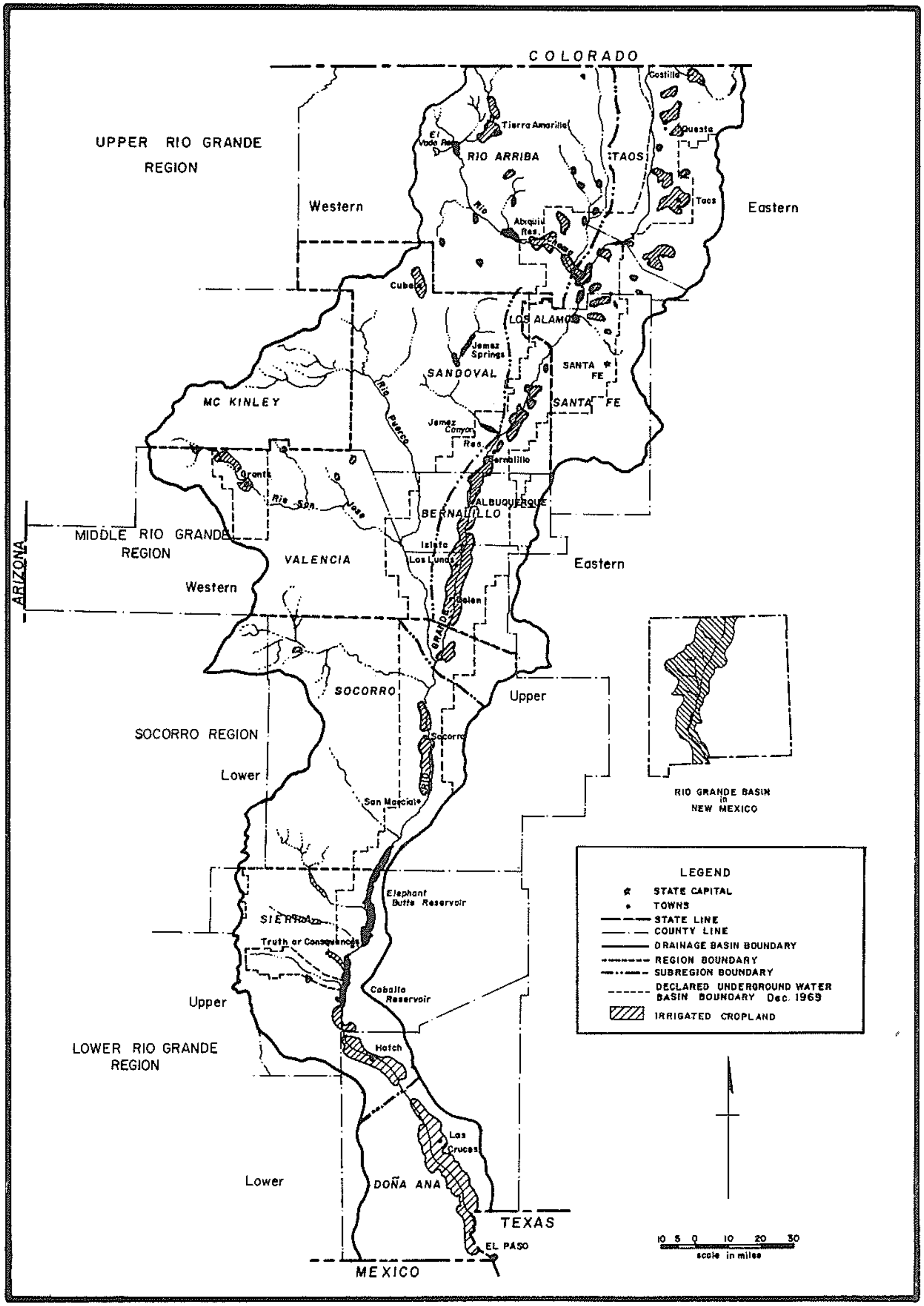

Figure 1. Rio Grande drainage basin in New Mexico, for this study.

GENERAL DESCRIPTION

The Socorro Region includes most of Socorro County and a small portion of Catron County in central New Mexico (Figure 2). The Socorro Region was divided, for this study, into the upper and lower Regions (Figure 2) at the San Acacia narrows.

The upper Region extends from the Socorro-Valencia county line to the San Acacia narrows. The lower Region extends from the San Acacia narrows to the Socorro-Sierra county line. The major population center is Socorro.

Topography and Climate

The Socorro Region is bounded from north to south on the east side by the Los Pinos and Fra Cristobal mountain ranges and Jornada del Muerto plain, and on the west side by the Gallinas and San Mateo mountain ranges. The topography of the area varies from fairly level areas in the Rio Grande Valley floor and Jornada to steep bluffs and mountains. The Valley floor has relatively smooth alluvial fans, and ranges in width from a few hundred feet at the San Acacia narrows to about two miles near Lemitar.

The climate of the Socorro Region is predominately semi-arid. It is characterized by clear and sunny days, large diurnal temperature ranges, low humidity, and low rainfall. The mean annual precipitation averages slightly less than 10 inches (Table 1). Temperatures in the Socorro Region average about 57 degrees Fahrenheit. The winters are usually mild and dry, and temperatures above 100 degrees Fahrenheit are not uncommon during the summer months. The growing season averages about 190 days from late April to late October (Table 1).

Drainage Area

The drainage area of the Rio Grande Basin in New Mexico, from the headwaters to the San Marcial gaging station (southern boundary of the Socorro Region), consists of approximately 24,760 square miles, of which ± 2,300 square miles are accounted for by the Socorro Region. The Rio Grande is the only perennial stream flowing through the Socorro Region and is the major source of surface and ground water for the river valley. Runoff is

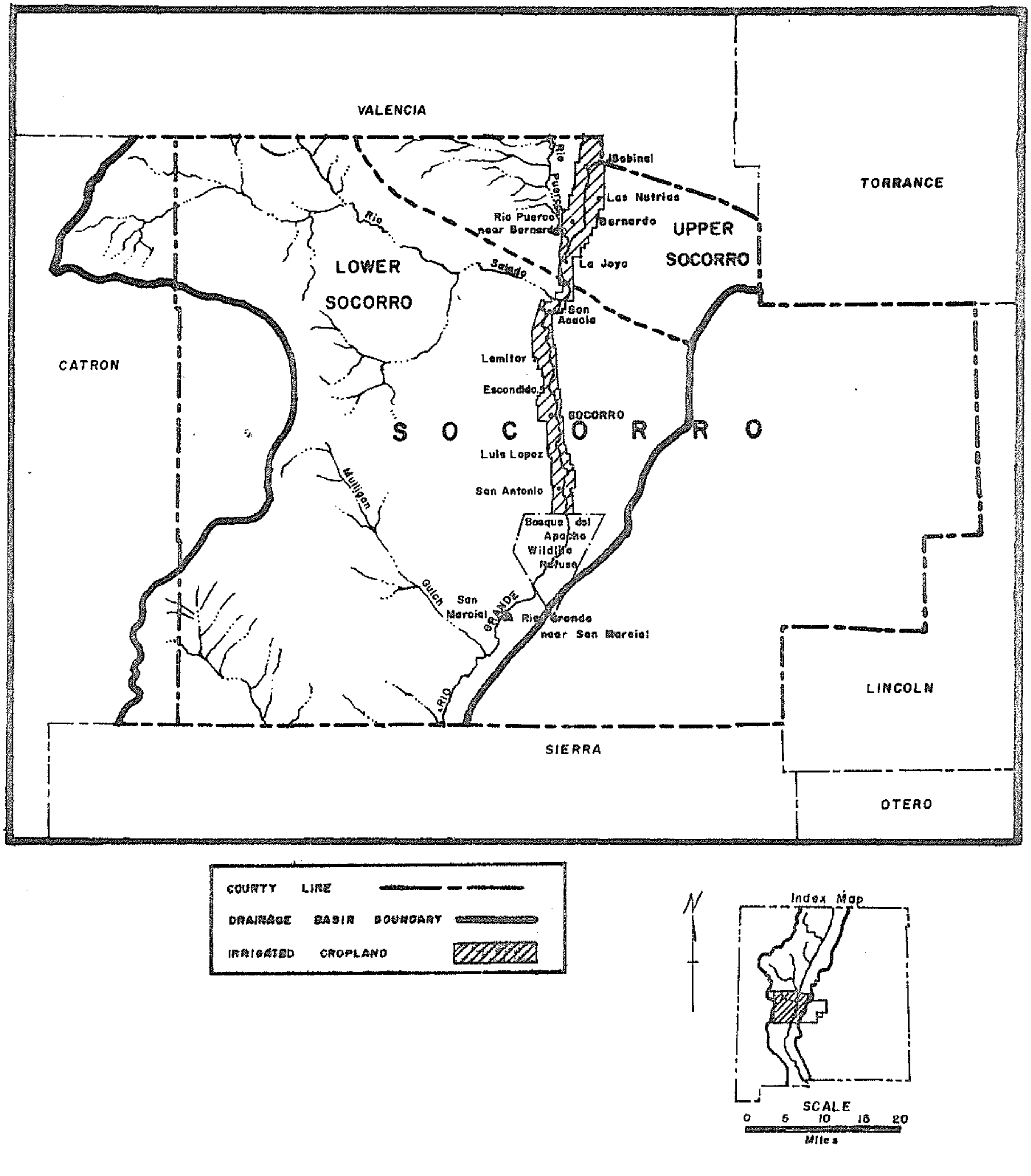

Figure 2. Map of the Socorro Region in New Mexico

Table 1. Annual average temperature, total precipitation, and frost-free period for Socorro, New Mexico, 1960-1970

Year	Average Temperature (degrees F)	Total Precipitation (inches)	Frost-free Period Length (days)	Frost-free Period Dates
1960	56.9	10.39	210	Apr 4 - Oct 31
1961	56.9	8.30	193	Apr 16 - Oct 26
1962	58.3	7.79	215	Apr 7 - Nov 8
1963	58.6	6.56	208	Apr 23 - Nov 17
1964	56.6	6.78	195	Apr 8 - Oct 20
1965	57.8	7.42	201	Apr 16 - Nov 3
1966	-	6.01	192	Apr 6 - Oct 15
1967	56.0	7.98	154	May 15 - Oct 16
1968	55.4	11.48	175	Apr 25 - Oct 17
1969	-	8.34	168	Apr 28 - Oct 13
1970	55.9	5.07	161	May 1 - Oct 9
Average	56.8*	9.64	188	Apr 21 - Oct 26

* Nine year average.
Source: U.S. Weather Bureau, *Climatological Data, New Mexico* (Annual Summaries), Vols. 64-74, 1960-70.

derived principally from snow melt in the northern part of the Rio Grande Basin in Colorado and New Mexico. Contributions to runoff from rainfall in the Socorro Region are minor. Rainfall, from high intensity short-duration summer and fall rainstorms that lead to flash floods in the ephemeral tributaries, averages about 10 inches per year. The Rio Salado is the only important ephemeral tributary, with an average discharge of 10,280 acre-feet per year. Runoff from the Lemitar-Magdalena-Socorro Mountains is mostly through ground-water flow, as can be seen from the ground-water contour lines (see Figure 9, p. 27).

Along the Rio Grande flood plain, a conveyance channel was constructed below the level of the flood plain to control the flow in a deeper, narrower channel and also to reduce the rate of evaporation from the flood plain by keeping the water level below land surface.

Hydrogeology

The Rio Grande trough in the Socorro Region has been named the Socorro Constriction (Kelley, 1952). The Socorro Constriction extends from about 40 miles north of San Acacia Channel to the San Marcial Basin on the south. It is a structural unit in the broad sense, but does not consist of a single graben or axial depression (Figure 3).

Besides the pronounced narrowing south of the Albuquerque Basin there is also a marked change in the structural alignment of the bordering uplifts. Chapin (1971) suggests that south of the Albuquerque Basin the rift widens to include a series of three major parallel basins separated by intrarift horsts: (a) the Socorro-San Marcial-Engle-Palomas-eastern Mimbres Basin, (b) the Jornada del Muerto-Mesilla Basin, and (c) the Tularosa-Hueco Basin.

Of these three basins, only the Socorro channel affects the Socorro Region, and appears to be the main linkage of the Albuquerque Basin with the San Marcial Basin. The channel lies between the Joyita uplift on the east and the Socorro uplift on the west. The Rio Grande depression along this channel is only 5-to-10 miles wide and is filled with Santa Fe type deposits. Santa Fe type deposits also occur in the La Jencia-Snake Hills Basin which lies between the low Socorro uplift to the east and high Magdalena uplift to the west. Denny (1940, pp. 84-97) has shown that the Socorro uplift, separating the Socorro channel from the La Jencia basin, probably was initiated in Miocene Time, i.e., past Santa Fe Time. Although faulting along the eastern base of the Socorro uplift may suggest it, there is no proof of a complete separation of this east (Socorro) and west (La Jencia) graben.

Two principal aquifer systems can be differentiated. Quaternary alluvium of unconsolidated gravels, sands, and silts is of least importance; it varies in thickness from a few feet on the upper valley slopes and along arroyo bottoms to perhaps a hundred feet and more in the river flood plain (Waldron, 1956). Underlying this alluvium is the Santa Fe formation of Quaternary-Tertiary age. It consists of sands and gravel interbedded with clays and silts, and may be several thousand feet thick. It is the major aquifer system in the Socorro Region. In general, the valley fill (Santa Fe group) and the valley alluvium are difficult to distinguish (Spiegel,

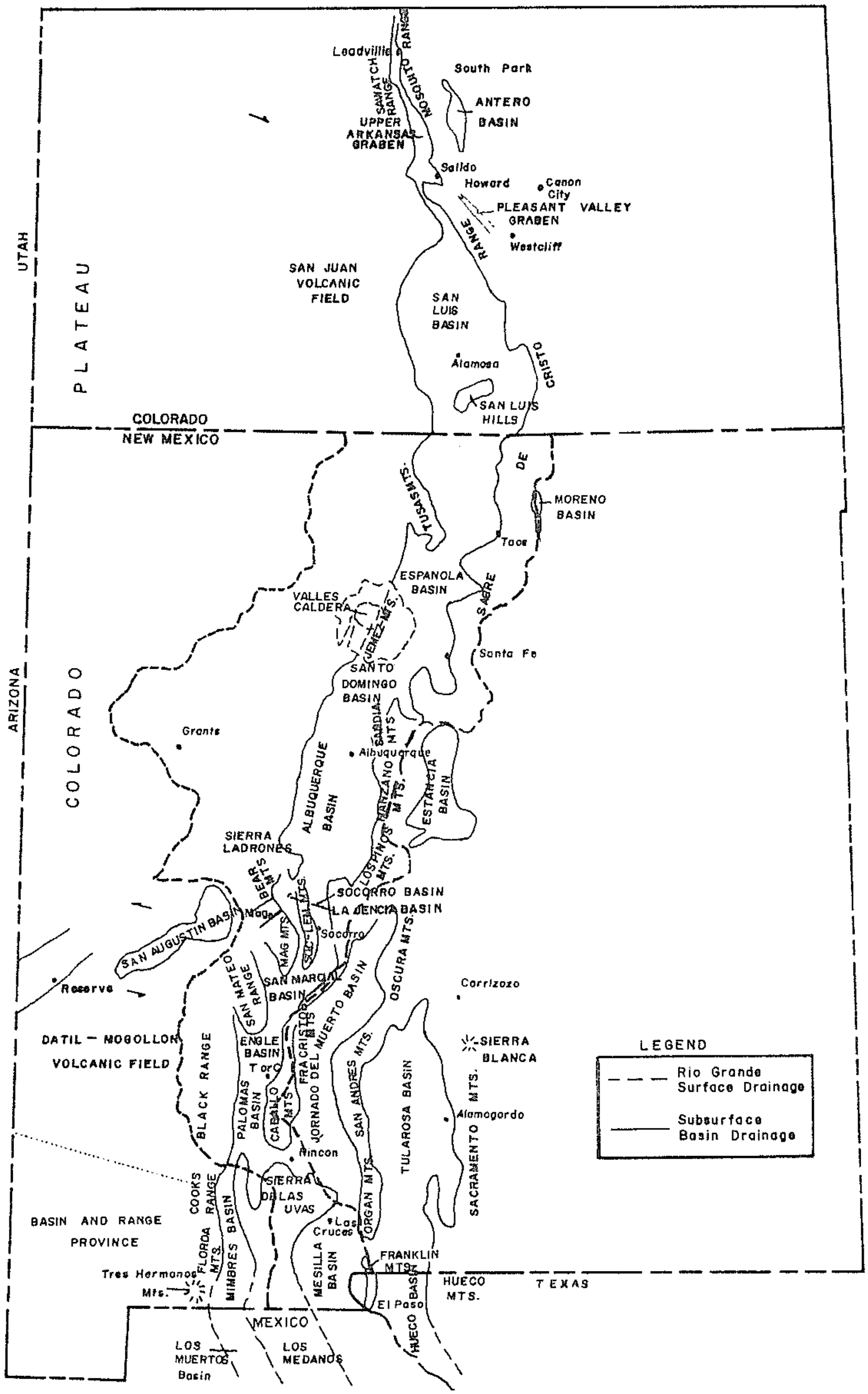

Figure 3. Generalized map of the Rio Grande Rift (after Chapin, 1971).

1955). Wells in these two aquifer systems produce from less than 300 gpm to more than 2500 gpm and are from 30 to 200 feet deep.

There may be considerable regional subsurface flow from the Snake Ranch Flats downward to the Socorro Basin. The regional water-table map (Figure 9, page 27) indicates an average difference in water-table elevation between both systems of 1,100 feet. Seepage at the surface is evidenced through springs, two of which maintain a constant year-round supply for the Socorro municipal system. City records show a combined flow of 470 gpm and a constant temperature of 92 degrees F. This rather warm water suggests considerable regional flow. The water-table map further demonstrates the existence of steep eastward gradients (30-50 ft/mi) along the Socorro Polvadera Mountains and may be another argument in favor of the suspected regional relationship between the Snake Ranch Flats ground-water regime and the Rio Grande ground-water basin.

In the Rio Grande Valley, water-table contours run about perpendicular to the river system, indicating a major southward ground-water movement with an average gradient of 4-5 ft/mi. This southward movement can be expected to exist also at great depths. Seepage from irrigation ditches and irrigated fields, ground-water recharge from and discharge to the rivers, recharge in arroyo bottoms, and seepage to ditches and drains will cause local deflections of water-table contours. Obviously, these same factors cause considerable fluctuation of water-table elevation, but there has been no great change over time in the water-table elevation along the river valley. Figure 4 reflects this behavior (average for 34 wells).

Transmissivities in the Valley are rather large: measurements of 330,000 gpd per foot are common from tests in the Lemitar and Socorro areas (Hantush, 1961). Extensive pumping, therefore, will establish shallow, though extensive, cones of depression.

Bushman (1963) estimated 3.9 million acre-feet of water in storage in the upper half of the aquifer (Santa Fe formation). Hantush (1961) determined this aquifer to be at least 600 feet thick; however, gravity surveys (Anderson, 1955; Sanford, 1968) suggest a thickness of over 5,000 feet; and Kelley et al. (1970) show saturated thicknesses in excess of 10,000 feet, of which the upper 1,000 to 4,000 feet are fresh water (i.e., less than

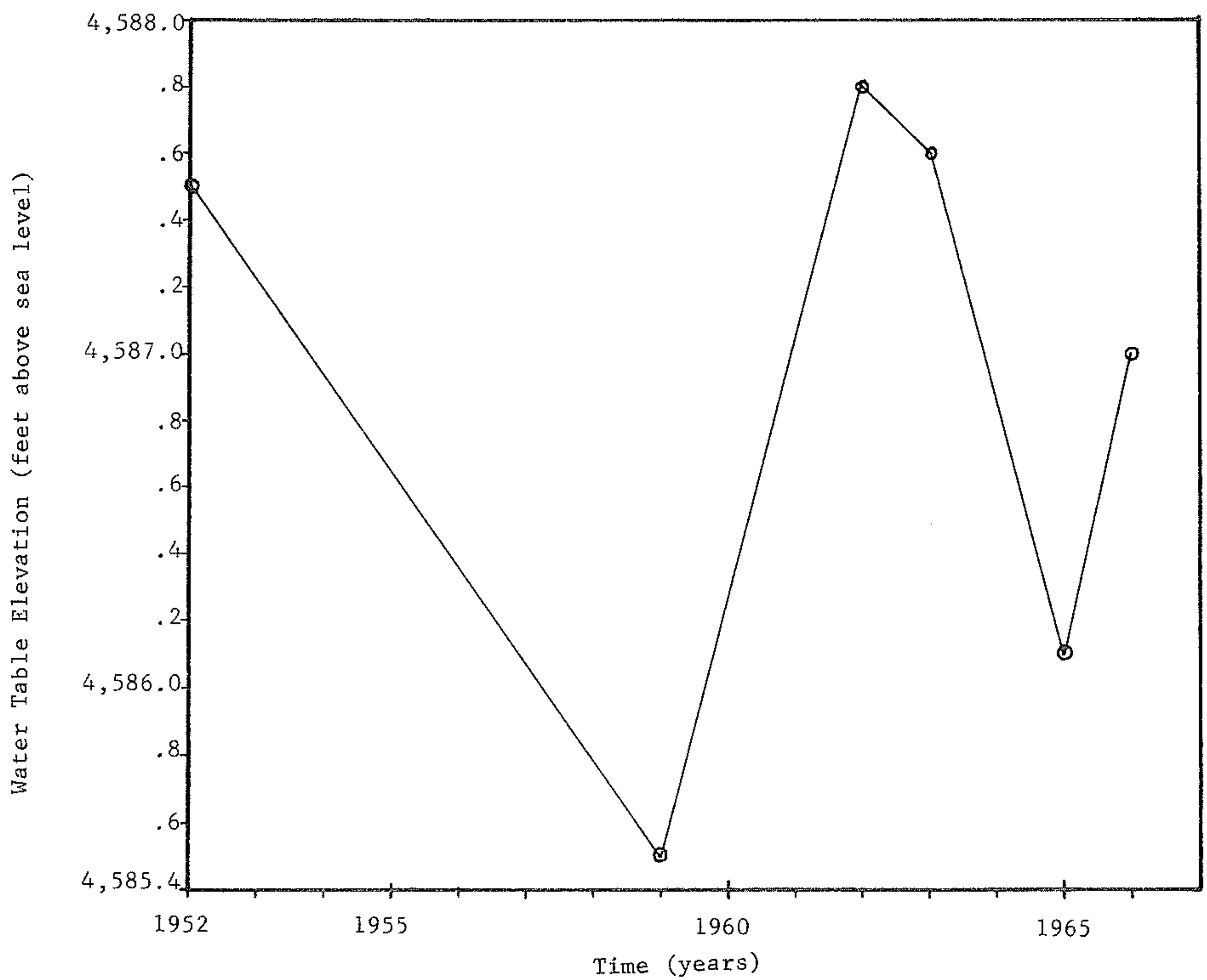

Figure 4. Average water-table fluctuation (average of 34 wells), Socorro Region, New Mexico, 1952-1966.

one gram per liter dissolved solids). Bushman also suggested about 27 acre-feet of underflow per day based on a transmissivity of 330,000 gpd per foot, a valley width of six miles, and storage coefficient of .15. This is probably slightly underestimated because, among other reasons, (1) he assumed water-table contours to be approximately perpendicular to the river with a southward water-table slope of 4 to 5 ft/mi., which elimanates any possible regional subsurface leakage from the Snake Ranch Flats, and (2) there may be larger aquifer thicknesses. A subsurface flow of 30 acre-feet a day is very small when compared to the surface-water passage of 1,580 acre-feet a day. The tremendous storage capability of the Rio Grande aquifer, therefore, suggests its possible use as a more efficient river flow regulator; i.e., the aquifer could be pumped more extensively, thereby inducing recharge from the river into the aquifer.

