THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Rio Grande Region

Second National Water Assessment by the U.S. Water Resources Council

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Foreword

The Water Resources Planning Act of 1965 (Public Law 89-80) directs the U.S. Water Resources Council to maintain a continuing study of the Nation's water and related land resources and to prepare periodic assessments to determine the adequacy of these resources to meet present and future water requirements. In 1968, the Water Resources Council reported the results of its initial assessment. The Second National Water Assessment, a decade later, provides a comprehensive nationally consistent data base for the water resources of the United States. The results of the Second National Water Assessment were obtained by extensive coordination and collaboration in three phases.

Phase I: Nationwide Analysis

The Council member agencies researched, analyzed, and prepared estimates of current and projected water requirements and problems and the implications of the estimates for the future.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed State and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting State and regional objectives, and (3) problems and conflicts needing resolution.

Phase III: National Problem Analysis

The Council conducted this final phase in three steps: (1) An evaluation of phases I and II, (2) an analysis that identified and evaluated the Nation's most serious water resources problems, and (3) the preparation of a final report entitled "The Nation's Water Resources--1975-2000."

The final report of the Second National Water Assessment consists of four separate volumes as described below. These volumes can assist Federal, State, local, and other program managers, the Administration, and the Congress in establishing and implementing water resources policies and programs.

Volume 1, Summary, gives an overview of the Nation's water supply, water use, and critical water problems for "1975," 1985, and 2000 and summarizes significant concerns.

Volume 2, Water Quantity, Quality, and Related Land Considerations, consists of one publication with five parts:

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the numerous documents that are part of the assessment, and identifies the individuals and agencies that contributed to the assessment.

II, "Water-Management Problem Profiles," identifies ten general water problem issues and their implications and potential consequences.

Part III, "Water Uses," focuses on the national perspectives regarding existing ("1975") and projected (1985 and 2000) requirements for water to meet offstream, instream, and flow-management needs. State-regional and Federal perspectives are compared.

Part IV, "Water Supply and Water Quality Considerations," analyzes the adequacy of fresh-water supplies (ground and surface) to meet existing and future requirements. It contains a national water budget; quantifies surface- and ground-water supplies, reservoir storage, and transfers of water within and between subregions; describes regional requirements and compares them to supplies; evaluates water quality conditions; and discusses the legal and institutional aspects of water allocation.

Part V, "Synopses of the Water Resources Regions," covers existing conditions and future requirements for each of the 21 water resources regions. Within each regional synopsis is a discussion of functional and location-specific water-related problems; regional recommendations regarding planning, research, data, and institutional aspects of solving regional water-related problems; a problem-issue matrix; and a comparative-analysis table.

Volume 3, Analytical Data, describes the methods and procedures used to collect, analyze, and describe the data used in the assessment. National summary data are included with explanatory notes. Volume 3 is supplemented by five separately published appendixes that contain data for the regions and subregions:

Appendix I, Social, Economic, and Environmental Data, contains the socioeconomic baseline ("1975") and growth projections (1985 and 2000) on which the water-supply and water-use projections are based. This appendix presents two sets of data. One set, the National Future, represents the Federal viewpoint; the other set, the State-Regional Future, represents the regional sponsor and/or State viewpoint.

Appendix II, Annual Water Supply and Use Analysis, contains baseline water-supply data and baseline and projected water withdrawal and water-consumption data used for the assessment. Also included are a water adequacy analysis, a natural flow analysis, and a critical-month analysis.

Appendix III, Monthly Water Supply and Use Analysis, contains monthly details of the water-supply, water-withdawal, and water-consumption data contained in Appendix II and includes an analysis of monthly water adequacy.

Appendix IV, Dry-Year Conditions Water Supply and Use Analysis, contains both annual and monthly baseline and projected water-withdrawal and water-consumption data for dry conditions. Also, a dry conditions water-adequacy analysis is included.

Appendix V, Streamflow Conditions, contains detailed background information on the derivation of the baseline streamflow information. A description of streamflow gages used, correction factors applied, periods of record, and extreme flows of record, are given for each subregion. Also included is the State-Regional Future estimate of average streamflow conditions.

Volume 4, Water Resources Regional Reports, consists of separately published reports for each of the 21 regions. Synopses of these reports are given in Volume 2, Part V.