WATER MANAGEMENT

Management of water and related lands involves several federal and state agencies, municipal and county governments, irrigation districts, conservancy districts, and innumerable private entities. The New Mexico statutes provide for irrigation or conservancy districts which are formed in cooperation with the United States. Once a conservancy or irrigation district is formed, it is a legally stable institution with broad powers to perform the purposes for which it was organized. The districts are able to borrow money, tax lands for the indebtedness, and charge for the water they deliver.

Surface Water

Since the early 1900's, surface-water irrigation in the Rio Grande Basin in New Mexico has been under the jurisdiction of irrigation districts, conservancy districts, and community ditch systems. The only district in the Socorro Region is the Middle Rio Grande Conservancy District, formed in 1925 and serving 81,610 acres. The district services 14,760 acres in the Socorro Region.

Most of the surface-water irrigated cropland in the reach of the main stem of the Rio Grande from Otowi Bridge to San Marcial comprises the Middle Rio Grande Conservancy District. This district is divided into four divisions: Cochiti, Albuquerque, Belen, and Socorro. The district also furnishes surface water to the Indian Pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta, and has contracted with the Bureau of Reclamation to maintain and operate the system which consists of 180 miles of main canals, 587 miles of laterals, and 399 miles of open and concrete pipe drains.

In addition to the MRGCD there are publicly owned game refuges that use water from the Rio Grande in the Socorro Region: these are La Joya State Game Refuge south of Bernardo and the Bosque del Apache Wildlife Refuge south of San Antonio operated by the federal government.

Ground Water

The management of the ground-water resources in the Rio Grande drainage basin is primarily a private entity function. However, the New Mexico State Engineer can control the use of ground water in an area by defining and declaring a ground-water basin. Nearly all of the irrigated cropland in the Socorro Region is in a declared ground-water basin with only isolated tributary units outside of these basins (Figure 1). Therefore, the development of ground water is under the jurisdiction of the New Mexico State Engineer.

RESOURCES

Population

Table 2 presents a summary of the population of the Socorro Region from 1950 to 1970, utilizing data from the Bureau of the Census. Although there was a small increase in population from 1950-1960, the decrease from 1960-1970 eliminated the gains; thus, the overall population picture from 1950-1970 shows little change. The total population figures in 1950 and 1970 are very similar, as are the urban to rural percentages (55.2 percent rural in 1950 and 52 percent rural in 1970).

Table 2. Urban and rural population* for the Socorro Region, New Mexico, 1950-1970

Year and County	Urban	Percent Urban	Rural	Percent Rural	Total	Percent Change from Previous Census
1970						
Socorro	4,687	48.0	5,076	52.0	9,763	- 4.0 (10,168)
1960						
Socorro	5,271	51.8	4,897	48.2	10,168	5.1 (9,670)
1950						
Socorro	4,344	44.8	5,336	55.2	9,670	-15.3 (11,422)

Major Cities	1950	1960	Percent Change	1970	Percent Change
Socorro	4,334	5,271	21.62	4,687	-11.1
Magdalena	1,297	1,211	- 6.63	652	-46.2

* County definition.

Industrial Development

Socorro County has long been predominantly agriculturally oriented. However, recently the electronics industry has become established in the area, as well as some lumber and wood-related industries. With this increase in basic manufacturing has come a noticeable boost in the commercial and trade sectors. These two particular sectors have also been helped by the significant increase in the government sector. Mining has continued to decrease in importance, and there are very few areas of oil and natural gas production with potential for development. Thus, there is little likelihood in the county of any industry developing that is associated with resource extraction. The only exception will be the concrete, sand, and stone products sector that will be needed to supply local construction growth.

If the government sector continues to dominate the picture in Socorro County, industrial development will be a slow and painful process. Also, as agriculture is phased out (due somewhat to decreased water quality and outright purchase of the available water rights), this portion of the economy and its related and dependent industries will decrease in importance and magnitude. Unless manufacturing or some other type of economic development comes about to take the place of the declining sectors, any type of growing industrial base will not be forthcoming for Socorro County.

Employment

Table 3 presents employment data for Socorro County for the years 1960 and 1970. Although there was a decrease in population during this period, there was a marked increase in the labor force and a substantial decrease in unemployment. The major employment sector for the county is the government--state, local, and federal. Employment in agriculture decreased substantially, but it is still the third largest employment sector. Non-agricultural wage and salary employment increased substantially, with the largest increases occurring in manufacturing and construction. Employment in the Trade; Services; Finance, insurance, and real estate; and Government sectors also increased. The biggest decrease in non-agricultural employment occurred in mining operations.

Land

Within the Rio Grande region there are approximately 16.9 million acres but only 1.7 percent, or 280,785 acres, are irrigated. The land ownership of the Rio Grande drainage basin is reported in Table 4. Federal and state ownership account for about 43 percent of the total land area in the Rio Grande region (Table 4).

The Socorro Region accounts for approximately 2.88 million acres (about 17 percent of the total land area within the Rio Grande region), of which 16,500 are irrigated. Within the Socorro Region, federal ownership accounts for about 46 percent of the total land area: The acreage of forest land controlled by the Forest Service accounts for about 23 percent of the total land area; land administered by the Bureau of Land Management (BLM) accounts for about 20 percent; defense less than 1 percent; and other federal ownership about 3 percent. State ownership accounts for about 10 percent. Private ownership accounts for about 41 percent. Indian ownership accounts for

Table 3. Employment* in the Socorro Region, New Mexico, 1960-1970

Employment (County Definition)	Socorro County 1960	Socorro County 1970	Socorro County Percent Change
Total civilian work force	3,080	3,524	14.42
Unemployment	386	334	-13.47
Rate	12.5%	9.5%	-24.00
Employment	2,695	3,190	18.37
Non-ag. wage and salary	1,714	2,350	37.11
Manufacturing	36	151	319.44
Mining	136	31	-338.71
Contract construction	31	115	270.97
Public utilities and transportation	101	103	1.98
Wholesale & retail trade	328	406	23.78
Finance, insurance, and real estate	25	51	104.00
Services & miscellaneous	148	168	13.51
Government	908	1,325	45.93
All other non-ag.	542	532	-1.85
Agriculture	439	308	-29.84

* Derived from New Mexico Employment Security Commission data.

about 2 percent. Inland water accounts for less than 1 percent of the total land area.

Irrigated Cropland. The irrigated cropland is located in a somewhat narrow strip along the river in the Socorro Region (Figure 2). The acreages of the various crops produced in the lower basin are reported in Table 5. In terms of acres, alfalfa was the most important crop in 1970, accounting for about 40 percent of the total irrigated cropland and about 45 percent of the cropped acreage. Irrigated pasture was the second most important crop in terms of acreage, with about 15 percent of the total acreage and about 17 percent of the cropped acreage. The remaining acreage was composed of both high income-generating crops such as lettuce, chile, and cotton and low income-generating crops such as small grains, sorghum, and other

Table 4 Land ownership, in acres, in the Rio Grande drainage basin, New Mexico, 1971

Region and County[1]	Federal Forest	Federal BLM	Federal Defense	Federal Other	Federal Total	State[2]	Private	Indian[3]	Total Land Area	Inland Water	Total Area
Upper Rio Grande											
Taos	461,200	199,800	--	24,300	685,300	102,700	545,200	110,300[4]	1,443,500	400	1,443,900
Rio Arriba	1,154,200	215,000	--	45,600	1,414,800	181,400	816,500	185,000	2,597,700	10,000	2,607,700
Mora	9,900	--	--	--	9,900	--	--	--	9,900	--	9,900
San Miguel	6,900	300	--	--	7,200	600	1,900	--	9,700	--	9,700
Santa Fe	158,600	61,000	--	35,200	254,800	38,400	409,800	75,700	778,700	300[5]	779,000
Los Alamos	--	--	--	68,300	68,300	--	3,700	--	72,000	--	72,000
Subtotal	1,790,800	476,100	--	173,400	2,440,300	323,100	1,777,100	371,000	4,911,500	10,700	4,922,200
Middle Rio Grande											
Sandoval	418,400	192,580	2,600	177,400	790,980	93,060	903,730	516,740	2,304,510	1,200[6]	2,305,710
Bernalillo	53,100	17,520	45,800	140	116,560	28,500	271,020	268,230	684,310	--	684,310
Torrance	49,140	2,400	--	--	51,540	19,800	53,600	16,400	141,340	--	141,340
Valencia	262,620	211,100	--	--	473,720	102,260	1,008,540	626,380	2,210,900	1,300	2,212,200
McKinley	15,370	149,520	--	35,500	200,390	65,300	398,580	173,800	838,070	480	838,550
Subtotal	798,630	573,120	48,400	213,040	1,633,190	308,920	2,635,470	1,601,550	6,179,130	2,980	6,182,110
Socorro region											
Socorro	598,050	556,000	3,800	80,300	1,238,150	277,780	1,129,570	65,700	2,711,200	13,900[7]	2,725,100
Catron	75,400	15,500	--	--	90,900	14,900	51,000	--	156,800	--	156,800
Subtotal	673,450	571,500	3,800	80,300	1,329,050	292,680	1,180,570	65,700	2,868,000	13,900	2,881,900
Lower Rio Grande											
Sierra	403,500	450,500	--	1,900	855,900	218,700	434,700	--	1,509,300	36,100	1,545,400
Dona Ana	--	915,670	21,640	7,800	945,110	230,120	232,700	--	1,407,930	--	1,407,930
Subtotal	403,500	1,366,170	21,640	9,700	1,801,010	448,820	667,400	--	2,917,230	36,100	2,953,330
Basin Total	3,666,380	2,986,890	73,840	476,440	7,203,550	1,373,520	6,260,540	2,038,250	16,875,860	63,680	16,939,540

[1]Includes only county area lying within the Rio Grande Drainage Region (Figure 2)
[2]Includes state trust and deeded land and lands administered by other state agencies.
[3]Includes both trust and deeded Indian lands.
[4]Includes transfer of 48,000 acres from Forest Service to Taos Indian Pueblo.
[5]Includes 56 acres for proposed Nambe Falls Reservoir.
[6]Includes 1,200 acres for Cochiti Lake under construction.
[7]Includes 1,801 acres for La Joya and Bosque del Apache Lakes.

Source: Estimated from Bureau of Land Management Quadrangle Maps; acreage of lakes and reservoirs from New Mexico State Engineer Office Preliminary Report, "Reservoirs and Lakes in New Mexico with 40 or more surface acres," February 8, 1971.

Table 5. Acres of irrigated cropland by use in the Socorro Region, Rio Grande Basin, New Mexico, 1970

Land Use	Socorro Region Upper	Lower	Total	Percent
	. . . . . .	acres		
Cotton	--	1,402	1,402	8.5
Alfalfa	1,966	4,396	6,362	38.6
Sorghum	5	680	685	4.2
Corn	246	733	979	5.9
Small grains	731	1,018	1,749	10.6
Improved pasture	816	1,531	2,347	14.2
Other hay and native pasture	--	12	12	0.1
Chile	13	87	100	0.6
Orchards	11	25	36	0.2
Spring lettuce	(25)*	--	(25)*	(0.2)*
Fall lettuce	27	--	27	0.2
Spring onions	--	--	--	--
Fall onions	69	--	69	0.4
Miscellaneous vegetables and family gardens	36	70	106	0.6
Subtotal Cropped Acreage[a]	3,920	9,954	13,874	84.1
Diverted and fallow[b]	421	1,206	1,627	9.9
Prepared land	210	179	389	2.4
Subtotal Cultivated Acreage[c]	4,551	11,339	15,890	96.3
Idle[d]	156	454	610	3.7
Out of Production[e]	--	--	--	--
Total Irrigated Cropland[f]	4,707	11,793	16,500	100.0

a. Double cropped acreage, not included in total.
b. Irrigated cropland on which crops were growing at the time the field survey was conducted, and on which crops had been produced during the current crop year.
c. Acreage of irrigated cropland which was not cropped under provisions of the Agricultural Adjustment Programs or had been tilled in the past two years.
d. Irrigated cropland to which cultural practices were actively applied during the preceding two years, including the year in which this study was conducted. (Includes cropped, fallow, and diverted acreage.)
e. Irrigated cropland not actively farmed for the past two consecutive years but farmed within the past five years. (Includes suspended land which was not serviced by ground water.)
f. Irrigated cropland not actively farmed within the past five years.
g. Irrigated cropland: Land on which water is artificially applied for the production of agricultural products, on which the owner has the physical facilities or right to engage in such practices.

Source: Adjusted from: Lansford, R.R., and E.F. Sorensen, "Planted Cropland Acreage in New Mexico in 1969, 1970," *New Mexico Agriculture--1970*, Agricultural Experiment Station Research Report 195, New Mexico State Univ., Las Cruces, N.Mex., pp. 6-12, Tables 6 and 8; and Lansford, R.R., "Planted Cropland Acreage in New Mexico in 1970 and 1971," *New Mexico Agriculture--1971*, Agricultural Experiment Station Research Report 235, New Mexico State Univ., Las Cruces, N.Mex., pp. 31-37, Tables 17 and 18.

forage crops. The low income-generating crops acreage far exceeded that of the high income-generating crops.

Soil productivity. The soils in the valley floor of the lower Region consist primarily of highly-stratified alluvial deposits of mixed origin. The principal soil types vary in texture from sand to clay, but the medium, moderately fine, and fine are the more common textures. The most extensive soils usually have a surface layer of loam underlain by stratified loams and sandy loams. The soils of the alluvial fans and terraces immediately above the valley flood plain are generally deep and sandy. These soils were formed from alluvial and eolian sediments of mixed origin and have an extremely sandy texture (Isaacson, 1940).

About 9 percent of the irrigated cropland in the Region is Group I soil (Table 6) and occurs primarily in the lower Socorro Region (Figure 5). These soils are primarily loams, clay loams, and fine sandy loams of the Gila series. They are level and deep and are considered to be highly productive. These soils are moderately stratified with thin layers of light- and heavy-textured subsoils. They have moderate permeability, moderate to good drainage, and good water-holding capacity. While stratified layers present slight problems with some soils in this group, they are deep enough to allow deep plowing and other corrective measures and they respond well to the application of improved management practices.

Table 6. Acres of irrigated cropland by soil productivity groups, Socorro Region, New Mexico, 1970

Soil Productivity Group*	Total	
	(acres)	(percent)
Group I	1,501	9.1
Group II	9,158	55.5
Group III	5,841	35.4
Total	16,500	100.0

* Soils included in each group are described in Appendix A.

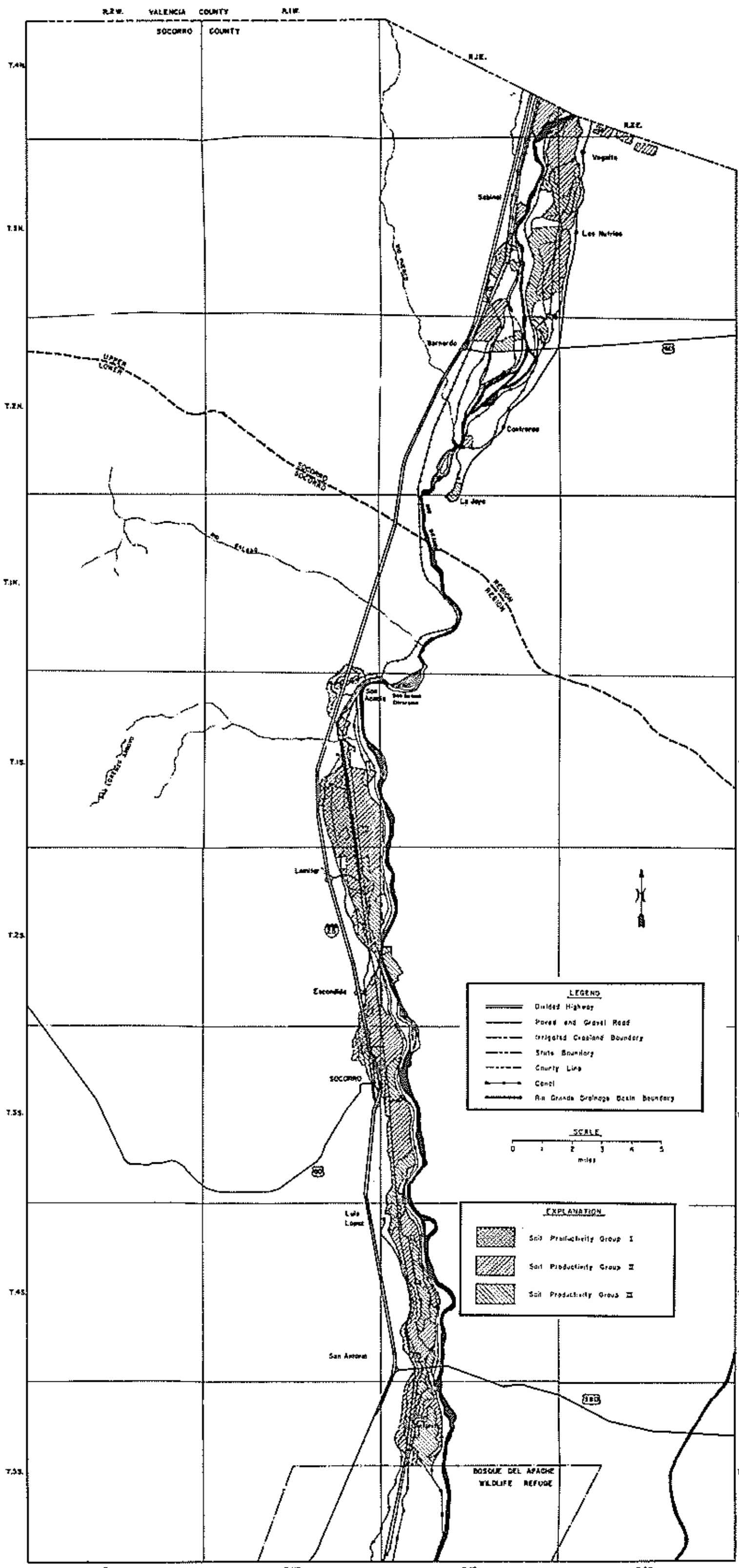

Figure 5. Soil productivity map, Socorro Region, New Mexico

Group II consists of over 55 percent of the soils in the Region which have moderate limitations that restrict maximum production. These soils are similar to the soils in Group I, but are characterized by low permeability and are affected by a shallow water-table or the accumulation of alkali or salinity. They are typically heavier in texture than the soils in Group I and are moderately stratified. The soils in Group II consist primarily of the heavier-textured soils of the Gila and Sandoval series and the lighter-textured soils of the Anthony series. These soils are the most extensive in the basin. In general, they respond favorably to the use of improved management practices. Under improved management, crop yields are similar to Group I soils.

Group III soils account for almost 35 percent of the soils in the Region. In relation to total acreage they were more important in the upper Socorro Region than in the lower Region (Figure 5). The primary difficulties with these soils are the sandy textures, the extremely heavy textures, and the existence of heavy or impervious layers in the subsoils. Common problems also include shallow depth, high water-tables, and accumulation of salts. These soils occur primarily along the river, along old river channels, and in the tributary areas. A large percentage of the irrigated cropland which is out-of-production was included as Group III soil.

HYDROLOGIC DATA

Nearly all of the surface water of the Socorro Region is supplied by the outflow from the Middle Rio Grande Region. The Socorro Region is an area of water consumption and not of water generation.

Surface Water

Most of the Region's water supply and use is along the main stem of the Rio Grande. Nearly all of the surface water is supplied by the Middle Rio Grande Conservancy District. The water supply of the MRGCD comes primarily from the flow of the Rio Grande diverted below the gage at Otowi. The Middle Rio Grande Conservancy District distributes the water in both the Middle and Socorro Regions.

Although the hydrologic boundary for the Socorro Region does not coincide exactly with the county line, the error caused by using the two different boundary lines is negligible. The outflow of the Middle Region, as measured at Bernardo, is the inflow to the Socorro Region. The inflow to the Socorro Region is the flow of the Rio Grande, the Rio Puerco, and various canals and drains. Table 7 presents the average monthly flows for the Rio Grande near Bernardo. The average monthly flows for the Rio Grande near Bernardo include the Floodway, Conveyance Channel, Bernardo Interior Drain, and La Joya East-side Drain. Usable records were available from 1944 through 1968. Table 8 presents the average monthly flows for the Rio Puerco near Bernardo. The flow of the Rio Puerco is essentially a free-flowing stream and is not used for irrigation.

The outflow from the Socorro Region is measured at the Rio Grande at San Marcial. The streamflow records at San Marcial were begun in February 1895, and have been continuous since February 1896. The records were obtained from a gage located on the Atchison, Topeka and Santa Fe Railway bridge until October 1964; since that time, the flows of the Rio Grande within the Conveyance Channel and within the Floodway have been reported separately. To make the historical data comparable, the flows in the Floodway and Conveyance Channel were combined. The data for the flow at San Marcial are presented in Table 9.

The relationship between the inflow to the Region (Rio Grande and Rio Puerco near Bernardo) and the outflow from the Region (Rio Grande at San Marcial) is presented in Table 10. This Region is a consumer of water during all months of the year. In no other Region of the Rio Grande does consumption appear for every month.

Surface-water availability within the Socorro Region is reported in Table 11. As defined for this study, surface-water availability is the sum of the outflow from the Region and the agricultural depletion as estimated from the consumptive irrigation requirement.

Mass flow curves of the entire periods of record for the Rio Grande at San Marcial, the Rio Puerco near Bernardo, and the Rio Grande near Bernardo are presented in Figures 6, 7, and 8, respectively. Because the period of record for the Rio Grande near Bernardo is the shortest, equivalent data for the other two stations were also plotted on Figure 8 for comparison. Mass flow curves give prominence to periods of high or low flow, and the slope between any two points is equivalent to the average flow for that time period.