For compiling and analyzing water resources data, the Nation has been divided into 21 major water resources regions and further subdivided into 106 subregions. Eighteen of the regions are within the conterminous United States; the other three are Alaska, Hawaii, and the Caribbean area.

The 21 water resources regions are hydrologic areas that have either the drainage area of a major river, such as the Missouri Region, or the combined drainage areas of a series of rivers, such as the South Atlantic-Gulf Region, which includes a number of southeastern States that have rivers draining directly into the Atlantic Ocean and the Gulf of Mexico.

The 106 subregions, which are smaller drainage areas, were used exclusively in the Second National Water Assessment as basic data-collection units. Subregion data point up problems that are primarily basinwide in nature. Data aggregated from the subregions portray both regional and national conditions, and also show the wide contrasts in both regional and national water sources and uses.

The Second National Water Assessment and its data base constitute a major step in the identification and definition of water resources problems by the many State, regional, and Federal institutions involved. However, much of the information in this assessment is general and broad in scope; thus, its application should be viewed in that context, particularly in the area of water quality. Further, the information reflects areas of deficiencies in availability and reliability of data. For these reasons, State, regional, and Federal planners should view the information as indicative, and not the only source to be considered. When policy decisions are to be made, the effects at State, regional, and local levels should be carefully considered.

In a national study it is difficult to reflect completely the regional variations within the national aggregation. For example, several regional reviewers did not agree with the national projections made for their regions. These disagreements can be largely attributed either to different assumptions by the regional reviewers or to lack of representation of the national data at the regional level. Therefore, any regional or State resources-management planning effort should consider the State-regional reports developed during phase II and summarized in Volume 4 as well as the nationally consistent data base and the other information presented in this assessment.

Additional years of information and experience show that considerable change has occurred since the first assessment was prepared in 1968. The population has not grown at the rate anticipated, and the projections of future water requirements for this second assessment are considerably lower than those made for the first assessment. Also, greater awareness of environmental values, water quality, ground-water overdraft, limitations of available water supplies, and energy concerns are having a dramatic effect on water-resources management. Conservation, reuse, recycling, and weather modification are considerations toward making better use of, or expanding, available supplies.

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Physiography

Description

The Rio Grande originates on the east slopes of the Continental Divide in a basin formed by the San Juan and the Sangre de Cristo ranges of the Rocky Mountains in Colorado. The river flows south the full length of New Mexico to enter Texas at El Paso. At El Paso the river flows in a southeasterly direction, forming the international boundary between the United States and Mexico for 1,244 miles, until it reaches the Gulf of Mexico near Brownsville, Texas. The total drainage is 230,000 square miles of which 93,000 square miles are in Mexico and 137,000 square miles are in the United States.[1] Of the 137,000 square miles in the United States, only 89,000 square miles contribute runoff to the Rio Grande. Forty-eight thousand square miles drain into closed basins. The Pecos River is the largest tributary in the United States. It rises in north-central New Mexico, flows south into Texas, then southeasterly to join the Rio Grande near Langtry, Texas (Figure 13-1). It is important to recognize the closed basins to fully understand the hydrology of the region.

The principal tributaries of the Rio Grande are the Pecos River, New Mexico and Texas (35,200 square miles); Rio Conchos, Mexico (26,400 square miles); Rio Salado, Mexico (23,300 square miles); Rio Puerco, New Mexico (7,350 square miles); and the Rio Chama, New Mexico (3,144 square miles).

There are five subregions (1301, 1302, 1303, 1304, and 1305) in the Rio Grande Region. There are 8,900 square miles in Colorado, 73,600 in New Mexico and 54,630 in Texas. Colorado includes all or parts of eight counties in subregion 1301: Sagueche, Rio Grande, Alamosa, Conejos, Mineral, Costillo, Hinsdale, and San Juan. There are 14 New Mexico counties in subregion 1302: Rio Arriba, Taos, Los Alamos, Sandoval, Santa Fe, Bernalillo, Valencia, Torrance, Socorro, Lincoln, Sierra, Otero, Luna, and Dona Ana. Five New Mexico counties are in subregion 1304: San Miguel, Guadalupe, DeBaca, Chaves, and Eddy. The Texas counties of El Paso and Hudspeth are in subregion 1302. There are 13 Texas counties in subregion 1303: Culberson, Loving, Winkler, Ward, Reeves, Jeff Davis, Crane, Upton, Pecos, Presidio, Brewster, Terrell, and Crockett. Ten Texas counties are in subregion 1305: Sutton, Valverde, Kinney, Maverick, Webb, Zapata, Starr, Hidalgo, Willacy, and Cameron.

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[1] This is the sum of the areas of counties used to approximate the hydrologic area of the region. Land use and other socioeconomic data are related to this area. The drainage area in the United States within the hydrologic boundary is 132,790 square miles.

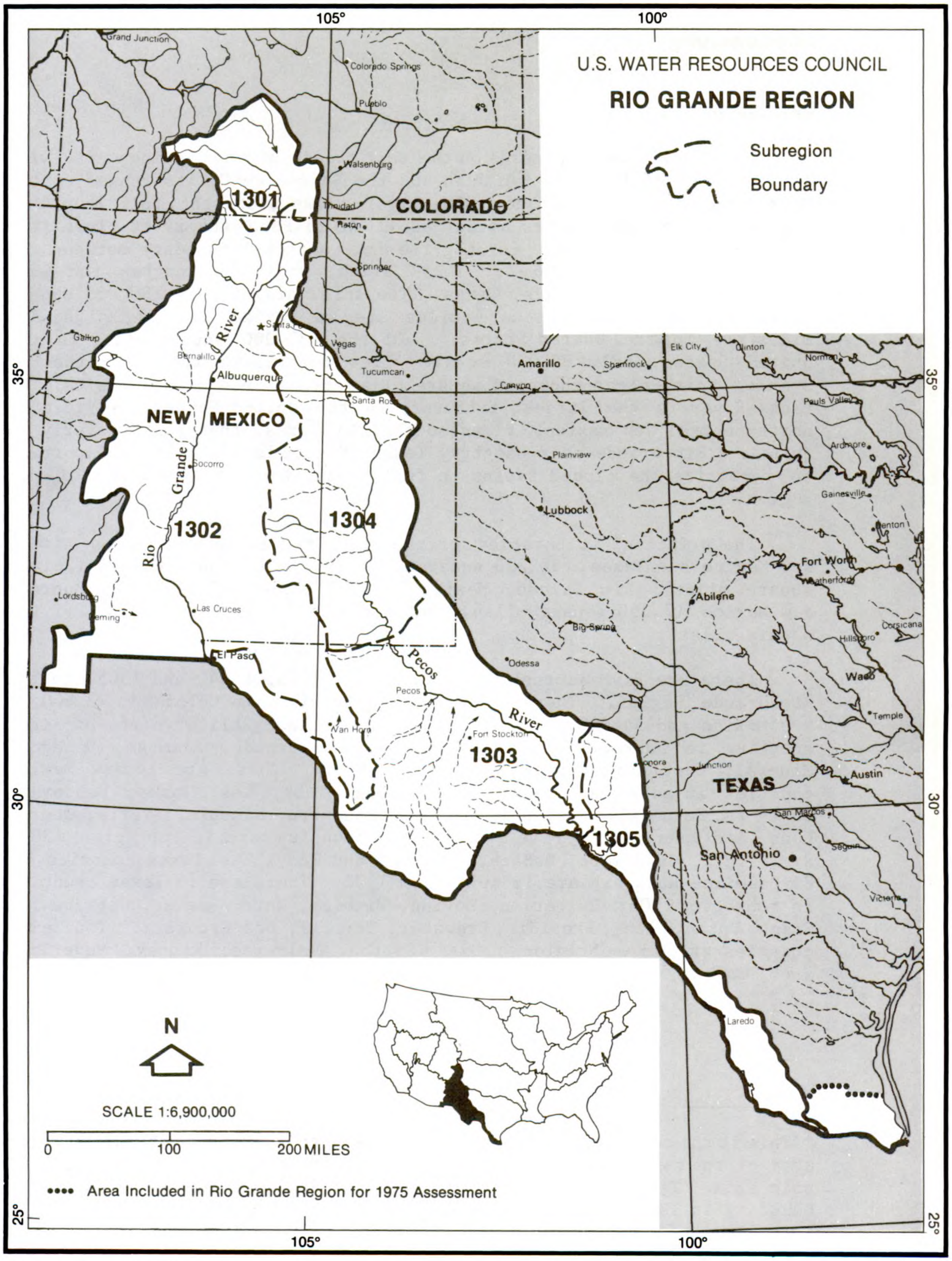


Figure 13-1. Region Map

Geology

From the headwaters of the Rio Grande in southern Colorado to the vicinity of El Paso, Texas, the main stem drainage basin is associated with a rift-zone valley, or crustal break, and flanking mountain ranges. The rift zone consists of a chain of grabens or structural basins in which enormous thicknesses of alluvial valley fill and local lava flows have accumulated. From El Paso downstream to the vicinity of Big Bend National Park, the basin is in a region of fault-block mountain ranges and intervening intermontane basins. On the valley slopes and in the valley proper, considerable thicknesses of alluvial outwash and valley fill have accumulated. From Big Bend National Park to the Lower Rio Grande Valley, the basin crosses essentially flat-lying consolidated sedimentary rocks predominantly of limestone, shale, and sandstone. In the Lower Rio Grande Valley, alluvium underlies the basin and makes up terraces and the river's delta. Limestone, sandstone, shale, gypsum, and salt underlie the Pecos River Basin. Locally, as in the Roswell-Artesia area and near the New Mexico-Texas State line, there are notable accumulations of alluvial and eolian valley fill.

The alluvial valley fill in the upper and middle main stem of the Rio Grande Basin constitutes the major fresh-water aquifer. Locally in New Mexico the valley fill is reported to be as much as 9,000 feet in thickness, and up to 30,000 feet in thickness in the San Luis Valley in southern Colorado. Between Big Bend National Park and the lower Rio Grande Valley, consolidated sedimentary rocks of limestone and sandstone are highly variable but locally quite productive. In the lower Rio Grande Valley, the alluvium in the Rio Grande Delta is an erratic but locally productive aquifer. In the Pecos River Basin, beds of solutioned limestone and gypsum constitute productive aquifers; however, much of the ground water contains considerable quantities of dissolved solids. Where the alluvial valley fill is thickest, it is a significant aquifer along the Pecos River.