Table 7. Average monthly flows for the Rio Grande near Bernardo, New Mexico, including Floodway, Conveyance Channel, Bernardo Interior Drain, and San Juan Riverside Drain (La Joya Eastside Drain)

Period	Average Monthly	Average Monthly Flow for March-October	Average Monthly Flow for November-February
	. . . .	acre-feet	
1944-1957	55,044	59,531	43,070
1958-1968	54,710	56,432	51,267
1944-1968	54,337	58,167	46,677

Note: Records prior to 1944 are incomplete.

Table 8. Average monthly flows for the Rio Puerco near Bernardo, New Mexico

Period	Average Monthly Flow	Average Monthly Flow for March-October	Average Monthly Flow for November-February
	. . . .	acre-feet	
1940-1957	3,817	5,573	305
1958-1968	2,131	3,110	175
1940-1968	3,178	4,639	256

Table 9. Average monthly flows for the Rio Grande at San Marcial, New Mexico

Period	Average Monthly Flow	Average Monthly Flow for March-October	Average Monthly Flow for November-February
	. . . .	acre-feet	
1895-1968	77,740	96,125	40,969
1916-1968	71,544	86,689	43,383
1940-1968	57,585	65,365	42,387
1958-1968	50,282	50,634	49,577

Table 10. Average monthly flows for the Rio Grande near Bernardo and for the Rio Grande at San Marcial, New Mexico, 1958-1968

Month	Flows near Bernardo Rio Grande	Flows near Bernardo Rio Puerco	Total Inflow	San Marcial	Gain	Loss
	................(acre-feet)................					
January	43,341	3	43,344	41,633	--	1,711
February	45,220	426	45,646	42,971	--	2,675
March	49,939	1,524	51,463	45,069	--	6,394
April	95,402	573	95,975	77,621	--	18,354
May	146,120	1,024	147,144	117,540	--	29,604
June	82,681	797	83,478	74,092	--	9,386
July	21,337	2,032	23,369	21,787	--	1,582
August	32,056	12,958	45,014	36,311	--	8,703
September	11,311	5,129	16,440	14,953	--	1,487
October	12,606	841	13,447	9,750	--	3,689
November	58,398	268	58,666	52,405	--	6,261
December	58,110	1	58,111	54,238	--	3,873
Total	656,521	25,576	682,097	588,378	--	93,719
Net Consumption between Bernardo and San Marcial						93,719

Table 11. Total surface water available for the Socorro Region, New Mexico

	March-October	November-February	Yearly
	............(acre-feet)............		
Surface water outflow -- main stem	397,131	191,247	588,378
Agricultural depletions	26,981	1,003	27,984
Total surface water available	424,112	192,250	616,362

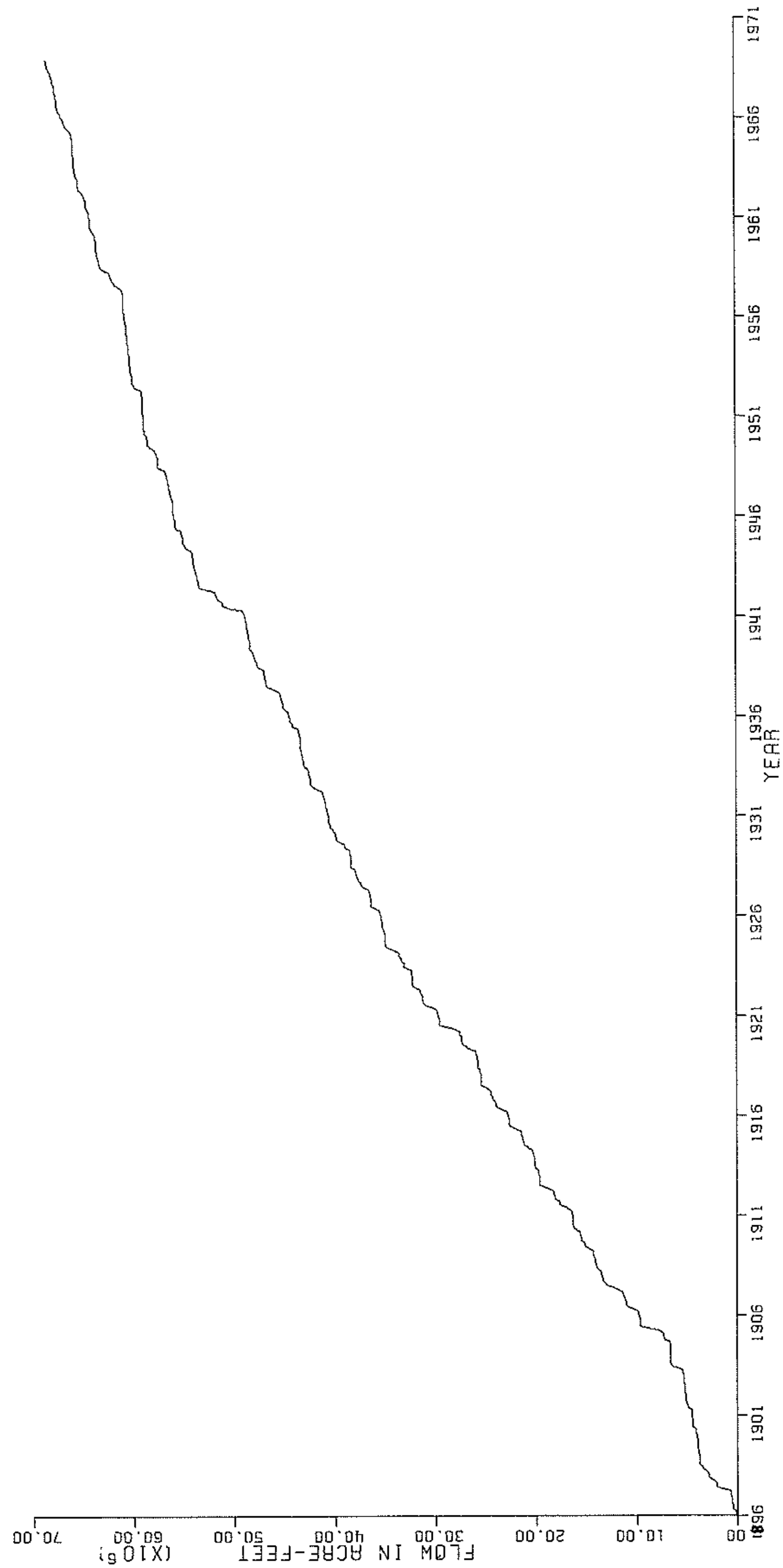

Figure 6. Mass flow curve for the Rio Grande at San Marcial, New Mexico.

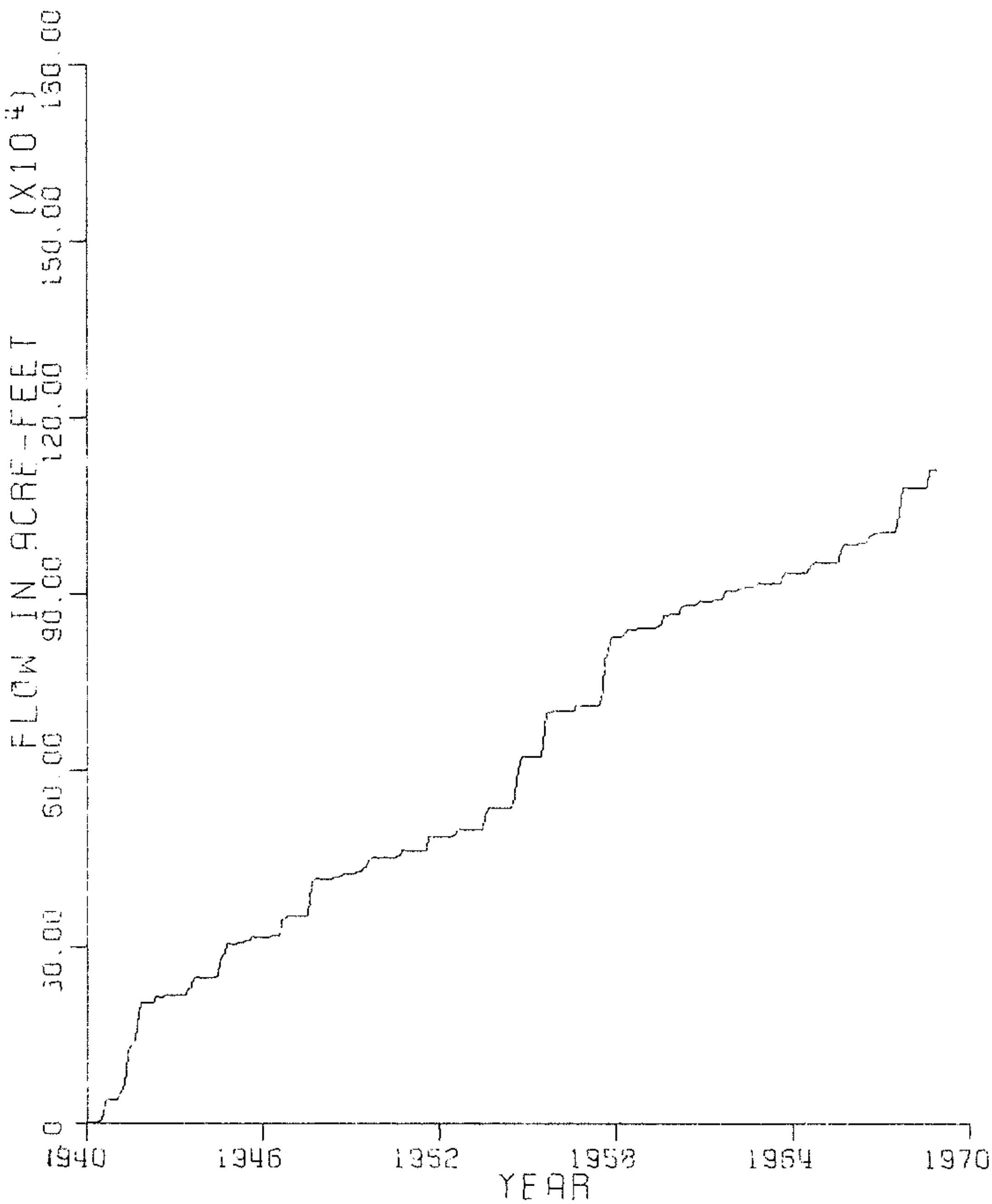

Figure 7. Mass flow curve for the Rio Puerco near Bernardo, New Mexico.

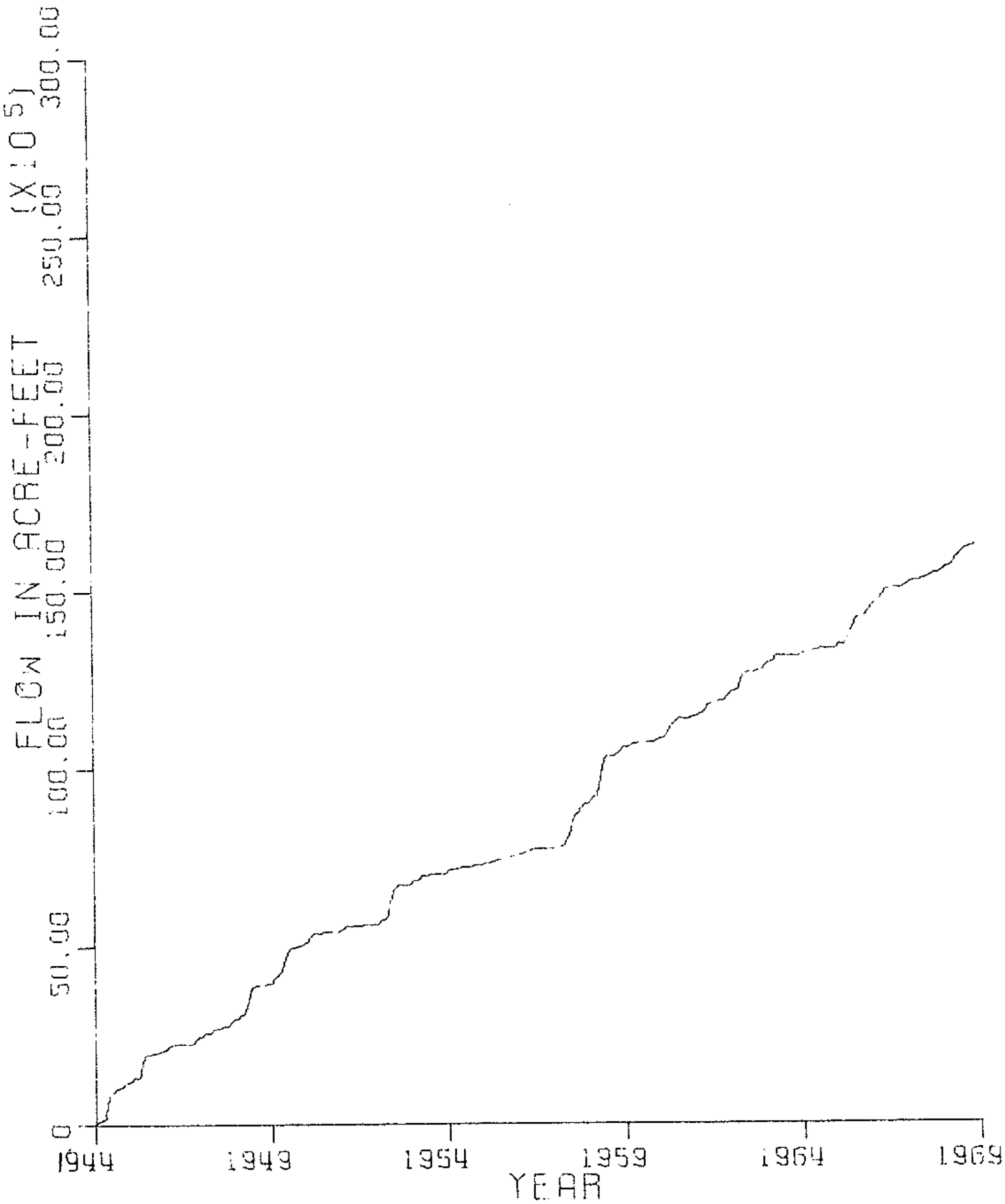

Figure 8. Mass flow curve for the Rio Grande near Bernardo, New Mexico.

Ground Water

The ground-water analysis of the Socorro Region involves the study of water-table behavior as a function of hydrologic events and man-made interventions such as municipal, industrial, and agricultural water demands.

Agriculture, in supplementing its surface-water irrigation, is by far the largest user of ground water. Therefore, Socorro's ground water is characterized by seasonal fluctuations. Under present conditions, a near hydrologic equilibrium appears to be establishing. The 1962 to 1966 data shows little variation (Figure 9). Water-table maps for the Socorro Region are shown in Figures 9 and 10 for 1962 and 1966, respectively. The 1962 map (Figure 9) includes the Snake Ranch Flats water-table with the distribution of springs along the fault zone between this basin and the Socorro valley.

For the conjunctive-use surface- ground-water model of the Socorro valley, the area was subdivided into a 12 x 21 grid system. The total area covered is shown by the rectangles on Figures 9 and 10. Water-table elevations were obtained from the water-table contour maps. Total aquifer thicknesses are unknown for the area; however, aquifer transmissivities can be utilized to determine flow. In unconfined aquifers, transmissivities will vary with saturated thickness. It is therefore desirable to estimate saturated thickness and hydraulic conductivity from the transmissivity value in order to account for its variation as a function of water-table drop or rise. Transmissivities in this area varied from 6,000 to 360,000 gpd per foot (Hantush, 1961). The lower values apply in the alluvial fans along the mountain ranges, and the higher values in the central portion of the valley. Areas of lower hydraulic conductivity along the mountain ranges can be identified from the water-table map where much steeper gradients can be noticed.

Specific yields for the Socorro valley as computed by Hantush (1961) were within very close range, i.e. 0.23 to 0.24. Since the test well (less than 100 feet in depth) only partially penetrated the aquifer, it may be that these values are slightly overestimated and that a value around 0.20 may be considered more reasonable because of compaction with depth.

The verification procedure for the Socorro Region consisted of simulating the historical conditions from 1962 to 1964. Seasonal fluctuation of

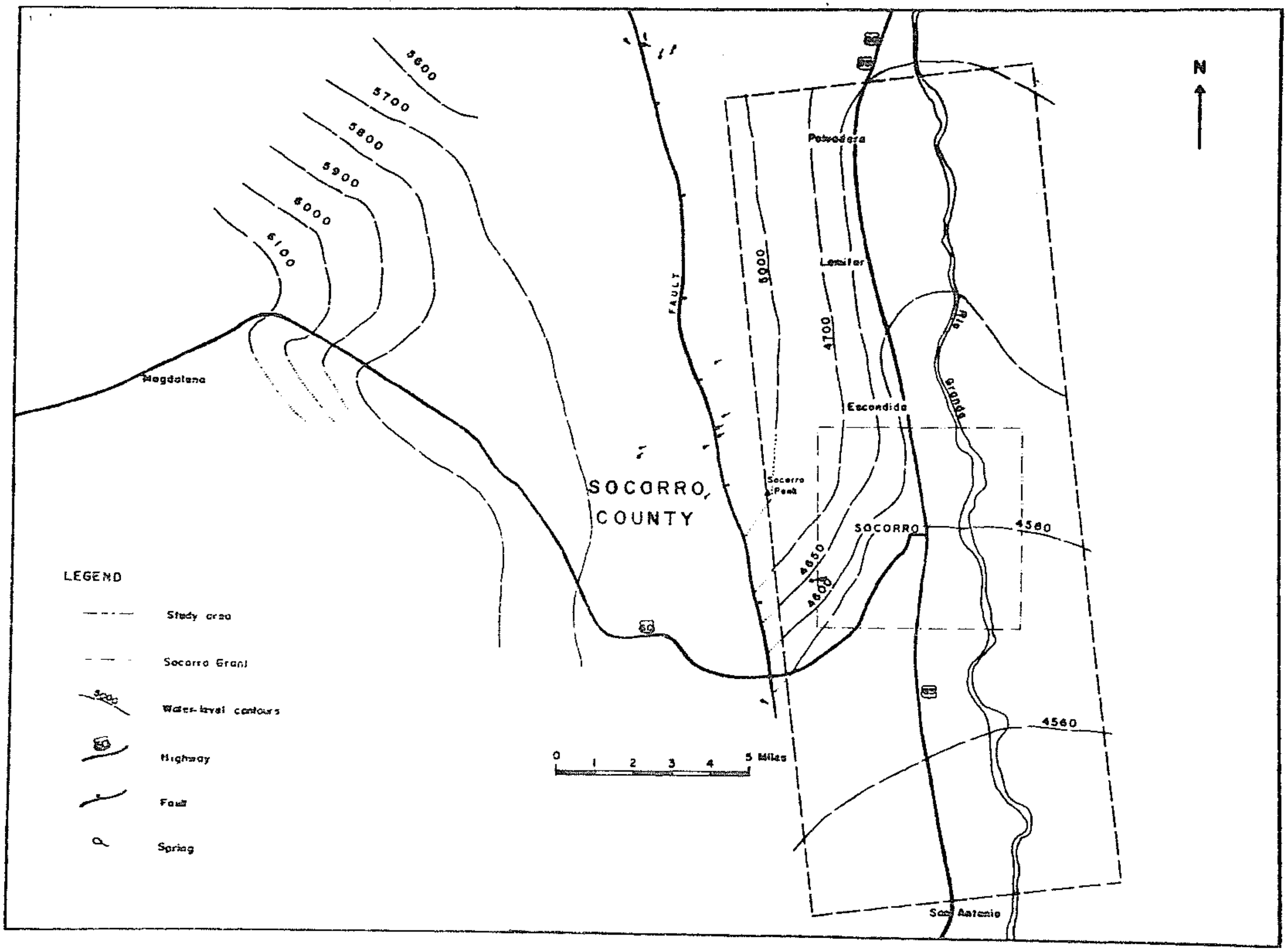

Figure 9. The Socorro Region water-table contour map for 1962

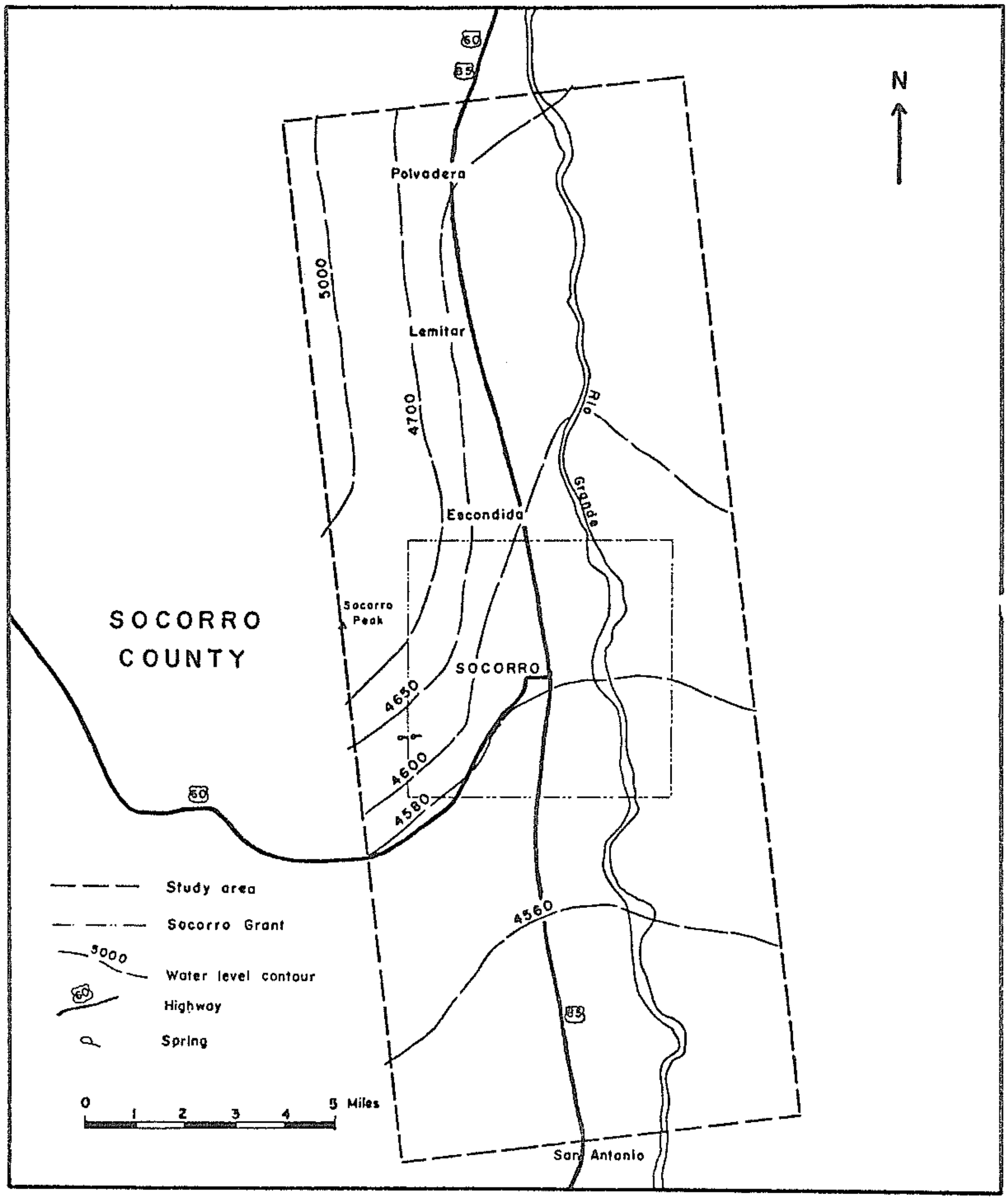

Figure 10. The Socorro Region water-table contour map for 1966

hydrologic variables as well as agricultural withdrawal schedules were programmed for each of the 12 x 21 grids of the study area. A net (positive or negative) withdrawal value was thus obtained for each grid in each time step.