Topography

The Rio Grande Region is surrounded on the west, north, and east sides by mountain ranges having peaks extending above 14,000 feet in elevation. The San Luis Valley is open to the south and has an average elevation of about 7,700 feet. The northern part of the region lies within a closed basin with no surface drainage outlet. The Rio Grande, as it flows out of Colorado, becomes entrenched in a gorge that dissects a plain bordered on the east by the Sangre de Cristo Mountains and on the west by the San Juan and Jemez mountains. The gorge, extending to below Taos, is designated a National Wild and Scenic River. Throughout its course in New Mexico, the Rio Grande is a complex river, flowing in an inner valley from one basin to another. The river has cut a valley many hundreds of feet below the original upland surface. The inner valley, or flood plain, has a nearly flat floor in all basin areas and varies in width from 1 to 6 miles. The altitude of the river at Albuquerque is 4,946 feet. The flood plains contain most of the irrigable land.

The Pecos River rises in the Sangre de Cristo Mountains near Santa Fe, New Mexico. The elevation near Santa Rosa, New Mexico, is 4,538 feet and at Langtry, Texas, is 1,133 feet. The western boundary is formed by a north-south extension of the Rocky Mountains. The eastern boundary trails off through rolling hills and the high plains area without marked relief. Between the Pecos and the Rio Grande are the Tularosa and Estancia closed basins.

The Rio Grande enters Texas at El Paso at an elevation of 3,720 feet. The river becomes deeply entrenched below El Paso and traverses an area of canyon lands incised in rolling plains. The Rio Grande below Falcon Dam is at an elevation of 228 feet and flows 225 miles to the Gulf of Mexico. This section of the Rio Grande is often referred to as the lower Rio Grande and is quite flat with many drainage and flood problems.

Climate

A semiarid to arid climate with low humidity and erratic rainfall are characteristic of the region. Average annual precipitation ranges from 30 inches in the high mountains and lower Rio Grande coastal plain to only 8 inches in the middle valley area where most of the precipitation occurs as intense thunderstorms. Winters are severe in Colorado and in the high mountains of New Mexico, but generally mild throughout the lower areas. Summer days are warm with cool nights, resulting in the enchanting sun-country climate. Growing seasons vary from a few days per year in the high mountains to almost year-round in the lower Rio Grande. Blizzard conditions are often experienced in the northern part of the region, but snow seldom falls in the lower portion. Intense thunderstorms with occasional hail are experienced throughout the region, but tornado-type storms are relatively rare. The lower Rio Grande experiences hurricanes coming inland from the Gulf of Mexico. The aftermath of hurricane storms are intense rainstorms that cause flooding in the lower valley.

People and the Resources

Population

Spanish conquerors came to the region from Mexico in 1540. However, it was not until 1598 that the Spanish invaders seriously settled in the region. In that year Don Juan de Onate took formal possession of the area. In 1610 the Spanish established headquarters at La Villa Rael de la Santa Fe de San Francisco de Assisi, now called Santa Fe, present capital of New Mexico. This is the oldest seat of government in the United States. At the same time the Spanish were settling the northern Rio Grande Region, similar settlements were being established at El Paso and in the lower valley.

A large proportion of the population is of Spanish heritage, either descendents of the original settlers or migrants from Mexico. There also are 18 Indian pueblos and two Indian reservations within New Mexico with a population of about 30,000. There is no doubt that the Spanish and Indian heritages have an impact upon the culture and economy of the region.

NF data on population are based on the OBERS Series E projection, which shows a 1975 population of 1,695,000 for the Rio Grande Region. Densities vary from 2 to 30 people per square mile in subregions 1303 (Rio-Grande-Pecos) to 1305 (Lower Rio Grande), respectively. Projected population is estimated to be 1,780,000 for 1985, and 1,875,000 for the year 2000.

Economy

The Rio Grande Region is blessed with an enchanting sun-country environment, but it does not have the natural resources to support a vigorous economy. With a per capita income of only $4,761, the region ranks within the bottom 10 percent nationally. Eighty percent of the employment is in the non-product sector such as trades and services. Of the remaining 20 percent, 10 percent is employed in manufacturing, 7 percent in agriculture, and 3 percent in mining. Only 35 percent of the total population is employed, which is symptomatic of the economy.

The region is arid; agricultural production relies upon irrigation. There is more than enough irrigable land, but the limited water supply will irrigate only about 2 million acres. Livestock grazing utilizes 72 percent of the land area and dominates the agricultural industry. Much of the rangeland is fragile and requires careful management to maintain productivity. The crops produced are generally livestock feed or high-yield truck crops. This is particularly true of the Lower Rio Grande subregion which produces winter vegetables, cotton, sugar cane, alfalfa hay, and citrus.

Manufacturing generally relates to light water-using industries, such as clothing, electronics, and assembly-type plants. Manufacturing is looked upon as a solution to improve per capita income and the under-employment situation. It is projected that employment must about double in the manufacturing sector by 2000 to accommodate the in-migration to the sun-country environment. Water supply is a key problem to suport the manufacturing base.

Mining currently provides about 2.4 percent of earnings. There are rich deposits of uranium, potash, and coal within the region, and more than adequate resources of oil and gas. Gold, silver, and copper are also actively mined within the region. The mining industry is projected to increase its present employment 1.7 times. Environmental concerns impact the mining industry in the region. (See Table 13-1.)

Table 13-1.--Rio Grande Region earnings--1975, 1985, 2000
(million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing	567	854	1,408
Agriculture	538	549	653
Mining	151	155	163
Other	5,093	7,268	12,052
Total	6,349	8,826	14,276

In the services sector there are elements that could be considered analogous to the export-type industries. Tourism and winter-resort living are important to the economy of the region and are growing.

Government-supported research is an important segment of the services-type industrial sector. The trades and services sectors are projected to more than double by 2000. Those are particularly encouraged within the region because of their minimal water supply requirements.

Natural Resources

There are 87,222,000 acres of land within the region. Seventy percent of the lands are in private, State, or municipal ownership, 27 percent in Federal ownership, and 3 percent are Indian lands. Of the 27 percent federally-owned, 13 percent are national resource lands, 9 percent national forest lands and 5 percent other, including National Parks, national defense lands, wildlife refuges, and Bureau of Reclamation lands. Within the region, the State of Colorado has 44 percent Federal ownership with 34 percent administered by the Forest Service. Also, within the region, New Mexico has 42 percent Federal ownership with 22 percent national resource lands, 13 percent Forest Service lands, 6 percent national defense lands and about 1 percent in other lands. Five percent of regional lands in New Mexico are in Indian ownership. Texas lands are primarily private, State, or municipally-owned lands with only about 4 percent in Federal ownership. Land ownership is a significant issue in the Rio Grande Region as it influences attitudes concerning the Federal role.