Annual pumped volumes were estimated mainly from the declaration forms of well owners and from distribution charts of irrigated croplands and crop patterns. The consumptive use of pumped water for agricultural usage was estimated at 70 percent; i.e., 30 percent was returned to the ground-water system. Phreatophyte losses were estimated from Blaney and Hanson (1965).

In general, flow velocities in the Socorro ground-water basin are rather small (roughly 0.10 feet per day) and, therefore, the system should be quite sensitive to pumping and recharge on a short-term basis. This behavior was pronounced in the calibration runs of the Socorro Region.

Based on the above data, fifteen cases were analyzed combining simulated changes in pumping pattern, precipitation, and river stage; each case covered a period of 25 years. The river was shown to have a significant effect upon the ground-water system of the Socorro Region, and pumping rate was shown to be the dominant factor affecting changes of the ground-water table.

The stepwise multiple regression analysis of the data obtained from the simulation runs gave the following surface- ground-water use interrelationship for the Socorro Region:

$$d = -384.3 - 0.00336\, d_n - 0.00028\, d_n^2 + 60.7 \log_{10}(L + 0.2 \times 10^7)$$

in which d = decline (-) or rise (+) of the water table in any year (feet), d_n = depth (feet) to the water table in antecedent year with respect to river level considered as zero, and L = a lump factor in acre-feet per year. The lump factor consists of the following: river inflow (+), river outflow (-), 5 percent of average annual precipitation (+), nonbeneficial evapotranspiration losses (-), and the agricultural, municipal, and industrial water needs supplied by the ground-water system (-).

Figure 11 presents water-table behavior over time for three different initial water-table elevations of 20, 10, and 0 feet, respectively. At present, the average elevation of the water table above river level is

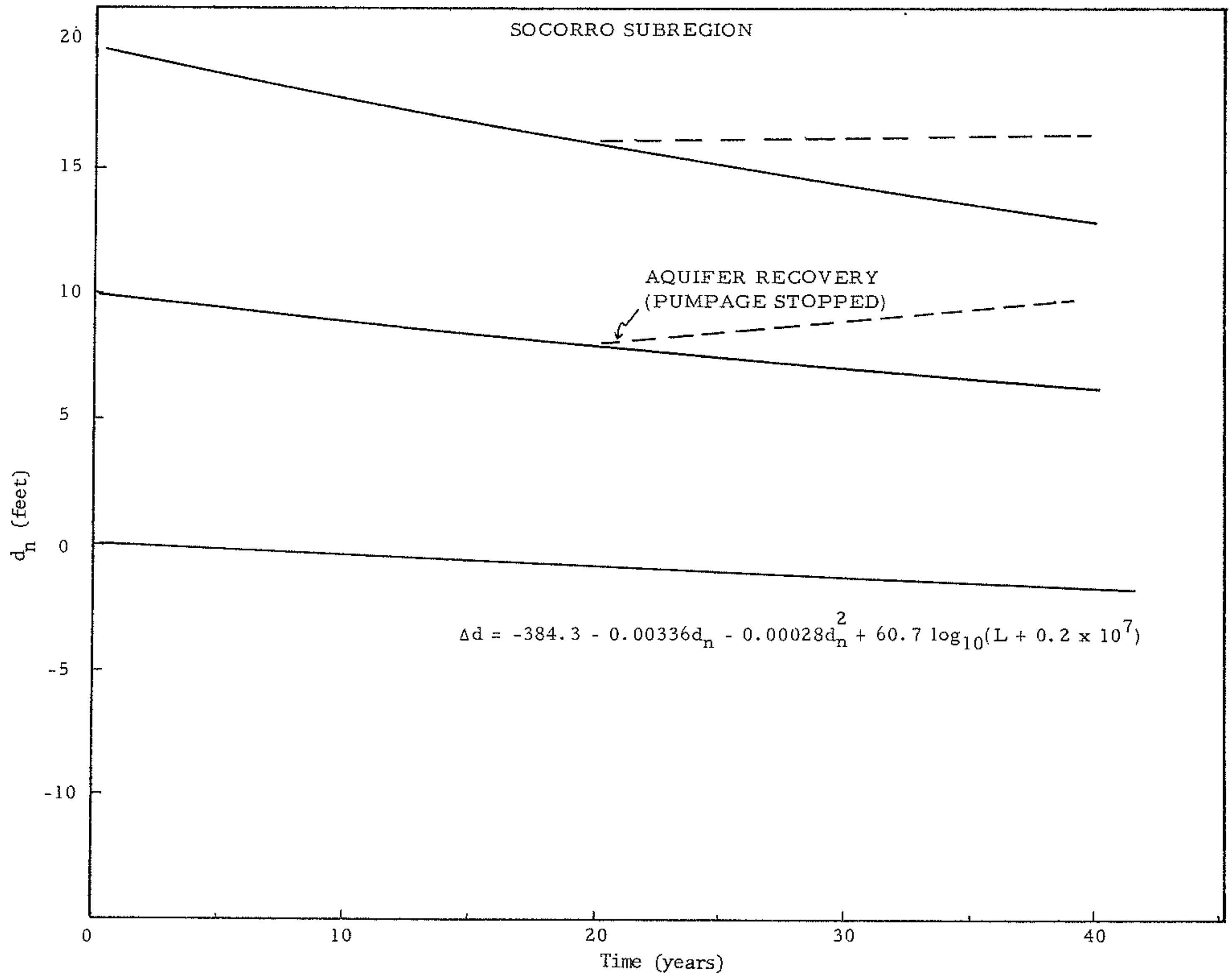

Figure 11. Depth (feet) to the water table [d_n] with respect to time for the Socorro Region, New Mexico.

almost 20 feet. Using this value as a starting point for $[d_n]$, for 1970, and projecting water demands for the Socorro area, including expected growth, water levels are calculated to drop about 7 feet by the year 2010 (Figure 11). If pumping were discontinued after 20 years, a slow recovery of the average water-table elevation would be observed (Figure 11). These results demonstrate that the Socorro ground-water system is in near hydrologic equilibrium under present conditions.

Water Quality

Surface water. The quality of the surface water of the Rio Grande reflects the use of the water upstream. Table 12 illustrates the general decline of the water quality along the Rio Grande during a recent year. Below Otowi Bridge, all ionic constituents increase and flow decreases. The consumption of water by agriculture tends to concentrate constituents. In addition, deep percolation and return flows to drains tend to compound the problem. Many of the drains are used for irrigation canals further downstream; this results in lower quality water than that of the river. Electrical conductivity (FC x 10^6 @ 25°C) and Sodium Adsorption Ratio (SAR) are used to define the salinity and sodium hazards, and are also used in determining the economic classification of land.

Large concentrations of sediment in the Rio Grande constitute another major water-quality problem. Table 13 presents total loads of suspended sediment as measured at selected gaging stations during 1967. Substantial loads are carried by the Rio Grande to be deposited in Elephant Butte Reservoir. Sediment management and control is a major problem throughout the Middle Rio Grande Conservancy District. Heavy silt loads carried by the Rio Grande below its confluence with the Rio Puerco near Bernardo have settled and caused the river bed to become aggraded. Most of the sediment is produced by the collapse of channel walls where tributaries flow through deep gorges in silty soil, and by the surface erosion of lands with sparse vegetation.

Ground water. Ground water flowing from the north into the Socorro Region is of lower quality than that of the ground water around Socorro (Figure 12). This low-quality water may come from the Puerco and the Salado valleys through the graben fault zone. Titus (1963) mentioned

Table 12. Surface water quality of the Rio Grande at selected gaging stations, 1967

Station	Average Discharge CFS	Ca mg/l	Ma mg/l	Na mg/l	Cl mg/l	SO_4 mg/l	HCO_3 mg/l	Dissolved Solids mg/l	Electrical Conductivity Ec x 10^6 at 25^oC
Rio Grande at Otowi Bridge 1967 Water Year.	802	49	8.0	29	8.6	81	150	276	429
Rio Grande Conveyance Channel at San Marcial 1967 Water Year.	454	90	16	99	--	--	218	632	972
Rio Grande at El Paso, Texas 1967 Calendar Year.	321	87	19	151	130	262	--	809	1,220

Note: Discharge and quality parameters are time averaged. Parameters not measured or reported are identified by --.

Table 13. Total suspended sediment loads at selected gaging stations, 1967 Water Year

Station	Suspended Sediment (tons/year)
Rio Chama near Chamita 3 miles upstream from mouth	3,016,743
Rio Grande at Otowi Bridge near San Ildefonso	2,650,962
Galisteo Creek at Domingo 4 miles upstream from mouth	1,251,818
Rio Grande near Bernalillo	4,379,253
Rio Puerco near Bernardo 3 miles upstream from mouth	12,257,979
Rio Grande Conveyance Channel at San Marcial	10,502,515
Rio Grande Floodway at San Marcial	2,633,789
Rio Grande at El Paso, Texas	208,112*

*Reported for Calendar Year 1967.

that water from wells and springs in the vicinities of Los Valles and the Rio Puerco fault zone contains moderate to large amounts of dissolved solids (up to 33,900 ppm). Spiegel (1955) reported that water near the Socorro county line contains larger concentration of dissolved solids than have been found elsewhere in the Santa Fe group east of the Rio Grande in Valencia County. He also reported that the water had a salty and bitter taste, and thought that the poor quality of the ground water in this area was caused by recharge to the Santa Fe group from gypseous water flowing intermittently in Abo arroyo in Socorro County. The ground water of the Santa Fe group of that area is high in sulfate.

Near Socorro, recharge from the west (Figure 9) appears to have a dilution effect which improves the water quality. South of Socorro, the total dissolved solids increase again, showing the effects of extensive irrigation.

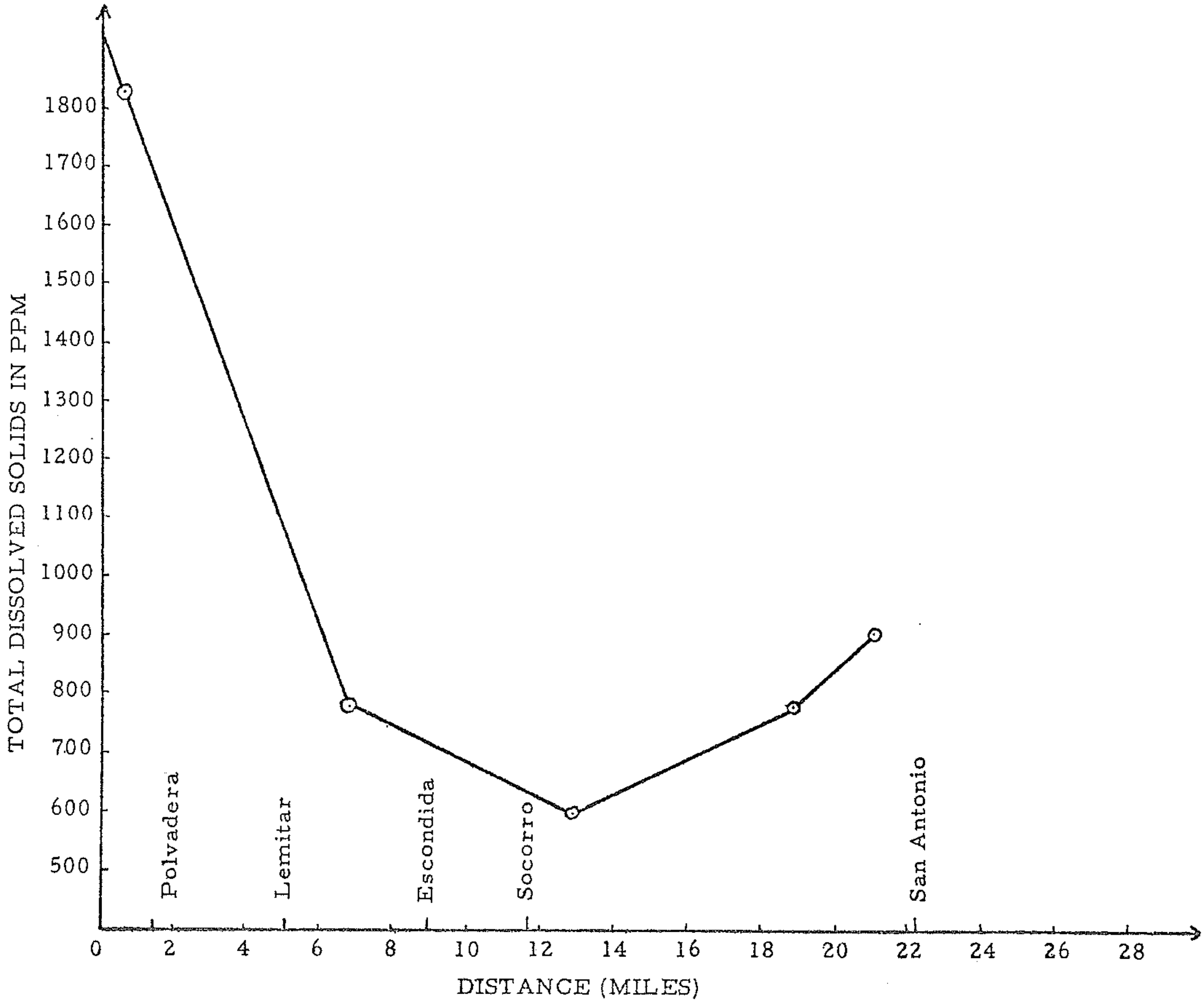

Figure 12. Average ground-water quality by location, Socorro Region, New Mexico.

A quality versus depth relationship is not well established although it appears that, in general, lower quality water may be found near the water table because of agricultural activities and, in some instances, because of evapotranspiration. The ground-water quality seems to be improving with depth but beyond 200 to 300 feet deep, no data are available.

Figure 13 is a quality versus time graph. These results are rather inconclusive in that over time large variations appear in total dissolved solids but specific conductance trends downward. No continuous records for the same well are available.

WATER DIVERSIONS AND DEPLETIONS

Irrigation

Irrigation water in the Socorro Region comes from both surface and ground sources. The surface water is supplied by the Middle Rio Grande Conservancy District, Rio Grande Project. Ground water is used primarily to supplement the surface source, but is the only source for about 850 acres of land, about 160 of which are cropped.

The Socorro Region was divided into two subregions: the upper Socorro Region and lower Socorro Region. Surface water for the upper Region is supplied through the facilities beginning at the Isleta Diversion Dam in Valencia County, and for the lower Region at the San Acacia Diversion Dam. Ground water is supplied by wells owned by individual farmers throughout the Region.

Surface-water quantity. The quantity of surface water diverted to the project lands in the Region has varied from year to year, dependent upon the total supply available. The water is diverted at the Isleta Diversion Dam into the Peralta Main Canal on the east side of the river. This canal delivers water into the San Juan Canal which services the upper Socorro Region west of the river. On the west side of the river the Region is serviced by the Belen High Line Canal. The water diverted at the San Acacia Diversion Dam to the Socorro Main Canal services the lower Socorro Region. Numerous smaller canals and laterals distribute the water throughout the irrigated area.

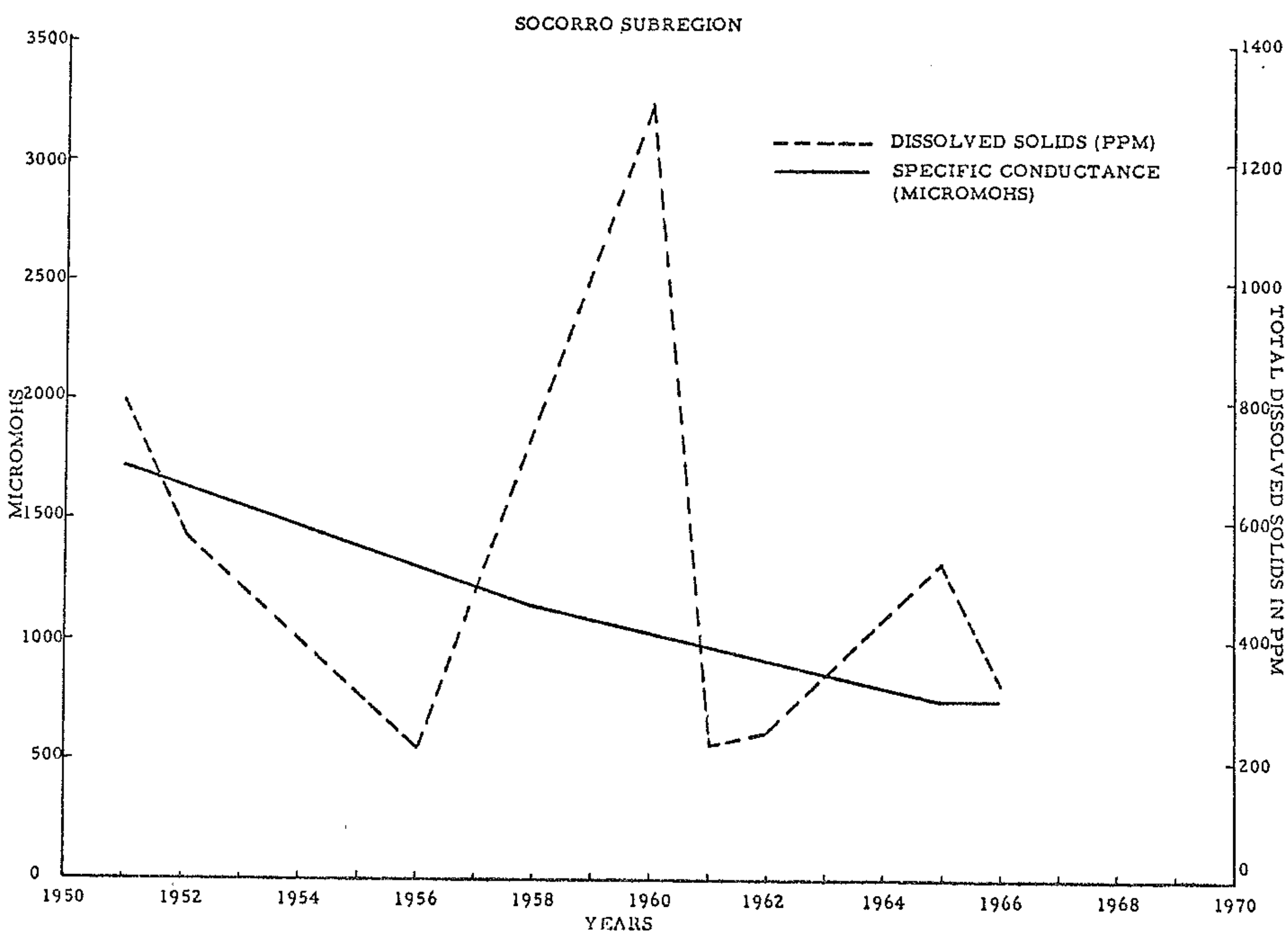

Figure 13. Ground-water quality, Socorro Region, New Mexico, 1950-1970.

The gross annual diversions for the lower Socorro Region are reported in Table 14 for the 1960-1970 period. The average total diversion for the period was 81,400 acre-feet. A portion of this total is returned to the river through drainage ditches and may be diverted again by the next lower unit. The canal waste or return is of an operational nature and results because of extra diversions for irrigation head and cancellation of water orders. Other losses from the canals include seepage losses, evaporation from the water surface in the canals, and transpiration by plants along the banks of the canals. It should be noted that excess water for irrigation head, seepage losses, canal wastage, etc., are lower in this area than for the areas upstream, primarily because of the lower volume of water available. In some areas, downstream users have reported shortages of water in some years.

The monthly surface-water deliveries to the lands in the Socorro Region are reported in Table 15. The deliveries for the upper Socorro Region were calculated for 1970 based on the total deliveries to the Isleta Division, which includes Valencia County and about 3,900 acres in northern Socorro County. The deliveries reported for the Socorro Division are for the lower Socorro Region only. The average annual delivery to the lands in the lower Region was about 2.57 acre-feet per cropped acre, or about 28,600 acre-feet.

Ground-water quantity. The ground water in the valley fill is derived from a number of sources, and the quantity from each is generally indistinguishable. The water results from seepage from the river, canals and laterals, irrigation water applied to the lands, ground-water flow from the bordering mesa lands, precipitation upon the valley floor and adjacent mesas, and a small amount from runoff in arroyos from the mesas to the valley.

Consumptive irrigation requirements calculated by the Blaney-Criddle formula (1962) on the basis of the 1970 cropping pattern for the lands serviced by the Middle Rio Grande Conservancy District in the Socorro Region are reported in Table 16. A total of about 30,074 acre-feet of irrigation water was necessary for crop consumption during the full season. Requirements calculated for the summer season (March through November) were about 28,821 acre-feet, and for the winter season (December through February) about 1,253 acre-feet. These requirements are the quantities of irrigation water, exclusive of precipitation, stored soil moisture, or ground water required

Table 14. Gross annual diversions of irrigation water from the Rio Grande in the Middle Rio Grande Conservancy District, New Mexico, 1960-1970.

Year	MIDDLE RIO GRANDE REGION[a]		SOCORRO REGION[b]	
	Cochiti Division[c]	Albuquerque and Belen Divisions[d]	Socorro Division[e]	TOTAL
	. . . .	acre-feet	. . . .	
1960	42,280	269,590	64,910	376,780
1961	38,660	300,100	84,190	422,950
1962	43,910	285,170	83,280	412,360
1963	46,550	203,950	55,640	306,140
1964	49,020	255,610	55,490	360,120
1965	52,560	355,800	94,570	502,930
1966	48,950	265,090	80,200	394,240
1967	43,230	285,830	79,280	408,340
1968	38,750	271,530	98,200	408,480
1969	43,310	315,560	114,000	472,870
1970	52,430	291,090	85,640	429,160
Average	45,423	281,756	81,400	408,579

a Includes upper Socorro Region diversions.
b Does not include upper Socorro Region diversions.
c Diversion at Cochiti Diversion Dam to Cochiti Eastside Main Canal and Sili Main Canal.
d Diversion at Angostura Diversion Dam to Albuquerque Main Canal and Atrisco Feeder Canal, and at Isleta Diversion Dam to Belen High Line Canal, Chical Lateral, Chical Acequia, Cacique Acequia, and Peralta Main Canal.
e Diversion at San Acacia Diversion Dam to Socorro Main Canal north.

Source: United States Department of Interior, Bureau of Reclamation, Albuquerque Office (unpublished data sheets), 1960-1970, 10 pp.

Table 15. Monthly deliveries[a] of surface water to the lands in the Socorro Region, Middle Rio Grande Project, Rio Grande Basin, New Mexico, 1960-1970.

YEAR	MONTH Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
	acre-feet												
						UPPER SOCORRO REGION[b]							
1970	-	-	650	1,330	1,690	1,470	1,280	1,110	1,360	1,230	-	-	10,120
						LOWER SOCORRO REGION							
1960	0	0	2,440	5,410	5,570	5,820	5,140	3,090	1,770	1,740	0	0	30,980
1961	0	0	2,670	4,620	4,940	5,960	4,340	3,480	2,120	3,460	0	0	31,590
1962	0	0	2,130	4,940	5,650	5,140	4,720	3,090	1,850	2,280	0	0	29,800
1963	0	0	2,690	3,670	4,500	2,450	1,030	2,480	1,210	560	0	0	18,590
1964	0	0	2,640	3,120	3,570	2,380	1,250	1,550	1,210	320	0	0	16,040
1965	0	0	2,440	6,120	5,330	5,680	5,960	5,430	3,570	6,530	410	0	41,470
1966	0	0	1,880	4,450	6,960	5,690	3,850	6,130	3,470	1,930	0	0	34,360
1967	0	0	1,240	2,900	2,730	2,920	2,530	2,660	2,170	2,830	0	0	19,980
1968	0	0	1,820	4,620	6,830	6,320	5,200	1,890	2,570	3,510	0	0	32,760
1969	0	0	1,480	4,020	4,260	7,390	5,480	4,940	3,750	1,440	0	0	32,760
1970	0	0	1,580	2,230	5,130	4,580	3,290	3,180	2,430	3,150	0	0	25,620
AVERAGE	0	0	2,092	4,191	5,043	4,939	3,890	3,447	2,375	2,523	37	0	28,541

a Amount of water delivered to the farm headgates. Excludes canal wastage, diversion for head, and other unaccounted-for losses.

b Deliveries for period 1960-1969 are included in deliveries for Middle Rio Grande Region; for 1970 deliveries were calculated by applying deliveries per acre for Albuquerque and Belen Divisions to the Upper Socorro Region surface-supplied cropped acreage of 3,900 acres.

Source: United States Department of Interior, Bureau of Reclamation, Albuquerque Office (unpublished data sheets), 1960-1970, 10 pp.

Table 16. Seasonal and total consumptive irrigation requirements and irrigation requirements by crop for lands serviced by the Rio Grande Project in the Socorro Region, Rio Grande Basin, New Mexico, 1970

Crop	Consumptive Irrigation Requirements[a]			Irrigation Requirements[b]		
	Summer[c]	Winter[d]	Total	Summer[c]	Winter[d]	Total
	. . . .		acre-feet	. . . .		
UPPER SOCORRO REGION						
Cotton	-	-	-	-	-	-
Alfalfa	4,934	138	5,072	9,868	276	10,144
Sorghum	7	-	7	14	-	14
Corn	375	-	375	750	-	750
Small grains	890	124	1,014	1,780	248	2,028
Improved pasture	1,868	180	2,048	3,736	360	4,096
Other hay and native pasture	-	-	-	-	-	-
Chile	23	-	23	46	-	46
Orchards	21	1	22	42	2	44
Spring lettuce	-	-	-	-	-	-
Fall lettuce	-	-	-	-	-	-
Spring onions	-	-	-	-	-	-
Fall onions	-	-	-	-	-	-
Misc. vegetables and family gardens[e]	211	-	211	422	-	422
Total	8,329	443	8,772[f]	16,658	886	17,544
Weighted Average	2.13	0.11	2.23[f]	4.27	0.23	4.50
LOWER SOCORRO REGION						
Cotton	2,332	-	2,332	4,664	-	4,664
Alfalfa	11,148	311	11,459	22,296	622	22,918
Sorghum	987	-	987	1,974	-	1,974
Corn	1,118	-	1,118	2,236	-	2,236
Small grains	1,239	173	1,412	2,478	346	2,824
Improved pasture	3,347	322	3,669	6,694	644	7,338
Other hay and native pastures	25	3	28	50	6	56
Chile	155	-	155	310	-	310
Orchards	47	1	48	94	2	96
Spring lettuce	-	-	-	-	-	-
Fall lettuce	-	-	-	-	-	-
Spring onions	-	-	-	-	-	-
Fall onions	-	-	-	-	-	-
Misc. vegetables and family gardens[e]	94	-	94	188	-	188
Total	20,492	810	21,302	40,984	1,620	42,604
Weighted Average	2.08	0.08	2.16	4.17	0.16	4.33

a The quantity of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, that is required consumptively for crop production (Blaney & Hanson, 1965, p. 5).

b The quantity of water, exclusive of precipitation, that is required for crop production or the consumptive irrigation requirement divided by the irrigation efficiency (60 percent), (Blaney & Hanson, 1965, p. 5).

c Months of March through November.

d Months of December through February.

e Also includes crops for which consumptive-use values were not available.

f Does not add because of rounding.

consumptively for crop production. They do not include surface evaporation or other economically unavoidable wastes normally associated with irrigation. The surface-water deliveries were estimated at the farm headgate and, to be comparable, the irrigation requirements were calculated using a farm irrigation-efficiency of 50 percent. The calculated irrigation requirements for the lands serviced by the MRGCD are also reported in Table 16. The total irrigation requirements for the summer season were 51,642 acre-feet, or about 4.20 acre-feet per cropped acre. Surface-water deliveries for the same season averaged about 35,740 acre-feet, indicating that about 21,902 acre-feet were pumped from wells during the summer season, and about 2,506 acre-feet were pumped during the winter season. This gave a total of 24,408 acre-feet for the year.

Outside of the MRGCD, about one percent of the cropped acreage relies on surface water only. The total consumptive irrigation requirements for the area outside the district in the Socorro Region were calculated to be 412 acre-feet, or 2.59 acre-feet per cropped acre, based on the 1970 cropping pattern (Table 17). Using the farm irrigation-efficiency of 50 percent, the total irrigation requirements were 824 acre-feet, or 5.18 acre-feet per cropped acre (Table 17). The total pumpage of ground water for irrigation outside of the irrigation district boundaries was estimated to be 824 acre-feet.

The total quantity of irrigation water required for crop production in the Socorro Region is reported in Table 18 along with the surface-water deliveries and the estimated pumpage. Total requirements of irrigation water were 60,972 acre-feet based on the 1970 cropping pattern: the 1970 surface-water deliveries were calculated to be 35,740 acre-feet, indicating that about 24,408 acre-feet were pumped from the ground-water source (about 1.82 acre-feet per cropped acre).

Municipal and Industrial

Municipal water use depends primarily upon two factors: the number of urban water users, and the per capita use of water. Industrial water use depends partially on the number of employees and the per-employee use of water in the production of goods and services. Using figures from the

Table 17. Seasonal and total consumptive irrigation requirements and irrigation requirements by crop for lands not serviced by the Rio Grande Project in the Socorro Region, Rio Grande Basin, New Mexico, 1970

Crop	Consumptive Irrigation Requirements[a]			Irrigation Requirements[b]		
	Summer[c]	Winter[d]	Total	Summer[c]	Winter[d]	Total
	. . . .	. . . . . .	acre-feet	. . . . . .	. . . . . .	. . . . . .
UPPER SOCORRO REGION						
Cotton	----	----	----	----	----	----
Alfalfa	51	1	52	102	2	104
Sorghum	----	----	----	----	----	----
Corn	----	----	----	----	----	----
Small Grains	----	----	----	----	----	----
Improved pasture	59	6	65	118	12	130
Other hay and native pasture	----	----	----	----	----	----
Chile	----	----	----	----	----	----
Orchards	----	----	----	----	----	----
Spring lettuce	----	----	----	----	----	----
Fall lettuce	----	----	----	----	----	----
Spring onions	----	----	----	----	----	----
Fall onions	----	----	----	----	----	----
Misc. vegetables and family gardens[e]	----	----	----	----	----	----
Total Weighted Average	110 2.44	7 0.16	117 2.60	220 4.89	14 0.31	234 5.20
LOWER SOCORRO REGION						
Cotton	----	----	----	----	----	----
Alfalfa	----	----	----	----	----	----
Sorghum	----	----	----	----	----	----
Corn	----	----	----	----	----	----
Small grains	----	----	----	----	----	----
Improved pasture	269	26	295	538	52	590
Other hay and native pasture	----	----	----	----	----	----
Chile	----	----	----	----	----	----
Orchards	----	----	----	----	----	----
Spring lettuce	----	----	----	----	----	----
Fall lettuce	----	----	----	----	----	----
Spring onions	----	----	----	----	----	----
Fall onions	----	----	----	----	----	----
Misc. vegetables and family gardens[e]	----	----	----	----	----	----
Total Weighted Average	269 2.36	26 0.23	295 2.59	538 4.72	52 0.46	590 5.18

a The quantity of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, that is required consumptively for crop production (Blaney & Hanson, 1965, p. 5).
b The quantity of water, exclusive of precipitation, that is required for crop production or the consumptive irrigation requirement divided by the irrigation efficiency (60 percent), (Blaney & Honson, 1965, p. 5).
c Months of March through November.
d Months of December through February.
e Also includes crops for which consumptive-use values were not available.

Table 18. Total irrigation requirements for crop consumption, 1970 annual surface-water deliveries, and the estimated ground-water pumpage in the Socorro Region, Rio Grande Basin, New Mexico, 1970

Area	Irrigation Requirements[a]			Surface Water Deliveries[b]			Ground Water Pumpage[c]		
	Summer[d]	Winter[e]	Total	Summer[d]	Winter[e]	Total	Summer[d]	Winter[e]	Total
	acre-feet								
Upper Socorro Region									
Surface supplied	16,658	886	17,544	10,120	---	10,120	6,538	886	7,424
Ground supplied	220	14	234	---	---	---	220	14	234
Total	16,878	900	17,778	10,120	---	10,120	6,758	900	7,658
Weighted average[f]	4.28	0.23	4.51	2.57	---	2.57	1.71	0.23	1.94
Lower Socorro Region									
Surface supplied	40,984	1,620	42,604	25,620	---	25,620	15,364	1,620	16,984
Ground supplied	538	52	590	---	---	---	538	52	590
Total	41,522	1,672	43,194	25,620	---	25,620	15,902	1,672	17,574
Weighted average[f]	4.17	0.17	4.34	2.57	---	2.57	1.60	0.17	1.77
Total									
Surface Supplied	57,642	2,506	60,148	35,740	---	35,740	21,902	2,506	24,408
Ground Supplied	758	66	824	---	---	---	758	66	824
Total	58,400	2,572	60,972	35,740	---	35,740	22,660	2,572	25,232
Weighted average[f]	4.20	0.19	4.39	2.57	---	2.57	1.63	0.19	1.82

a The quantity of water, exclusive of precipitation, required for crop production.
b Surface water deliveries for 1970, supplied by Rio Grande Project.
c Irrigation requirements minus surface-water deliveries.
d Months of March through November.
e Months of December through February.
f Total acre-feet per cropped acre (cropped acreage: upper Socorro Region - 3,945, lower Socorro Region - 9,954).

State Engineer Office, an estimate was made of water use for the urban population in 1960 and 1970. Municipal use includes more than urban population: light industrial as well as commercial activities within a region are dependent upon the municipal water supply. An estimate was made separately for this type of user, which includes the public sector composed of government and associated enterprises. Due to the lack of reliable primary data, these estimates should serve only as crude approximations to the actual water use within the Socorro Region. Four hundred acre-feet represent a probable approximate maximum during the years 1969 and 1970 for municipal use, 25 acre-feet for industrial use, and commercial trade and services 200 acre-feet.

Over 90 percent of the municipal and industrial water users obtained their supplies from ground-water systems. Very little surface water is diverted or depleted by any user other than agriculture.

Rural Domestic

Rural use of water is dependent upon the same two factors, population size (rural only) and the per capita use of water, as the urban population use. The 200 acre-feet of water consumed by the rural domestic population was assumed to be derived from ground water.

Livestock

Livestock use of water depends upon both use per animal within the region, and the number of, and evaporation from, stock ponds located in the region. To obtain an estimate of the use of water by livestock, an inventory by Capener and Sorensen (1971) for both the number of livestock and the number of stock ponds was used.

Stock ponds are primarily supplied from surface water, but some livestock water comes from the ground supply. However, the most significant portion of water used can be assumed to be from surface supplies.

Between 1960 and 1970, there was no appreciable change in water consumption by livestock, but since 1960 the number of stock ponds increased. Consequently, only an estimate of livestock use was made for 1970.

The actual consumption by livestock was estimated to be 700 acre-feet in 1970 for the Socorro Region: stock-pond evaporation was estimated to be

800 acre-feet. Irrigated pasture, for which no sale of commodity is involved, must be added to these figures. Approximately 9,400 acre-feet of water was used to irrigate pasture land for grazing by livestock. Therefore, in the Socorro Region approximately 10,900 acre-feet was consumed each year in the late 60's by the livestock sector.

Recreation

There are no reservoirs in the Socorro Region for recreational use. The State Game and Fish Department has the La Joya State Game Refuge, and the federal government has Bosque del Apache Wildlife Refuge which encompasses about 1,800 acres of shallow lakes for fish and birds.

Non-beneficial

Each year a large portion of the water supply of the Socorro Region is lost through non-beneficial depletions. These losses are primarily in the form of evaporation from the surface-water areas and from evapotranspiration by phreatophytes.

Phreatophytes. The phreatophyte classification describes a distinct ecological group of desert plants that have adapted their root systems to survive in arid areas where the water table is between 5 and 30 feet below ground. The phreatophytes, which include salt cedar, saltgrass, cottonwood trees, and willow are found in areas such as the lower flood plain of arid river basins where it is difficult to account for the sources and interaction of surface and ground-water flow.

Phreatophytes, as defined by Blaney and Hanson (1965), are plants that habitually grow where they can send their roots down to the water table or to the capillary fringe immediately overlying the water table. Saltgrass and salt cedar are the two most common phreatophytes in the Socorro Region. Blaney and Hanson (1965) listed consumptive use of ground water by saltgrass as 29.3 inches per year, and for salt cedar 57.2 inches per year. The flood-plain areas of the Rio Grande in the Socorro Region are generally covered with saltgrass and salt cedar (Figure 14). Salt cedar is the predominant type of phreatophyte in the Region. The Bureau of Reclamation, in 1971, reported phreatophyte consumptive use in the Socorro Region at about 111,000 acre-feet annually. The total area of phreatophytes in the Region was estimated

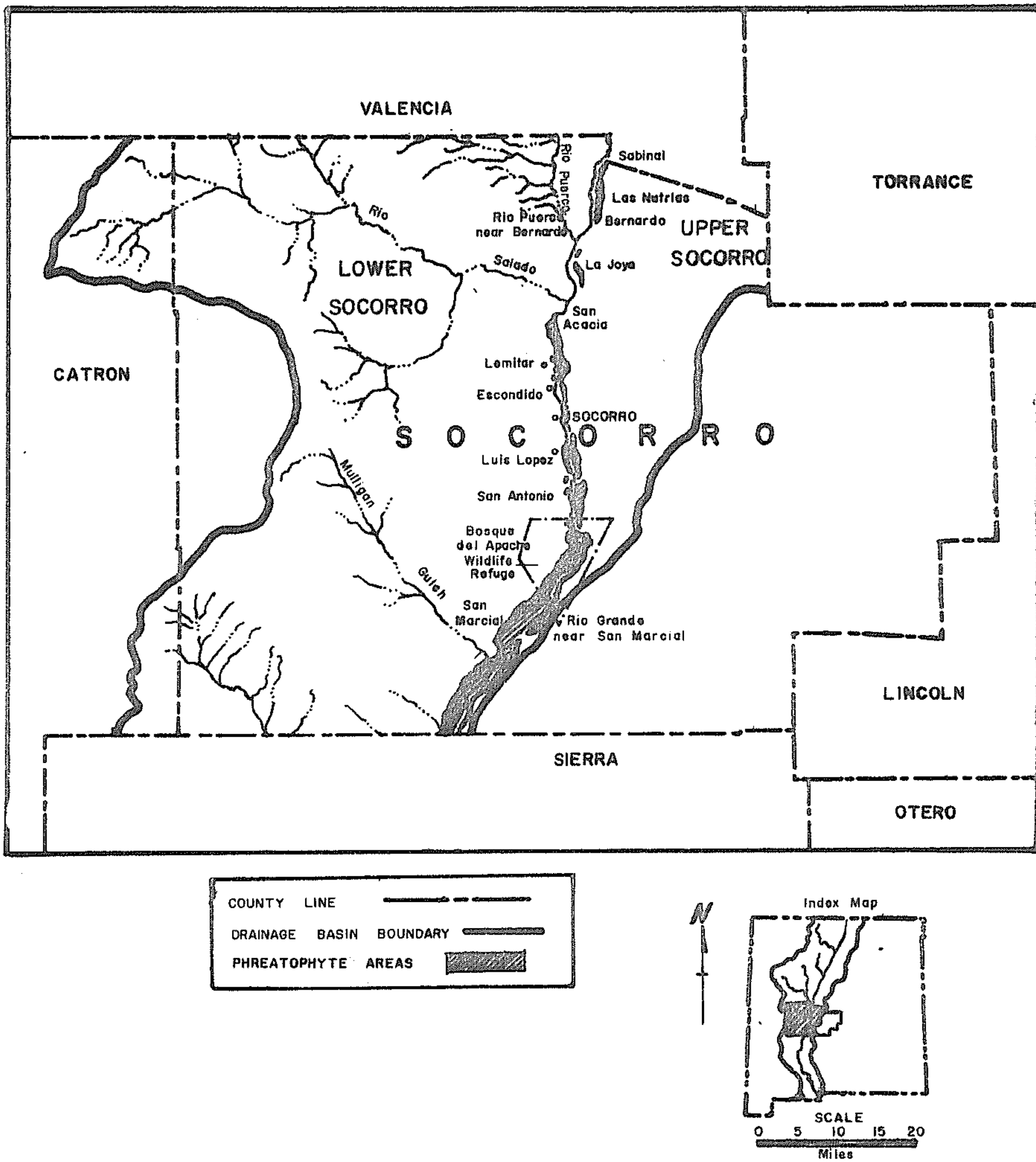

Figure 14. Major phreatophyte areas, Socorro Region, New Mexico, 1970.

(U.S. Department of Interior, Bureau of Reclamation, 1971) at 31,500 acres.

Evaporation. Losses due to evaporation from reservoirs, lakes, and ponds affect the net water supply available. Studies of evaporation from storage reservoirs indicate that during long periods of deficient streamflow, reservoirs may yield, for useful purposes, as little as 50 percent of the total water supply. The primary evaporation loss in the Socorro Region comes from open canals and drains, and surface evaporation on 1,800 acres of lakes on the La Joya and Bosque del Apache game refuges. Phreatophyte losses, however, are far greater than evaporation losses.

ECONOMIC LAND CLASSIFICATION

An economic land classification of the 16,500 acres of irrigated cropland in the Socorro Region was based on an adaptation of the Cornell system using soil productivity and irrigation water quality and quantity as the primary variables. This classification was conducted, primarily for use with the socio-economic model, to provide basic information on the relative economic productivity of the irrigated cropland areas within the Region. The delineation of areas with slight, if any, moderate, and severe limitations provided information for the water and land resource reallocation criteria used in the model.

None of the irrigated cropland acreage in the Socorro Region was considered to have only the minor income expectancy limitations required for classification as Economic Class I (Table 19). The primary reasons for lower classification of some of the cropland were lower soil productivity, reduced water quantity, small farm size, and problems associated with urban encroachment. About 57 percent of the irrigated cropland in the Socorro Region was classified as Economic Class II (Table 19). Soil productivity and farm size are the primary limiting factors associated with these lands. The Economic Class II lands are distributed throughout the Region, but over three-fourths of the Class II lands are located in the lower Socorro Region (Figure 15). Most of it is for full-time commercial farming. Inputs are high per acre, buildings are well maintained and in good condition, and fields are large and well suited for the most efficient use of modern machinery and irrigation

Table 19. Acreage of irrigated cropland by economic land classes, Socorro Region, New Mexico

Economic Land Classification	Total	
	acres	percent
Class I	0	0
Class II	9,360	56.7
Class III	7,140	43.3
Total	16,500	100.0

practices. Farm size was the primary limitation in classifying most of the Group I soils into Economic Land Class II. The small field sizes and high per-acre investment in improvements were considered as limitations to consolidation into commercial units.

Slightly more than 43 percent of the land in the Socorro Region has severe limitations and was classified as Economic Class III. Many of the farms are small and are operated on a part-time basis, and fields are irregular in shape, having been divided by canals and drains or limited by terrain. Farmsteads and buildings are generally in poor condition and some are structurally obsolete. Machinery and equipment typically was also small and out-of-date. Deficiencies in soil, unfavorable topography, small farm size, and likelihood of urban encroachment were the primary limitations imposed on these lands. The Class III lands are located primarily along the river, in the tributary areas, in old playa lakes, and in strips throughout the Valley.

The potential for declines in ground-water levels, reduced surface flows, and water-quality deterioration in the Region may result in the lowering of the economic productivity and profitability of the land. This will lower the economic land classification of these areas.