Land use in the region is dominated by pasture and rangeland as shown in Table 13-2. More than 72 percent is used for pasture and range. Forest and grazed woodlands comprise 17.1 percent of the total use. Only 3.3 percent is used for cropland cultivation. A total of 1,984,000 acres are irrigated lands. There is a very small use of lands for dry-crop farming in this arid area. Less than 1 percent of the lands are used for urban and built-up areas which are dominated by El Paso, Albuquerque, and Santa Fe. Almost 5.9 percent of the lands fall in the "other uses" classification, which includes local parks, military, wildlife refuges, and water resource developments.

There are 15,048,000 acres of timberlands within the region. Seventeen percent of the region's land area is timbered; 93 percent of the timberlands are in New Mexico, in subregions 1302 and 1304, mostly in mountainous areas. The region produces lumber and paper products from the timberlands, but the industry is relatively minor, contributing less than 1 percent of the total earnings.

Table 13-2.--Rio Grande Region surface area and 1975 land use

Surface area or land use type	1,000 acres	Percentage of total surface area
Surface area		
Total	87,764	100.0
Water	542	0.6
Land	87,222	99.4
Land use		
Cropland	2,869	3.3
Pasture & range	63,190	72.0
Forest & woodland	15,048	17.1
Other agriculture	611	0.7
Urban	396	0.5
Other	5,108	5.8

The region has some strategic minerals. New Mexico leads the Nation in uranium production; subregion 1304 leads the Nation in potash production. Ranked in terms of absolute value, petroleum and natural gas are the region's leaders in mineral production. Other minerals of commercial value produced within the region are copper, gold, silver, molybdenum, and general industrial and building materials. In addition to mineral processing plants, the energy base (uranium, petroleum, natural gas, and coal) holds promise for industrial potential. In addition solar energy may be potentially important to the region.

Agriculture

Agriculture accounts for only about 8.5 percent of the total regional earnings but contributes 39 percent of the earnings in the non-service sector. About 83 percent of the harvested cropland is irrigated. In 1975, 1,984,000 ares or 2.3 percent of regional land area was irrigated. Seventy-two percent of the land area or 63,190,000 acres was used for pasture and range. In addition, most of the 15 million acres of timberland are grazed; hence, ranching is a major part of the region's agricultural industry. Cattle and sheep are raised on the grazing lands, and feeder cattle and sheep are shipped to eastern feed lots. A 6 percent decrease in irrigated farmland is expected by 2000 (Table 13-3).

Table 13-3.--Projected changes in cropland and irrigated farmland in the Rio Grande Region--1975, 1985, 2000
(1,000 acres)

Land category	1975	1985	2000
Total cropland----------	2,869	2,809	2,811
Cropland harvested------	2,376	2,114	2,087
Irrigated farmland------	1,984	1,870	1,865

In the northern part of the region, potatoes and forage are the principal crops. The mid-region produces primarily forage, truck crops, and nuts, while in the lower valley sugar cane, citrus, and truck crops predominate. Forage, principally hay, is an important crop for the stabilization of the cattle industry. Agricultural earnings of $538 million in 1975 are projected to increase to $653 million by 2000.

Energy

In 1975, 10,773 gWh of electric energy were generated within the region. Less than 2 percent of this total was hydroelectric (See Table 13-4). There are only two hydroelectric plants within the region, Falcon and Elephant Butte dams, with 31,500 kilowatts and 24,300 kilowatts of installed capacity, respectively. Electric power is imported from surrounding regions. There is no apparent problem concerning electric energy availability. Coal is available within the region and in the Upper Colorado Region to supply all the region's demand within the foreseeable future. It is expected that in 2000 electric energy generation will be 2.5 times that of 1975.