Income expectancies measured in terms of the crop yields for selected crops in the Region were estimated for the different economic land classes (Table 20). Extreme differences in the yields between the economic land classes were not found in all cases because of the limited number of farms interviewed and differences in managerial ability of the farmers; however,

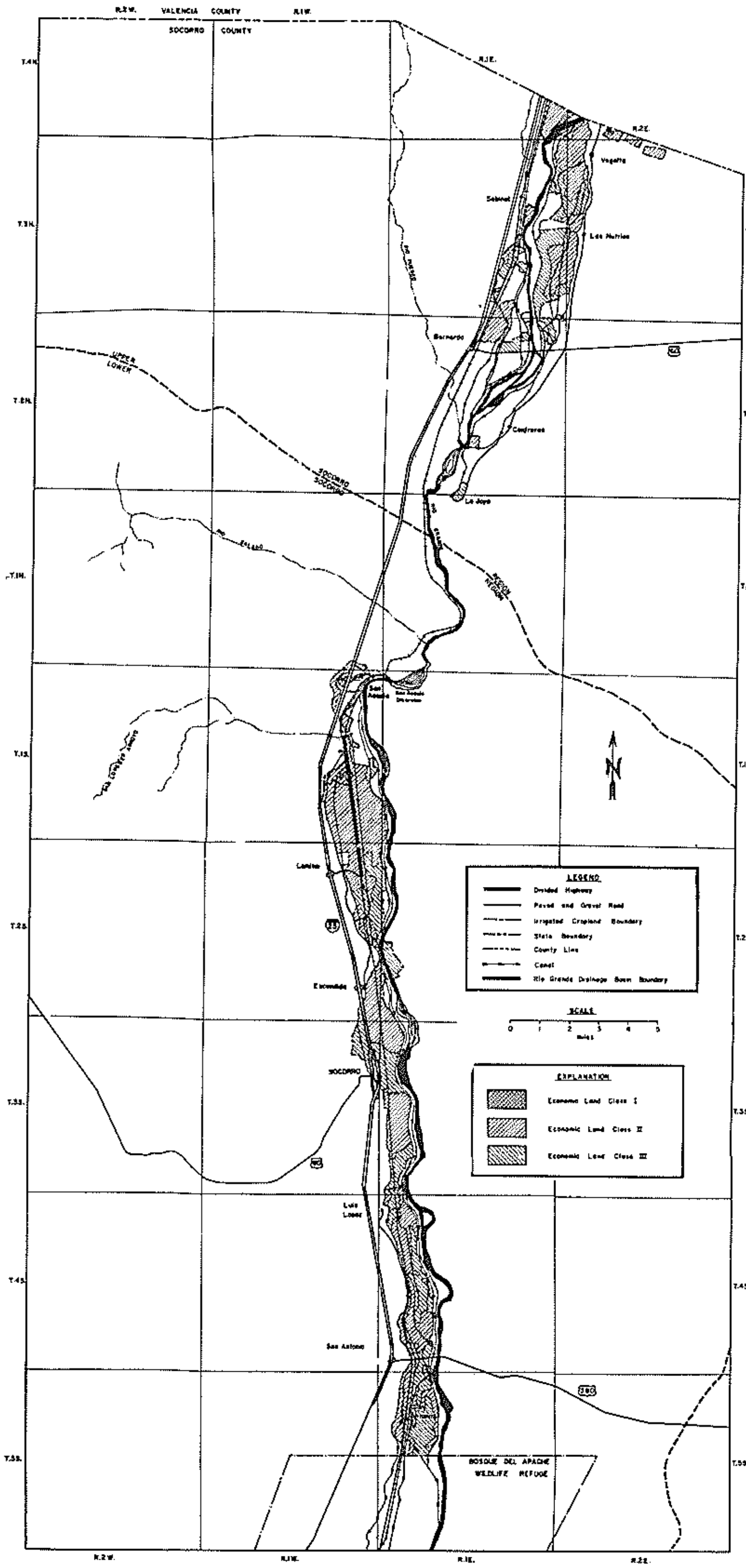

Figure 15. Economic land classification map, Socorro Region, New Mexico

consistent variations in yields were noted for the principal crops between land classes. Cotton, alfalfa, and grain sorghum yields were much higher for Class II land than for Class III.

Table 20. Expected yields for selected crops on different economic land classes in the Socorro Region, New Mexico

Economic Land Class	Crop Yield per Acre: Cotton	Alfalfa	Grain Sorghum
	pounds lint	tons	pounds
Class I	--	--	--
Class II	590	6.5	6,500
Class III	480	4.8	4,500

THE SOCIO-ECONOMIC MODEL

The socio-economic model was used to simulate long-run production and water utilization patterns in the Rio Grande Basin under alternative assumptions. Because of the difficulty of obtaining population, industrial activity, and employment data by drainage basin they were incorporated into the socio-economic model on a county basis. Therefore, the results from the socio-economic model reflect economic activity and water depletions for all of Socorro County, but economic activity and water depletions for the portion of Catron County that is within the Rio Grande drainage basin is excluded.

The Socorro Region and the other three Regions constitute the total socio-economic simulation model. Direct interpretations of the results for only the Socorro Region do not take into account the interactions with the other Regions; therefore, the Socorro Region will be highlighted as a part of the total Rio Grande region analysis.

Each simulation process starts with the same basic optimal solution to the model, and continues with annual changes to satisfy the alternative conditions for a period of 50 years. The basic solution used 1970 conditions and closely approximates the actual production levels attained and resources used in the base year 1970. Differences between the basic solution of the model and the actual production levels in 1970 result from the optimization procedures used. The optimal use of resources in the model allows for social considerations such as recreation demands and unemployment levels. This basic optimal solution of the model was used as a point of departure for the alternative solutions; hence, a description of the basic solution will be presented first.

Basic Optimal Solution of the Model

The economy of New Mexico was represented in the model by twenty-four production sectors (Table 21). All sectors were defined in the model in units of one million dollars of production. Each sector had its own demands for resources such as water, labor, etc., and its contribution to the total benefits to the state's economy, measured by the value added of each

Table 21. Definition and classification of production sectors

Production Sector	1960 I-O Study *	Major SIC Codes **	Production Sector Description
Agriculture			
1	1,2		Meat animals, farm dairy products and poultry
2	3		Food grains and feed crops
3	4		Cotton and cottonseed
4	5		Vegetables, fruits and nut trees, miscellaneous food products
5	6	7	Agricultural services
Mining			
6	7,8,11,12	10,12,14	Metals and non-metals
7	9,10	13	Crude petroleum and natural gas, oil and gas field services
Manufacturing			
8	13	201	Meat packing and other meat products
9	14	202	Dairy products
10	15	204,205	Grain mill and bakery products
11	16	remainder of 20	Miscellaneous food products
12	17,21	24,25,32	Lumber and wood products, concrete and stone products
13	19,20	28,29	Chemicals and petroleum refining
14	22,23	19,34,35,36,38, 371-373	Electrical machinery and equipment, scientific instruments, fabricated metal products
15	18,24	22,23,27,31,39	Printing and publishing, miscellaneous manufacturing
Transportation Communications Utilities			
16	25,26	40,41,42,45,47	Railroads and all other transportation
17	27	46,4924	Gas and oil pipelines
18	28,29,30	48,49	Communications, electric and gas utilities
Trade			
19	31,34	50,52,53,54,56,57,59	Wholesale trade and most retail trade
20	32,33	55,58	Retail auto dealers and gas stations, eating and drinking places
Finance, Insurance, and Real Estate			
21	35,36	60,61,62,63,64,65,67	Finance, insurance, and real estate
Services			
22	37,38,39,40	70,72,73,75,76,78,79	Hotels, motels, personal services, business services
23	41,42	80,81,82,88,89,37(p)	Medical and professional services, research and development
Construction			
24	47	15,16,17	Contract construction

*Source: New Mexico Bureau of Business Research, 1965
**Standard Industrial Classification

one-million-dollar unit. Tables 22 and 23 present some of the major results of the basic model and relate them to water utilization for both the total Rio Grande region and for the Socorro Region. Table 22 presents levels of production for all 24 sectors measured in terms of output. *Medical and professional services* and *research and development* (sector 23) generated the largest value of production at $517.96 million, and *agricultural services* (sector 5) generated the smallest value of production at $4.95 million. Within the agricultural sector, *meat animals, dairy products, and poultry* (sector 1) accounted for about 49 percent of the agricultural value of production; *fruits and vegetables* (sector 4) about 23 percent; *cotton* (sector 3) about 10 percent; *food grains and feed crops* about 12 percent; and *agricultural services* about 6 percent. The *metals* sector (sector 6) accounted for about 76 percent of the total value of production for the mining industry, and *oil and gas* (sector 7) accounted for the remaining 24 percent. In the manufacturing sectors, *electrical, scientific instruments, and fabricated metal products* (sector 14) accounted for 27 percent of the value of production ($70.345 million); *lumber and wood products, concrete and stone products* (sector 12) 22 percent; *printing and publishing, miscellaneous manufacturing* (sector 15) 20 percent; *meat packing* and *dairy products* (sectors 8 and 9) 18 percent; and the remaining 13 percent included *grain mill and bakery products* (sector 10) 5 percent, *miscellaneous food* (sector 11) 5 percent, and *chemicals and petroleum refining* (sector 13) 3 percent. The *Services* sectors (sectors 22 and 23) accounted for about 40 percent of the total value of production; *Trade* (sectors 19 and 20) about 25 percent; *Transportation, communications, and utilities* (sectors 16, 17, and 18) about 14 percent; *Finance, insurance, and real estate* (sector 21) about 10 percent; and *Construction* (sector 24) about 10 percent.

The value added generated by each sector ranges from 17.7 percent of the total value of output in the *meat packing industry* (sector 8) to 71.2 percent in *retail auto, gas stations, and eating places* (sector 20). The weighted average value added in the Rio Grande region was 58 percent of total output. The large coefficients of output per unit of water in the nonagricultural sectors are a result of the low water consumption in these sectors.

Table 22. Production, value added, employment, and water use by production sector in the Rio Grande region, and in the Socorro Region 1970--basic optimal solution

Sector		Total Rio Grande Region: Value of Production ($1 million)	Total Rio Grande Region: Value Added ($1 million)	Total Rio Grande Region: Employment	Total Rio Grande Region: Water Depletions (acre-feet)	Socorro Region: Value of Production ($1 million)	Socorro Region: Value Added ($1 million)	Socorro Region: Employment	Socorro Region: Water Depletions (acre-feet)
Agriculture	1	41.839	14.351	2,346	79,888	6.110	2.096	156	7,255
	2	9.886	6.357	1,424	224,748	1.306	0.840	103	27,116
	3	8.574	5.264	233	134,180	0.237	01146	18	3,599
	4	19.526	15.406	2,739	58,393	0.009	0.007	2	91
	5	4.950	3.024	454	59	0.000	0.000	0	0
Mining, Oil & Gas	6	81.785	52.342	1,731	2,977	2.446	1.565	99	108
	7	26.277	19.051	189	1,594	0.000	0.000	0	0
Manufacturing	8	20.651	3.655	273	62	0.000	0.000	0	0
	9	25.948	6.798	504	111	0.269	0.070	4	1
	10	14.277	4.183	537	20	0.000	0.000	0	0
	11	13.071	4.902	539	189	0.076	0.028	2	2
	12	56.155	26.730	2,332	854	0.079	0.466	51	24
	13	7.931	1.753	109	297	0.000	0.000	0	0
	14	70.345	29.615	4,018	157	1.041	0.438	145	2
	15	50.456	26.691	2,139	137	0.132	0.070	8	0
Trade & Services	16	109.842	72.935	5,004	274	13.590	9.024	37	34
	17	13.501	9.316	152	34	0.000	0.000	0	0
	18	104.925	68.201	4,518	4,484	1.861	1.210	61	95
	19	325.258	214.345	22,071	1,597	1.819	1.199	138	9
	20	98.281	69.976	11,298	579	1.894	1.349	247	11
	21	177.302	131.381	7,230	1,742	1.056	0.782	47	10
	22	151.463	88.303	13,158	1,940	1.401	0.817	146	19
	23	517.957	286.430	17,474	6,371	0.493	0.273	13	6
	24	172.462	71.744	9,559	3,039	1.058	0.440	107	19
	Total	2,122.660	1,232.753	110,030	523,722	35.777	20.819	1,383	38,401 0

Table 23. Production, employment, and water use for major sectors in the Rio Grande region, and in the Socorro Region, New Mexico--basic optimal solution

	Total Rio Grande Region				Socorro Region			
Major Sector	Total Output ($1 million)	Total Value Added ($1 million)	Employment	Total Water Depletions (acre-feet)	Total Output ($1 million)	Total Value Added ($1 million)	Employment	Total Water Depletions (acre-feet)
1. Agriculture	84.775	44.402	7,196	497,268	7.662	3.088	278	38,061
2. Mining, Oil & Gas	108.062	71.393	1,920	4,571	2.446	1.565	99	108
3. Manufacturing	258.834	104.327	10,451	1,826	2.497	1.073	210	29
4. Trade & Services	1,670.991	1,012.630	90,463	20,059	23.172	15.093	796	202
Total	2,122.660*	1,232.753*	110,030	523,722*	35.777	20.819	1,383	38,399*
	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)
1. Agriculture	4.0	3.6	6.5	94.9	21.4	14.8	20.1	99.1
2. Mining, Oil & Gas	5.1	5.8	1.8	0.9	6.8	7.5	7.2	0.3
3. Manufacturing	12.2	8.5	9.5	0.4	7.0	5.2	15.2	0.1
4. Trade & Services	78.7	82.1	82.2	3.8	64.8	72.5	57.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Does not add due to Rounding

The *Trades and Services* sectors represent about 82 percent of the employment within the Rio Grande region. *Wholesale trade, retail trade, gas stations, restaurants,* and *Services* (sectors 19, 20, 22, and 23) represent almost 60 percent of the total employment. Employment in *Manufacturing* accounts for about 10 percent of those employed in the RGR, primarily in *lumber and wood products*, and *concrete and stone products* (sector 12), *electrical machinery and equipment, scientific instruments, fabricated metal products* (sector 14), and *printing and publishing* and *miscellaneous manufacturing* (sector 15). These three sectors account for over 80 percent of the employment within the *Manufacturing* sectors. *Agriculture* represents about 7 percent of the RGR employment force, with about 38 percent employed in *vegetables and fruits* (sector 4), and about 33 percent in *meat animal and dairy production.*

Agricultural production accounted for 95 percent of the water depleted in the RGR with *food grains and feed crops* (sector 2) accounting for about 45 percent of the total depletions, and *cotton* (sector 3) accounting for another 27 percent. *Mining* sectors accounted for less than 1 percent, *Manufacturing* sectors only 0.3 percent, and *Trades and Services* 3.8 percent.

Table 23 magnifies the differences between the *Agriculture* sectors and all other producing sectors. While the *Agriculture* sectors produced only 4.1 percent of the total output, 3.9 percent of the total value added, and provided only 6.7 percent of the total employment, they consumed 95 percent of all the water used in production in the Rio Grande region. The *Trades and Services* sectors played the opposite role, using only 3.8 percent of all water depleted by the production sectors, but producing 78 percent of the total value of output and accounting for 81.9 percent of the total value added.

In the Socorro Region the agricultural sectors produced the second largest portion of the subregion's total output (21.1 percent) and total value added (14.8 percent), and also provided for the second highest employment rates (20.1 percent). *Agriculture* consumed the largest portion of the water used in production (99.1 percent of the regional total). *Mining* (sector 6) is more important in the Socorro Region than in the total Rio Grande region, producing 6.8 percent of the total output, 7.5 percent of the total value added, and providing for 7.2 percent of the employment. The *Manufacturing* sectors are less important in the Socorro Region than in the total Rio Grande region. The *Trades and Services* sectors in the Socorro Region are less important than in the total Rio Grande region; however, the general relationships that exist for the total Rio Grande region are also expressed in the Socorro Region: i.e., *Trades and Services* sectors were responsible for the largest portion of the total value of output (64.8 percent), but used only 0.5 percent of the water depleted. The single most important industry is *railroads and other transportation* (sector 16) accounting for almost 38 percent of the total value of production in the Socorro Region.

In the agricultural sectors, *meat animal and dairy production* (sector 1) accounted for 80 percent of the value of production, 68 percent of the value added by *Agriculture*, provided 60 percent of the agricultural employment, but consumed only about 19 percent of the agricultural water. *Food grains and feed crops* (sector 2) accounted for about 17 percent of the value of agricultural production, 27 percent of value added, 37 percent of agricultural employment, and 71 percent of the agricultural water consumed.

The single most important manufacturing sector in the Socorro Region is *electrical machinery and equipment, scientific instruments, fabricated metal products* (sector 14), followed by *lumber and wood products* and *concrete and stone products* (sector 12). These two manufacturing sectors account for 81 percent of the manufacturing value of production, 84 percent of value added, 93 percent of manufacturing employment, and 90 percent of the manufacturing depletions.

The single most important *Trades and Services* sector is *railroads and other transportation* (sector 16) comprising almost 60 percent of the value of production of *Trades and Services*, 60 percent of value added, but only 5 percent of the employment, and 17 percent of the water depletions. The next closest sectors in value of production are *retail auto dealers and gas stations, eating and drinking places* (sector 20), *communications, electric and gas utilities* (sector 18), and *wholesale trade and most retail trade* (sector 19): each of these sectors contributes about 8 percent. These three *Trades and Services* sectors account for about 83 percent of the

Trades and Services total value of production, 85 percent of the value added, 61 percent of the employment, and combined account for 74 percent of the *Trades and Services* water depletions.

The regional distribution of water depletions by major production sectors and municipal and rural uses is presented in Table 24. The significance of the agricultural sectors as major water users was maintained in all Regions, although their share is increased in the Socorro Region to 97.6 percent, where 1.5 percent of the total water use was for domestic The Socorro Region was responsible for the lowest water depletions in the Rio Grande region, utilizing 7 percent of the total water available.

Water recreation demands in the Rio Grande region in the base year (1970) and the distribution of supply by origin are presented in Table 25. The major supply area for water skiing and boating is the Lower Rio Grande. Recreationers from the Middle, Socorro, and Lower Regions, as well as out-of-state visitors, utilize the availability in the Lower Region.

In the concentrated population centers of the Middle Rio Grande Region, demands exceed supply of water-based recreation by 453,235 (551,654-98,419) activity-occasion days (AOD) in water skiing, 146,210 activity-occasion days in boating, and 807,318 activity-occasion days in fishing. The Lower Region supplies 589,672 activity-occasion days of water skiing but demands only 67,719, resulting in a difference of 521,953 AOD (Table 25); in boating there is a net supply of 293,943 AOD (Table 25); and in fishing there is a net supply of 382,904 AOD (Table 25). The Socorro Region supplies none of its demands for water skiing and boating, but supplies about 90 percent of its demand for fishing.

Three Water Management Alternatives

The socio-economic model was used to estimate the effects of population growth on the distribution of production and water requirements in the Rio Grande region for the period 1970-2020. Regional population projections used

Table 24. Summary of depletions by major sector in the Rio Grande region (acre-feet)--basic optimal solution

Major Sector	Region				Total Rio Grande Region
	Upper	Middle	Socorro	Lower	
	. . . . acre-feet				
Agriculture	111,084	125,795	38,061	222,328	497,268
Mining, Oil & Gas	2,852	1,500	108	111	4,571
Manufacturing	225	1,486	29	87	1,826*
Commercial Trade & Services	4,199	13,708	202	1,950	20,059
Municipal	3,862	25,568	407	4,362	34,199
Rural	2,042	2,527	203	1,051	5,823
Total	124,264	170,581	39,010	229,889	563,746*
	. . . . percent				
Agriculture	89.39	73.74	97.57	96.71	88.21
Mining, Oil & Gas	2.30	0.88	0.28	0.05	0.81
Manufacturing	0.18	0.87	0.07	0.04	0.32
Commercial Trade & Services	3.38	8.04	0.52	0.85	3.56
Municipal	3.11	14.99	1.04	1.90	6.07
Rural	1.64	1.48	0.52	0.46	1.03
	100.00	100.00	100.00	100.00*	100.00

*Does not add due to rounding.

Table 25. Water-based recreation by Region, Rio Grande region--basic optimal solution

Supplying Region	Upper	Middle	Socorro	Lower	Out of State	Total Supply
	(activity-occasion days)					
		WATER SKIING				
Upper	121,402				8,281	129,683
Middle		98,419				98,419
Socorro						
Lower		255,459	13,897	67,719	252,597	589,672
Total Rio Grande region	121,402	353,878	13,897	67,719	260,878	817,714
Rest of State	18,643	154,768				173,411
Out of State		43,008	1,544			44,552
Total Demand	140,045	551,654	15,441	67,719	260,878	1,035,737
		BOATING				
Upper	64,012				15,673	79,685
Middle		78,616				78,616
Socorro						
Lower		74,923	5,639	28,145	213,381	322,088
Total Rio Grande region	64,012	153,539	5,639	28,145	229,054	480,389
Rest of State		74,923				74,923
Out of State		16,364	1,023			17,387
Total Demand	64,012	244,826	6,662	28,145	229,054	572,699
		FISHING				
Upper	380,437	250,258			162,706	793,401
Middle		365,600				365,600
Socorro			30,760		9,371	40,131
Lower				264,910	408,909	673,819
Total Rio Grande region	380,437	615,858	30,760	264,910	580,986	1,872,951
Rest of State		549,268	3,230	26,005		578,503
Out of State		7,792				7,792
Total Demand	380,437	1,117,918	33,990	290,915	580,986	2,459,246

in the model were based on the New Mexico Bureau of Business Research county projections (BEA Projections) (Table 26). An increase in population affects the final demand for consumer products, the labor force, as well as the direct demand for water for municipal and rural use. The model assumes government employment to be a function of population; therefore, it was determined but not reported in the following analyses.

An increase in the final demand will affect all 24 sectors according to the interrelationships of the Input-Output Table. Because of these predetermined relationships, any change in the final product mix produced within the region will require a change in the model constraints.

Three alternative solutions of long-run production and water-use patterns, utilizing a linear population growth at an average rate of 1.19 percent annually or 59.5 percent for the period 1970-2020, are presented below. The three alternatives differ only in water constraints. In the first alternative, water availability was not constrained. The production sectors were permitted to grow as required in order to supply the products demanded. Thus, additional surface water for agricultural use would become available as needed: for example, by water importation or water-saving technological developments. Ground-water sources were assumed to be sufficient to permit the required increases in pumpage but not to substitute for surface sources.

The assumption that surface water can be imported to satisfy all future demands is not a realistic assumption. There are only limited opportunities for water importation to the Rio Grande Basin: i.e., the San Juan-Chama diversion. It is more likely that no additional surface water will be available in the foreseeable future. The second alternative reflects this assumption and places a constraint on surface-water availability: i.e., the 1970 surface water supplies plus the San Juan-Chama diversion water. Any increase in water demands is required to be satisfied within the region. In the model, surface and ground water are used in fixed proportions in the agricultural sectors, thus ground water cannot be substituted for surface water. The effect of limiting surface-water availability to 1970 levels (basic optimal solution) implies that growth in agricultural production can be expected only in areas where the availability of surface water exceeds depletions. No effect should be expected in the nonagricultural sectors because ground-water depletions have not been restricted. Under the legal

Table 26 Population projections by Region, Rio Grande region, New Mexico, 1970-2020

Year	Region: Upper Total Population	Upper % of Total	Middle Total Population	Middle % of Total	Socorro Total Population	Socorro % of Total	Lower Total Population	Lower % of Total	Total Rio Grande Region
1970	111,610	19.5	373,355	65.3	9,763	1.7	76,962	13.5	571,690
1980	123,372	19.3	4.9,897	65.6	10,870	1.7	85,630	13.4	639,769
1990	135,133	19.1	466,440	65.9	11,978	1.7	94,297	13.3	707,848
2000	146,895	18.9	512,982	66.1	13,085	1.7	102,965	13.3	775,927
2010	158,656	18.8	559,525	66.3	14,193	1.7	111,632	13.2	844,006
2020	170,418	18.7	606,067	66.4	15,300	1.7	120,300	13.2	912,085
Average Annual Percent Growth	1.054		1.247		1.134		1.126		1.191

Source: Based on county projections by the New Mexico Bureau of Business Research (BEA Projections).

constraints imposed by the water laws of New Mexico, the mining of ground water may be restricted by authority of the State Engineer to declare a ground-water basin and close it to future development. Most of the Rio Grande region in New Mexico lies within declared basins. To maintain the base flow of the Rio Grande, increased pumping effects on the river must be offset by retiring surface-water rights. This alternative approximates the current administration of water resources in the Rio Grande region.

The third alternative is much more restrictive than the second alternative of imposing a constraint only on the surface water. This alternative reflects constraints placed on both surface and ground-water resources. Total surface-water availability for use in the Rio Grande region was restricted to the average surface flow in the Rio Grande, including the supplementary flow from the San Juan-Chama project. Ground-water pumpage was initially restricted in this set to the total pumpage in 1970. It was assumed that any future growth will require the transfer of surface-water rights from agriculture to other production sectors, rural, domestic, and municipal uses. A transfer mechanism was added to the model to allow the transfer of surface rights to ground-water rights. Additional pumpage was permitted only to the extent that surface-water depletions were reduced.

Additional diversions refer to the effect of pumpage upon the flows of the river. Within the alluvial deposits of the Rio Grande the surface water and ground water are connected, and pumpage either diverts water from the river or intercepts water destined for the river.

In order to maintain interregional deliveries over time, the total surface-water availability in each Region was reduced annually to compensate for the additional effects of pumping upon the flow of the river.

Alternative 1: No water constraint. The long-run effects of population growth under the above assumptions are presented in Table 27 for the RGR and for the Socorro Region. Table 27 presents the production levels, value added, employment, and water depletions required to satisfy the increases in local demand and expected increases in nonagricultural out-of-state sales. Total value of output in the Rio Grande region is expected to increase at approximately the same rate as the population. This amounts to an increase

Table 27. Production, value added, employment, and water use by production sector in the Rio Grande region, and in the Socorro Region, 2020--no water constraint

Sector		Total Rio Grande Region				Socorro Region			
		Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)	Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)
Agriculture	1	55.812	19.144	3,302	102,831	6.590	2.260	167	7,825
	2	14.502	9.325	2,004	332,144	1.627	1.046	128	33,780
	3	13.530	8.307	368	211,735	0.383	0.235	29	5,816
	4	25.812	20.366	3,629	77,802	0.112	0.088	20	1,137
	5	7.588	4.636	693	91	0.000	0.000	0	0
Mining, Oil & Gas	6	129.705	83.011	2,731	4,699	3.832	2.452	155	169
	7	41.219	29.884	296	2,499	0.000	0.000	0	0
Manufacturing	8	33.501	5.930	442	101	0.000	0.000	0	0
	9	41.866	10.969	814	179	0.422	0.111	6	2
	10	22.792	6.678	854	32	0.000	0.000	0	0
	11	20.971	7.864	864	303	0.117	0.004	3	3
	12	89.420	42.564	3,721	1,360	1.512	0.720	78	37
	13	12.868	2.844	177	482	0.000	0.000	0	0
	14	113.719	47.876	6,485	254	1.630q	0.686	227	3
	15	80.783	42.734	3,424	219	0.205	0.108	13	0
Trade & Services	16	175.304	116.402	8,068	437	21.279	14.129	57	53
	17	21.588	14.896	245	54	0.000	0.000	0	0
	18	168.080	109.252	7,250	7,164	2.891	1.879	96	147
	19	522.722	344.473	35,423	2,567	2.786	1.836	211	14
	20	157.470	112.119	18,097	925	2.941	2.094	383	17
	21	284.080	210.503	11,577	2,791	1.596	1.183	71	16
	22	242.044	141.112	20,955	3,099	2.176	1.269	227	29
	23	838.294	463.576	28,442	10,311	0.773	0.427	20	10
	24	276.625	115.076	15,316	4,874	1.657	0.689	168	29
	Total	3,390.292	1,969.539	175,178	766,950	52.529	31.258	2,061	49,085

of more than $1,267.6 million (59.7 percent) in the total value of output for the period 1970-2020.

Agricultural production is expected to increase only 38.3 percent ($32.5 million) in the Rio Grande region compared to an increase of 59.7 percent in total value of output. This smaller increase results from the assumption that additional surface water will not be made available for agricultural exports and will be used only for local increases in demand for agricultural products. The major increases in agricultural products are expected in the Middle Rio Grande Region which also expects the largest population increase. This results from the interregional Input-Output matrix structure which does not allow for changes in the interregional transfer coefficients. The expected increase varies from 58 percent for *cotton* (sector 3) to 32 percent for *vegetables and fruits* (sector 4), with *agricultural services* up 53 percent (sector 5), 47 percent for *food grains and feed crops* (sector 2), and *meat animals, dairy, and poultry* up only 33 percent (sector 1).

The total nonagricultural production is expected to increase by $1,235 million. The expected increase in agricultural production represents only 2.6 percent of the total increase in the value of production while it represents 85.2 percent of the additional water depletions required. The value of production for the *Mining* sectors is expected to increase about 58 percent from 1970 to 2020, *Manufacturing* up about 61 percent, and *Trades and Services* are expected to increase about 60 percent (Table 28).

Water depletions in the year 2020 for the Rio Grande region are expected to reach almost 830,000 acre-feet. This increase of 266,743 acre-feet over the depletions in 1970 will be required to meet the projected population needs in 2020. However, by 2020 an additional 83,000 acre-feet of surface water will be required to maintain the base flow of the river out of the region to Texas. Of the 266,743 acre-feet, the agricultural sectors will require 227,336 acre-feet, the remaining production sectors 15,769 acre-feet, and domestic needs 23,516 acre-feet. The increase in agricultural depletions will be met by utilizing 191,720 acre-feet of surface water and 35,616 acre-feet of ground water. All increases in surface water will be used by agriculture.

Table 28. Production, value added, employment and water use for major sectors in the Rio Grande region, and in the Socorro Region, New Mexico, 1970-2020--no water constraint

		Total Rio Grande Region						Socorro Region					
		Value of Production				Water Depletions		Value of Production				Water Depletions	
Year	Sector	($1 million)	Change from 1970 (percent)	Value Added ($1 million)	Employment	(acre-feet)	Change from 1970 (percent)	($1 million)	Change from 1970 (percent)	Value Added ($1 million)	Employment	(acre-feet)	Change from 1970 (percent)
1970 (basic optimal solution)	Agriculture	84.775		44.402	7,195	497,268		7.662		3.088	278	38,061	
	Mining	108.062		71.393	1,920	4,571		2.446		1.565	99	108	
	Manufacturing	258.834		104.327	10,451	1,826		2.497		1.073	210	29	
	Trade & Services	1,670.991		1,012.630	90,463	20,059		23.172		15.093	796	202	
	Municipal & Rural	--		--	--	39,144		--		--	--	578	
	Total	2,122.660*		1,232.753*	110,030*	562,866*		35.776		20.819	1,383	38,977*	
2020	Agriculture	117.244	38.3	61.778	9,997	724,603	45.7	8.712	13.7	3.630	345	45,558	19.7
	Mining	170.924	58.2	112.895	3,027	7,199	57.5	3.832	56.7	2.452	155	169	56.5
	Manufacturing	415.920	60.7	167.459	16,781	2,928	60.3	3.886	55.5	1.669	328	44	51.7
	Trade & Services	2,686.207	60.8	1,627.409	145,374	32,221	60.6	36.099	55.8	23.506	1,233	315	55.9
	Municipal & Rural	--	--	--	--	62,660	60.1	--	--	--	--	906	56.8
	Total	3,390.292*	59.7	1,969.539*	175,178*	829,610*	47.4	52.529	46.8	31.258*	2,061	49,991*	28.3

*Does not add because of rounding.

In 1970 the Socorro Region accounted for slightly under 2 percent of the total Rio Grande region's value of production and is estimated to remain fairly constant at slightly under 2 percent in 2020. *Trades and Services* accounted for about 65 percent of the value of production in 1970, *Agriculture* 21 percent, *Manufacturing* 7 percent, and *Mining* approximately 7 percent of the value of production in the Socorro Region (Table 23). In the year 2020, *Trades and Services* are expected to increase to about 75 percent, *Agriculture* to decrease to about 12 percent, *Manufacturing* to remain constant at about 5 percent, and *Mining* to remain constant at about 8 percent of the value of production.

The economy of the Socorro Region is expected to grow at a lower rate than that for the total Rio Grande region. The expected increase in total value of production from 1970 to 2020 is 46.8 percent compared to 59.7 percent for the total RGR. *Agriculture* is expected to increase at a lower percentage rate of growth (13.7 percent for the Socorro and 38.3 percent for the RGR) and the remaining sectors to increase at a rate of about 56 percent for the Socorro Region.

Employment in the Socorro Region is expected to increase 49 percent from 1970 to 2020, with agricultural employment increasing 24 percent and the other sectors increasing about 71 percent.

Water depletions in the Socorro Region in 1970 accounted for about 7 percent of the total Rio Grande region's water depletions but are expected to decrease slightly to about 6 percent in 2020. *Agriculture* is the largest water user, accounting for 99 percent of total depletion in the Socorro Region in 1970 and 91 percent in 2020 (Table 28).

Alternative 2: Surface-water constraint. Table 29 presents production levels, value added, employment, and expected water depletions by sector under the surface-water constraints for the Rio Grande region and for the Socorro Region, and is summarized by major sector in Table 30. The Rio Grande regional value of production with a constraint would be $3,390.3 million, and $3,372.2 million without a surface-water constraint; thus, the cost of imposing a surface-water constraint is $18.1 million (0.53 percent reduction). Direct *Agriculture* production would decrease $6.9 million,

Table 29. Production, value added, employment, and water use by production sector in the Rio Grande region, and in the Socorro Region, 2020--surface-water constraint

Sector		Total Rio Grande Region				Socorro Region			
		Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)	Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)
Agriculture	1	55.813	19.144	3,303	102,835	6.590	2.260	168	7,825
	2	8.127	5.226	1,261	196,466	1.053	0.677	83	21,863
	3	13.357	8.201	364	209,026	0.383	0.235	29	5,816
	4	25.812	20.366	3,629	77,802	0.112	0.088	20	1,137
	5	7.196	4.397	657	86	0.000	0.000	0	0
Mining, Oil & Gas	6	129.704	83.011	2,731	4,699	3.8e2	2.452	155	169
	7	41.218	29.883	296	2,499	0.000	0.000	0	0
Manufacturing	8	33.500	5.929	442	101	0.000	0.000	0	0
	9	41.866	10.969	814	179	0.422	0.111	6	2
	10	22.788	6.677	854	32	0.000	0.000	0	30
	11	20.971	7.864	864	303	0.117	0.044	3	3
	12	89.368	42.539	3,719	1,359	1.509	0.718	78	37
	13	12.849	2,840	177	481	0.000	0.000	0	0
	14	113.515	47.790	6,474	253	1.630	0.686	227	3
	15	80.772	42.728	3,423	219	0.205	0.108	13	0
Trade & Services	16	175.294	116.395	8,067	437	21.279	14.129	57	53
	17	21.582	14.892	245	54	0.000	0.000	0	0
	18	168.010	109.206	7,247	7,161	2.886	1.876	95	147
	19	522.539	344.353	35,411	2,566	2.780	1.832	210	14
	20	157.350	112.033	18,083	925	2.928	2.085	382	17
	21	283.816	210.308	11,566	2,788	1.587	1.176	71	16
	22	241.851	140.999	20,936	3,096	2.167	1.263	226	29
	23	828.282	458.040	27,955	10,188	0.773	0.427	20	10
	24	276.618	115.073	15,316	4,874	1.657	0.689	168	29
	Total	3,372.196	1,958.862	173,833	628,426	51.910	30.859	2,012	37,167

Table 30. Production, value added, employment, and water use for major sectors in the Rio Grande region, and in the Socorro Region, New Mexico, 1970-2020--surface-water constraint

		Total Rio Grande Region						Socorro Region					
		Value of Production				Water Depletions		Value of Production				Water Depletions	
Year	Sector		Change from 1970	Value Added	Employment		Change from 1970		Change from 1970	Value Added	Employment		Change from 1970
		($1 million)	(percent)	($1 million)		(acre-feet)	(percent)	($1 million)	(percent)	($1 million)		(acre-feet)	(percent)
1970 (basic optimal solution)	Agriculture	84.775		44.402	7,196	497,268		7.662		3.088	278	38,061	
	Mining	108.062		71.393	1,920	4,571		2.446		1.565	99	108	
	Manufacturing	258.834		104.327	10,451	1,826		2.497		1.073	210	29	
	Trade & Services	1,670.991		1,012.630	90,463	20,059		23.172		15.093	796	202	
	Municipal & Rural	--		--	--	39,144		--		--	--	578	
	Total	2,122.660*		1,232.753*	110,030	562,866*		35.777		20.819	1,383	38,977*	
2020	Agriculture	110.305	30.1	57.334	9,213	586,215	17.9	8.138	6.2	3.261	300	36,640	-3.7
	Mining	170.922	58.2	112.894	3,027	7,199	57.5	3.832	56.7	2.452	155	169	56.5
	Manufacturing	415.629	60.6	167.336	16,767	2,926	60.2	3.883	55.5	1.667	328	44	51.7
	Trade & Services	2,675.342	60.1	1,621.299	144,827	32,088	60.0	36.057	55.6	23.478	1,229	314	55.4
	Municipal & Rural	--	--	--	--	62,660	60.1	--	--	--	--	906	56.8
	Total	3,372.196*	58.9	1,958.862*	173,833*	691,086	22.8	51.910	45.1	30.859*	2,012	38,073	-2.3

*Does not add because of rounding.

Manufacturing production would decrease $0.3 million, and *Trades and Services* are expected to decrease $10.9 million. *meat animal, dairy, and poultry* sector (sector 1) would not be affected by a surface-water constraint, but the value of production for *food grains and feed crops* (sector 2) would be decreased $6.4 million, *cotton* (sector 3) reduced $0.2 million, *fruits and vegetables* (sector 4) would be unchanged, and *agricultural services* (sector 5) down about $0.4 million. In the *Services* sectors, *medical and professional*, and *research and development* (sector 23) is expected to decrease about $10 million.

The level of employment in the Rio Grande region is expected to decrease by 1,344 employees in 2020 when a surface-water constraint is imposed. *Agriculture* production sectors (sectors 2, 3, and 5) are expected to account for 784 of these employees, with *food grains and feed crops* accounting for 88 percent of the decrease. *Services* production sectors are expected to account for 546 employees, with sector 23 accounting for all employees.

Surface-water depletions in the Socorro and Lower Regions in the base year 1970 approached the average annual availability for these Regions. The Upper and Middle Regions are expected to benefit from the additional surface water to be supplied by the San Juan-Chama diversion project. Thus the long-run average annual availability in these two Regions exceeds their 1970 depletions. Total surface-water availability is reduced over time because of the increased effect of ground-water pumping over time and the increases in pumpage necessary to satisfy growth requirements, and it is expected that 83,000 acre-feet of surface rights will be retired by 2020. Because of the additional San Juan-Chama diversion water, surface-water depletions are expected to increase until about the year 2000 and then decrease. However, the Socorro and Lower Regions are expected to have reductions in surface-water depletions well before the Upper and Middle Regions because they do not benefit from the San Juan-Chama project. The surface-water usage decreases in the 50-year period due to the effect on the river of continued pumpage at an increasing rate, even though the total average flow in the Rio Grande is increased by 111,000 acre-feet (from the San Juan-Chama).

The decrease in ground-water depletions for agricultural use in the same years results from the fixed ground-surface water relationship assumed for agricultural production. This assumption was necessary in order to avoid further surface-flow depletions which would take place if ground water were substituted for surface water in agricultural production.

Total water depletions are expected to increase only 22.8 percent and reach 691,086 acre-feet in 2020. This is 138,524 acre-feet less than the amount required where no water constraint was imposed. *Agriculture* accounts for 136,388 acre-feet of this reduction. The remaining 136 acre-feet reduction includes 2 acre-feet in *Manufacturing* and 134 acre-feet in *Trades and Services*.

The demand for agricultural products which could not be satisfied in this case is allowed to be supplemented by agricultural imports or by reduction of exports.

The value of production in the Socorro Region in 2020 would be $52.5 million without a water constraint and $51.9 million when a surface-water constraint is imposed (Table 29). Direct agricultural production would decrease $0.6 million, and the indirect effects of agricultural production would account for about an $0.02 million decrease in manufacturing and services associated with agriculture. *Food grains and feed crops* (sector 2) accounts for all of the decrease in agricultural production.

Employment in the Socorro Region would decrease from 2,061 with no water constraint to 2,012 with a surface-water constraint. Again, *Agriculture* would account for nearly all (92 percent) of the reduction in employment.

Surface-water depletions in the Socorro Region in the base year 1970 approached the average annual availability because none of the San Juan-Chama diversion project is expected to supply additional surface water to the Socorro Region. The average annual depletions in 2020 with a surface-water constraint would be 8,918 acre-feet less than under the condition of no water constraint. Reduced agricultural depletions account for all (8,918 acre-feet) of the reduced depletions.

<u>Alternative 3: Surface- and ground-water constraint</u>. Production, value added, employment, and water depletions in this alternative for the Rio Grande region and the Socorro Region are presented in Table 31 and summarized by major sector in Table 32. The cost of imposing the additional constraint on ground water is $4.1 million in 2020 compared with a

Table 31. Production, value added, employment, and water use by production sector in the Rio Grande region, and in the Socorro Region, 2020--total water constraint

Sector		Total Rio Grande Region: Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)	Socorro Region: Value of Production ($1 million)	Value Added ($1 million)	Employment	Water Depletions (acre-feet)
Agriculture	1	55.813	19.144	3,303	102,835	6.590	2.260	168	7,825
	2	5.990	3.852	989	144,070	1.028	0.661	81	21,344
	3	12.989	7.975	354	203,262	0.383	0.235	29	5,816
	4	25.812	20.366	3,629	77,802	0.112	0.088	20	1,137
	5	6.812	4.162	625	82	0.000	0.000	0	0
Mining, Oil & Gas	6	129.704	83.011	2,731	4,699	3.832	2.452	155	169
	7	41.217	29.882	296	2,499	0.000	0.000	0	0
Manufacturing	8	33.500	5.929	442	101	0.000	0.000	0	0
	9	41.866	10.969	814	179	0.422	0.111	6	2
	10	22.786	6.676	854	32	0.000	0.000	0	0
	11	20.971	7.864	864	303	0.117	0.044	3	3
	12	89.353	42.532	3,718	1,359	1.509	0.718	78	37
	13	12.836	2.837	176	480	0.000	0.000	0	0
	14	113.713	47.873	6,484	254	1.630	0.686	227	3
	15	80.769	42.727	3,423	219	0.205	0.108	13	0
Trade & Services	16	175.279	116.385	8,067	437	21.279	14.129	57	53
	17	21.578	14.889	245	54	0.000	0.000	0	0
	18	167.978	109.186	7,246	7,159	2.886	1.876	95	147
	19	522.462	344.302	35,406	2,565	2.780	1.832	210	14
	20	157.299	111.997	18,077	924	2.927	2.084	381	17
	21	283.706	210.226	11,562	2,787	1.587	1.176	71	16
	22	240.775	140.372	20,826	3,082	1.166	0.680	122	16
	23	828.277	458.036	27,955	10,188	0.773	0.427	20	10
	24	276.613	115.071	15,316	4,874	1.657	0.689	168	29
	Total	3,368.097	1,956.264	173,402	570,242	50.883	30.258	1,905	366,34

Table 32. Production, value added, employment and water use for major sectors in the Rio Grande region, and in the Socorro Region, New Mexico, 1970-2020--total water constraint

Year	Sector	Total Rio Grande Region: Value of Production ($1 million)	Total Rio Grande Region: Value of Production, Change from 1970 (percent)	Total Rio Grande Region: Value Added ($1 million)	Total Rio Grande Region: Employment	Total Rio Grande Region: Water Depletions (acre-feet)	Total Rio Grande Region: Water Depletions, Change from 1970 (percent)	Socorro Region: Value of Production ($1 million)	Socorro Region: Value of Production, Change from 1970 (percent)	Socorro Region: Value Added ($1 million)	Socorro Region: Employment	Socorro Region: Water Depletions (acre-feet)	Socorro Region: Water Depletions, Change from 1970 (percent)
1970 (basic optimal solution)	Agriculture	84.775		44.402	7,196	497,268		7.662		3.008	278	38,061	
	Mining	108.062		71.393	1,920	4,571		2.446		1.565	99	108	
	Manufacturing	258.834		104.327	10,451	1,826		2.497		1.073	210	29	
	Trade & Services	1,670.991		1,012.630	90,463	20,059		23.172		15.093	796	202	
	Municipal & Rural	--		--	--	39,144		--		--	--	578	
	Total	2,122.660*		1,232.753*	110,030	562,866*		35.777		20.819	1,383	38,977*	
2020	Agriculture	107.416	26.7	55.499	8,900	528,050	6.2	8.113	5.9	3.245	298	36,121	-5.1
	Mining	170.921	58.2	112.894	3,027	7,199	57.2	3.832	56.7	2.452	155	169	56.5
	Manufacturing	415.794	60.6	167.407	16,776	2,926	60.2	3.883	55.5	1.667	325	44	51.7
	Trade & Services	2,673.967	60.0	1,620.464	144,699	32,070	59.9	35.005	51.3	22.894	1,125	300	48.5
	Municipal & Rural	--	--	--	--	62,660	60.1	--	--	--	--	906	56.8
	Total	3,368.097*	58.7	1,956.264	173,402	632,904*	12.4	50.833	42.2	30.258	1,905*	37,540	-3.7

*Does not add because of rounding.

surface-water only constraint, and $22.2 million compared with the alternative without any constraint on water. Direct *Agriculture* production would decrease $2.9 million as a result of imposing the additional ground-water constraint, but *Mining* (sector 6) is expected to remain constant, and the indirect effects of reduced *Agriculture* production would account for the other $1.2 million in *Manufacturing, Trade,* and *Services* associated with agriculture. The affected *Agriculture* sectors are expected to be *food grains and feed crops*, $2.14 million; *cotton*, $0.37 million; and *agricultural services*, $0.38 million. However, annual agricultural production in 2020 is expected to be $22.6 million more than in 1970, and nonagricultural production is expected to be $1,225.8 million above the 1970 level.

The level of employment is expected to decrease by 481 employees when the additional constraint is placed on ground water. *Agriculture* production sectors (sectors 2, 3, and 5) are expected to account for 314 of these employees, with *food grains and feed crops* production accounting for 71 percent of the total decrease.

The increased demand for water by the nonagricultural sectors required a transfer of 47,166 acre-feet from surface rights to ground-water pumpage. The average annual depletion with a total water constraint is expected to be 58,182 acre-feet less than under the condition of a surface-water constraint only, and 196,706 acre-feet less than the alternative of no water constraint. *Agriculture* depletions are expected to decrease 58,165 acre-feet, and *Trade and Services* water depletions are expected to decrease 18 acre-feet when the additional ground-water constraint is added.

The cost of imposing the additional constraint on ground water in the Socorro Region would be $1.03 million in 2020 compared with a surface-water constraint only, and $1.6 million compared with the alternative of no constraint on water. *Agriculture* production would account for $0.025 million of the $2.0 million of reduced production in 2020 and *Trades and Services*, the remaining $1.0 million. *Food grains and feed crops* account for all the reduction in agricultural production.

Employment in the Socorro Region would decrease an additional 107 employees when the additional ground-water constraint is added. *Agriculture* employment would account for only 2 of these employees, in the *food grains and feed crops* sector. The *Trade and Service* sectors would account for the other 105 employees.

Total depletions in 2020 in the Socorro Region are expected to decrease 533 acre-feet below that of a surface-water constraint only, and 9,451 acre-feet when compared with the alternative of no constraint on water. *Agriculture* depletions would account for 519 of the 533 acre-feet reduction in 2020.

Summary. In the previous discussion, three sets of water management alternatives were presented for the Rio Grande region. The first was an analysis of the region's growth with a water constraint. The second was an analysis of growth with a surface-water constraint. The third was an analysis of growth with both surface- and ground-water constraints. A summary of the solutions for these alternatives is presented in Table 33 for the total Rio Grande region and for the Socorro Region.

Without a water constraint, value of production, employment, and water depletions in the Rio Grande region are expected to exhibit the largest increase (59.7 percent, 59.2 percent, and 47.4 percent, respectively). The expected increase in value of production varies from 38.3 percent for *Agriculture* to 60.8 percent for *Trades and Services*. Water depletions are expected to increase 45.7 percent for *Agriculture*, 57.5 percent for *Mining*, 60.3 percent for *Manufacturing*, 60.6 percent for *Trades and Services*, and 60.1 percent for *Municipal and Rural* domestic purposes.

When a surface-water constraint is imposed, the expected value of production would be reduced by $18.1 million in 2020, employment by 1,344 employees, and water depletions by 138,523 acre-feet (16.7 percent) below the alternative of no water constraint (Table 33). Reduced *Agriculture* production would account for about 38 percent ($6.9 million) of the reduced value of production, and *Trades and Services* about 60 percent ($10.9 million). The level of employment in the RGR is expected to decrease by 1,344 employees in 2020. *Agriculture* production sectors are expected to account for about 58 percent and *Trades and Service* sectors about 41 percent. *Agriculture* water depletions are expected to represent about 85 percent of the total water depletion reduction when a surface-water constraint is imposed.

In 2020, when a total water constraint is imposed, value of production in the RGR is expected to be reduced to $3,368.1 million, decreased $4.1

Table 33. Summary of alternative solutions by major sectors in the Rio Grande region, and in the Socorro Region, New Mexico, 1970-2020

			Total Rio Grande Region						Socorro Region					
			Value of Production				Water Depletions		Value of Production				Water Depletions	
Alternative	Year	Major Sector		Change from 1970	Value Added	Employment		Change from 1970		Change from 1970	Value Added	Employment		Change from 1970
			($1 million)	(percent)	($1 million)		(acre-feet)	(percent)	($1 million)	(percent)	($1 million)		(acre-feet)	(percent)
BASIC OPTIMAL SOLUTION	1970	Agriculture	84.775		44.402	7,196	497,268		7.662		3.088	278	38,061	
		Mining	108.062		71.393	1,920	4,571		2.446		1.565	99	108	
		Manufacturing	258.834		104.327	10,451	1,826		2.497		1.073	210	29	
		Trade & Services	1,670.001		1,012.630	90,463	20,059		23.172		15.093	796	202	
		Municipal & Rural	--		--	--	39,144		--		--	--	578	
		Total	2,122.660*		1,232.753*	110,030	562,866*		35.777		20.819	1,383	38,977*	
NO WATER CONSTRAINT	2020	Agriculture	117.244	38.3	61.778	9,997	724,603	45.7	8.712	13.7	3.630	345	45,558	19.7
		Mining	170.924	58.2	112.895	3.027	7,199	57.5	3.832	56.7	2.452	155	169	56.5
		Manufacturing	415.920	60.7	167.459	16,781	2,928	60.3	3.886	55.5	1.669	328	44	51.7
		Trade & Services	2,686.207	60.8	1,627.409	145,374	32,221	60.6	36.099	55.8	23.506	1,233	315	55.9
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	906	56.8
		Total	3,390.292*	59.7	1,969.539*	175,178*	829,610*	47.4	52.529	46.8	31.258*	2,061	49,991*	28.3
SURFACE WATER CONSTRAINT	2020	Agriculture	110.305	30.1	57.334	9,213	586,215	17.9	8.138	6.2	3.261	300	36,640	-3.7
		Mining	170.922	58.2	112.894	3,027	7,199	57.5	3.832	56.7	2.452	155	169	56.5
		Manufacturing	415.629	60.7	167.336	16,767	2,926	60.2	3.883	55.5	1.667	328	44	51.7
		Trade & Services	2,675.342	60.1	1,621.299	144,827	32,088	60.0	36.057	55.6	23.478	1,229	314	55.4
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	906	56.8
		Total	3,372.196*	58.9	1,958.862*	173,833*	691,086	22.8	51.910	45.1	30.859*	2,012	38,073	-2.3
TOTAL WATER CONSTRAINT	2020	Agriculture	107.416	26.7	55.499	8,900	528,050	6.2	8.113	5.9	3.245	298	36,121	-5.1
		Mining	170.921	58.2	112.894	3,027	7,199	57.2	3.832	56.7	2.452	155	169	56.5
		Manufacturing	415.794	60.6	167.407	16,776	2,926	60.2	3.883	55.5	1.667	328	44	51.7
		Trade & Services	2,673.967	60.0	1,620.464	144,699	32,070	59.9	35.005	51.3	22.894	1,125	300	48.5
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	906	56.8
		Total	3,368.097*	58.7	1,956.264	173,402	632,904*	12.4	50.833	42.2	30.258	1,905*	37,540	-3.7

*Does not add because of rounding

million below the value obtained when only a surface-water constraint is imposed, and decreased by $22.2 million below the no-water-constraint alternative (Table 33). The level of employment is expected to decrease by 481 employees when a constraint is imposed on ground water. Again, *Agriculture* sectors account for 82 percent of the reduced employment.

Water depletions in the RGR are expected to decrease from 829,610 acre-feet without any water constraints to 632,904 acre-feet with a total water constraint, a 24 percent reduction. The Socorro Region is expected to deplete for nonagricultural uses all of the surface-water rights by the year 2075. Without water imports, increased pumpage restrictions will have to be placed on *Manufacturing*, *Trades and Services*, and *Municipal* water usage at this time. Any allocation of surface-water rights to *Agriculture* will require these changes at an earlier date. Another alternative might be inter-regional transfer of water rights. The other Regions are expected to have enough surface-water rights to last for many years. The Albuquerque metropolitan area has about 90 percent of the expected population increase in the total Rio Grande region, and the pumpage necessary to sustain its growth increases its effect on the Rio Grande flow by more than 1,000 acre-feet annually.

The Socorro Region is expected to follow the general trend of the total Rio Grande region but at a lower growth rate. The expected increase in total value of production from 1970 to 2020 is 46.8 percent. Employment is expected to increase 49 percent. Water depletions are expected to increase about 21 percent in 2020, with *Agriculture* accounting for 97 percent of total depletions in the Socorro Region at that time.

When a surface-water constraint is imposed, the value of production is expected to be reduced $0.6 million in 2020, employment by 49 employees, and water depletions by 8,918 acre-feet. *Agriculture* production sectors would account for nearly all of the reduction in production, employment, and water depletions.

When an additional constraint is imposed on ground water in the Socorro Region, value of production would be decreased $1.0 million in 2020, employment by an additional 107 employees, and water depletions by 533 acre-feet.

Trade and Service production sectors would account for over 95 percent of the expected reductions in production and employment, but *Agriculture* production sectors would account for about 97 percent of the water depletions.

The supply of water for water-based recreation is expected to be the highest under the alternative of no water constraint (Table 34), and reduced about 5 percent when a constraint is placed on the importation of surface water or mining of ground water. The major effect occurs on surface water where all of the water-based recreation occurs.

Table 34. Estimated water-based recreation by type in the Rio Grande region

	Water Skiing	Boating	Fishing
	. . . . (activity-occasion days)		
No Water Constraints			
1970	817,773	480,389	1,872,950
1980	858,247	504,584	1,904,992
2000	939,195	552,975	2,591,525
2020	1,132,085	596,668	2,643,000
Surface Water Constraints			
1970	817,773	480,389	1,872,950
1980	858,347	504,625	2,015,576
2000	939,285	553,210	2,595,245
2020	1,160,546	596,894	2,643,000
Surface & Ground Water Constraints			
1970	817,773	480,389	1,872,950
1980	858,273	504,624	1,904,542
2000	939,332	553,356	2,592,460
2020	1,134,160	596,919	2,643,000

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APPENDIX A

SOIL PRODUCTIVITY GROUPS IN THE
SOCORRO REGION, NEW MEXICO

Group I.

Soils in productivity Group I have few limitations that restrict their use for irrigated crop production and are suited to a wide range of crops, especially those common to the Socorro Region. The soils are deep and of desirable texture, which combined with a favorable structure makes them relatively easy to till; and under cultivation a good tilth can be obtained if properly handled. They are sufficiently drained and free from toxic concentrations of soluble salts. The soils in this group are naturally productive and practically free of gravel and stones. The water holding capacity is good, and consequently the amount of water required to produce crops is not excessive. The surface of the land in this group is level or very gently sloping which makes it susceptible to easy irrigation. There is no accelerated erosion of any type on these lands, and they are not subject to overflow from arroyos which would tend to deposit detrimental material. The production capacity is high since they either have a high fertility level or they respond well to fertilizer inputs. Permeability is generally moderate.

Some of these soils have certain slight limitations which require more careful management practices; however, in most cases these corrective management practices are easy to apply. The smallest portion of the irrigated acreage in the region occurs as Group I.

Group II.

Soils in Group II have certain moderate restrictions that reduce their productive capabilities, require special management practices, or both. The conservation and management practices required are usually more difficult to apply and maintain on these soils than on the Group I soils. These soils are fairly well adapted to irrigated agriculture, but were classified in this group because their productive capabilities were somewhat limited for general farming. These conditions are due to moderate amounts of alkali, unfavorable soil characteristics, topography, erosion, or impeded drainage. Soils with light-textured subsoils and sandy textures were included in this group. The amount of irrigation water required to produce crops is comparatively high as these soils have a low water holding capacity. They require frequent and light irrigations, and if water is not always available for these needed frequent irrigations, crop failures are apt to result.

In some areas of the Region, part of the soils in this group have limited use because of high water-table and low permeability. Each distinctive kind of soil in Group II has one or more special managerial requirements for successful use. This group accounts for the largest portion of the irrigated acreage in the Region.

Group III.

The soils in productivity Group III have limitations which limit their use for agricultural production. The character and properties of the soil itself were given the greatest consideration. Alkali was also an important factor in the classification of lands in this group. In general, however, alkali was usually associated with other limiting factors such as unfavorable soil characteristics and impeded drainage. Where alkali is the only limiting factor, these lands can be improved to Group II by the leaching out of excess salts under favorable water-table and drainage conditions.

This group also included lands mapped as nonagricultural but which were being farmed. These soils include shallow unproductive soils in areas subject to overflow from arroyos, and very heavy, compact, and moderately impervious clay soils which have a high content of salts and a rather high alkaline reaction.

This group includes about 35 percent of the irrigated cropland in the Socorro Region. They are located primarily along the river and near the sides of the Valley. In many cases these soils occur in small isolated areas within farming units where their influence is exerted on the surrounding farm land.

The above described soil productivity groups and those described in Tables A-1, A-2, and A-3 were defined for purposes of this study and are not necessarily consistent with Soil Conservation Service classifications.

APPENDIX A

Table A-1. Principal soils in productivity Group I, Socorro Region, New Mexico

Map Symbol	Soil Name	Soil Description
+/A-(2)1 +/AA-(2)1	Anthony clay, 0-1% Anthony clay, 1-3%	These soils are level to gently sloping. They have no apparent erosion or drainage problems, and the subsoils are predominantly of poorly stratified, light-textured materials. Strata of porous gravelly materials are also quite common in the subsoil. Typically, a slight lime accumulation zone is found at depths of 2 to 3 feet. Excellent drainage conditions exist over the major part of these soils.
+/A-(1)4	Gila clay loam, 0-1%	The surface of these soils is relatively level or very gently sloping. The surface soils are distinctly calcareous, and because of their age, little profile development has taken place. The subsoil consists of alternate layers of stratified materials which are also variable in texture. The distribution of this soil is very irregular, but in general it parallels either the present or former stream channels. These soils contain a fair amount of organic matter and are, in general, reasonably productive.
+/A-(2)2	Anthony sandy clay, 0-1%	These soils are similar to Anthony clay soils described above, with the exception of the sandy surface-texture.
+/A-(1)1	Gila clay, 0-1%	This soil is similar to the Gila clay loam described above, with the exception of the heavier surface-texture.
+/A-(1)5	Gila sandy clay loam, 0-1%	This soil is similar to the other soils of the Gila series. It is a medium-textured soil which is, in general, highly productive.

APPENDIX A

Table A-2. Principal soils in productivity Group II, Socorro Region, New Mexico

Map Symbol	Soil Name	Soil Description
+/A-(1)1-S	Gila clay, 0-1%, saline	These soils are similar to the Gila clay soils described in Group I, but exhibit saline conditions, slight erosion, or have a light-textured subsoil phase or a heavy-textured subsoil phase.
o/A-(1)1	Gila clay, 0-1%	
+/A-L(1)1	Gila clay, 0-1%, light-textured subsoil phase	
+/A-H(1)1	Gila clay, 0-1%, heavy-textured subsoil phase	
+/A-(1)3-S	Gila silty clay, 0-1%, saline	These soils are similar to other soils of the Gila series, but are typically saline.
+/A-(1)4-S	Gila clay loam, 0-1%, saline	These soils are similar to other Gila soils, but are saline or experience steeper slopes.
+/AA-(1)4	Gila clay loam, 1-3%	
+/A-(1)5-S	Gila sandy clay loam, 0-1%, saline	These soils are similar to other Gila soils, with the exception of being saline, having steeper slopes, experiencing slight erosion, and having gravelly subsoil phases.
+/AA-(1)5	Gila sandy clay loam, 1-3%	
⊕/AA-O(1)5	Gila sandy clay loam, 1-3%, gravelly subsoil phase	

APPENDIX A

Table A-2, continued

Map Symbol	Soil Name	Soil Description
$^{+}$/A-(1)10-S	Gila fine sandy loam, 0-1%, saline	These soils are lighter textured than those in Group I, experience saline conditions, steeper slopes, and slight erosion.
$^{+}$/AA-(1)10	Gila fine sandy loam, 1-3%	
⊕/A-(1)10	Gila fine sandy loam, 0-1%	
$^{+}$/A(1)11-S	Gila sandy loam, 0-1%, saline	These soils are similar to those of the Gila series, with the exception of being saline and having a light subsoil phase.
$^{+}$/A-L(1)11	Gila sandy loam, 0-1%, light-textured subsoil phase	
^{3}/AA-(2)1	Anthony clay, 1-3%	These soils are similar to the soils described in Group I, but experience moderate erosion hazards.
$^{+}$/AA-(2)2-S	Anthony sandy clay, 1-3%	These soils are similar to those described in Group I, but have steeper slopes and experience slight saline conditions.
^{0}/A-(2)4	Anthony clay loam, 0-1%	These soils are similar to those described in Group I, but have experienced from slight to moderate wind and water erosion.
^{2PK}/AA-(2)4	Anthony clay loam, 1-3%	

Table A-2, continued

May Symbol	Soil Name	Soil Description
⊕/AA-(5)5	Algodones sandy clay loam, 1-3%	These soils range in color from a reddish-brown to red in both the surface soil and subsoil. They occupy sloping to nearly level alluvial fans and intermittent stream bottoms just above the first bottom lands. They are low in organic matter but highly calcareous. The lime is disseminated throughout with no apparent accumulations. Visible specks and streaks of gypsum are quite common in the subsoil. They are well-drained and free from harmful concentrations of alkali. In general, they have high fertility, but are susceptible to erosion hazards.
⊕/A-(5)11	Algodones sandy loam, 0-1%	These soils are similar to the soil described above, but experience slight erosion hazards.

APPENDIX A

Table A-3. Principal soils in productivity Group III, Socorro Region, New Mexico

Map Symbol	Soil Name	Soil Description
$^{+}$/A-(1)1-W	Gila clay, 0-1%	These soils are similar to those described in Groups I and II, but experience shallow-water tables, light-textured subsoil phases, heavy subsoil phases, and slight to moderate erosion hazards. In many cases these soils have experienced deposition of materials, primarily silt, from irrigation waters, and some have experienced detrimental deposits from tributary arroyos.
$^{+}$/A-L(1)1-W	Gila clay, 0-1%, light-textured subsoil phase	
$^{+}$/A-H(1)1-W	Gila clay, 0-1%, heavy-textured subsoil phase	
$^{+}$/A-L(1)2-W	Gila sandy clay, 0-1%	
$^{+}$/A-(1)3-W	Gila silty clay, 0-1%	
$^{+}$/A-(1)4-W	Gila clay loam, 0-1%	
$^{+}$/A_1-(1)4	Gila clay loam, 0-1%	
$^{+}$/A-L(1)4	Gila clay loam, 0-1%, light	
$^{+}$/A_1-L(1)4	Gila clay loam, 0-1%, light	
$^{+}$/A-(1)5-W	Gila sandy clay loam, 0-1%	
$^{+}$/AA-H(1)5	Gila sandy clay loam, 1-3%, heavy phase	
^{PF}/A_1-(1)5	Gila sandy clay loam, 0-1%	
$^{+}$/A-(1)7-W	Gila loam, 0-1%	
$^{+}$/A-(1)10	Gila fine sandy loam, 0-1%	
$^{+}$/A_1-(1)10	Gila fine sandy loam, 0-1%	

APPENDIX A

Table A-3, continued

Map Symbol	Soil Name	Soil Description
$^{+}/A_1$-L(1)10	Gila fine sandy loam, 0-1%, light phase	(See above)
$^{⊕PF}/AA_1$-(1)10	Gila fine sandy loam, 1-3%	
$^{+}$/A-(1)11-W	Gila sandy loam, 0-1%	
$^{⊕}$/AA-⊕(1)11	Gila sandy loam, 1-3%	
$^{+}/A_1$-L(1)11	Gila sandy loam, 0-1%, light phase	
$^{+RL}/A_1$(1)13	Gila fine sand, 0-1%	
$^{+\hat{N}}$/AA-(1)14	Gila sand, 1-3%	
$^{⊕}$/AA-0(1)14	Gila sand, 1-3%, gravelly phase	
$^{⊕}/AA_1$-⊕(1)14	Gila sand, 1-3%	
$^{⊕PF}/A_1$-0(1)14	Gila sand, 0-1%	
^{WU}/A-(1)UN	Gila undifferentiated, 0-1%	
^{o}/A-(2)1	Anthony clay, 0-1%	These soils are similar to those of the Anthony series described in Groups I and II, with the exception of having erosion problems, shallow water-tables, and steeper slopes.
^{37}/AA-(2)1	Anthony clay, 1-3%	
^{o}/A-(2)5	Anthony sandy clay loam, 0-1%	

APPENDIX A

Table A-3, continued

Map Symbol	Soil Name	Soil Description
2RL/AA-0(2)11 2RM/AA-0(2)11	Sandoval sandy loam, 1-3% Sandoval sandy loam, 1-3%	These soils have the same general range in color, the same general conditions of relief and drainage, and a similar mode of formation as those of the Anthony series. They differ primarily in that they have been derived from finer-textured materials which have formed heavier-textured sub-soils. The subsoils consist predominantly of clay and sandy clay, with an occasional strata of lighter-textured material. Since the subsoils are of comparatively heavy texture, the permeability is rather low and the water holding capacity good. These soils are generally well adapted to irrigated agriculture, and with careful management, including weed eradication, crop rotations, and the incorporation of organic matter, good to excellent crop yields are possible. They are, in general, well drained, and alkali concentrations are negligible. The soils described in these mapping units are affected by high water-tables and slight to moderate erosion hazards.
+/A-(3)1-W +/A-H(3)1	Pima clay, 0-1% Pima clay, 0-1%, heavy phase	The soils of the Pima series differ primarily from those of the Gila series in the color of the surface soil and content of organic matter. The surface soil of the Pima series is a dark grayish-brown or nearly black, very often having a purplish and olive-green cast. This difference in color is due mainly to the development of this series under swampy and extremely poorly drained conditions, resulting in the accumulation of organic matter in the surface soil which

APPENDIX A

Table A-3, continued

Map Symbol	Soil Name	Soil Description
		extends to depths varying from 6 to 30 inches or more. This is underlain by the typical stratified Gila subsoil as described in other Gila series descriptions. This soil represents areas variously affected by alkali and drainage. Where it is well-drained and free from harmful concentrations of alkali, it has high fertility and the yields of crops are good. However, a large percentage of this series is so affected and has resulted in from fair to poor crop conditions. Still other areas in this series have such a high water-table, which is usually associated with toxic concentrations of alkali, that it has a low agricultural value.