Table 13-4.--Rio Grande Region electric power generation--1975, 1985, 2000
(gigawatt-hours)

Fuel source	1975	1985	2000
Fossil---------------------	10,638	5,110	3,190
Nuclear--------------------	0	0	23,360
Conventional hydropower---	135	244	244
Total generation	10,773	5,354	26,794

It is expected that the large deposits of uranium within the region and in the adjoining Upper Colorado Region will be exploited.

The Rio Grande Rift is being explored for potential geothermal energy; to date, the results are encouraging. The region, with its sun-country environment, has a great potential for the development of solar energy. Research is being pushed, and development is moving in the private sector.

Natural gas in the region is more than sufficient to meet needs. The future role of natural gas is uncertain and will not be clear until a national energy policy is adopted. Many of the region's irrigation pumps are gas-powered, and various apects of the emerging energy policy are of concern to the people in the region.

Navigation

Since the Rio Grande and its tributaries are not curently navigable streams, instream flows for navigation are not considered a water requirement.

Environment

The Rio Grande Region is noted for its sun-country environment, with New Mexico known as the Land of Enchantment. The mild climate at the lower elevations is interspersed with the cooler climate of the mountain areas. The lower elevations are arid with a desert setting, while the mountain areas receive more precipitation and furnish pleasant, forested retreat areas. The lower Rio Grande Valley approaches a tropical setting and is emerging as one of America's winter playgrounds.

The region is rich historically since it is one of the oldest settled areas in the United States. The colonial Spanish period gives the region a rich Spanish heritage. An effort is being made to blend the early Spanish heritage with the modern setting. The Spanish cultural heritage, by contrast, presents a unique environment attractive to sun-country migrants and tourists.

Indians in the region also have a rich historical heritage. Many of the Indian pueblos were here when the Spanish came and much of the Indian culture has been preserved on the reservations and in the pueblos.

Water is a precious resource in the region, and habitation reflects its conservation. Homes and cities adapt to minimal use of water with small lots and dry rock garden landscaping.

Fishery is minimal, with habitat limited to mountain streams and reservoirs. Utilization of streamflows also restricts the region's fishery potential. Wildlife adapted to arid areas utilize public lands, but the habitat has limited capability to sustain heavy hunting pressure. Waterfowl winter in the valley wetlands, and several refuges are maintained for that purpose.

The desert has a fragile environment that can be easily overexploited. Most ranchers recognize this condition and have learned the advantages of balanced utilization. However, range improvement for grazing through brush control is in conflict with many environmental groups' concept of proper management. Mining, particularly strip mining, is carefully monitored to maintain a quality environment.

One of the region's environmental assets is the area's pure air. Vistas 80 miles distant are not unusual, and maintaining this relatively pristine condition is of concern to area residents. This has an impact upon industry within the region.

Phreatophyte growth flourishes in the major stream valleys, particularly in those areas with a high water table. Salt cedar (Tamarisk) was introduced as an ornamental shrub into the Southwest, and now large dense thickets are expanding in the valleys. Efforts to eradicate these heavy water-using phreatophytes have been opposed by wildlife and environmental groups. This is an identified problem area that will be discussed in the specific problem analysis section.

Water

The Rio Grande Region is an arid land. Water is a vital necessity for human habitation. From the initial Spanish settlement it was recognized that use of water had to be administered by appropriate laws. The roots of the region's water laws emanate from Mexico, Spain, and ancient Rome. The doctrine of prior appropriation is generally applied among the States in the region. The prior appropriation doctrine is concerned with the uses to which water is put, the time at which such uses first were undertaken, and the diligence with which water utilization has continued. Beneficial use is the basis, measure, and limit of the right to use water. Priority in times of appropriations shall give the better right. In New Mexico and Colorado ground-water use is also administered under the prior appropriation doctrine.

The Rio Grande, in part of its length, forms the boundary between Mexico and the United States. Treaties between the two countries for regulating the use of the Rio Grande waters were entered into in 1906, in the Ratification Convention of 1933, and in 1944. The execution of the conditions of the treaties is entrusted to the International Boundary and Water Commission, United States and Mexico.

The Rio Grande flows through the three States of Colorado, New Mexico, and Texas. To achieve an equitable apportionment of the waters, a compact was entered into between the States in 1938. The Rio Grande Compact Commission administers the provisions of the compact. In addition to the Rio Grande Compact there are compacts between Colorado and New Mexico

(1963) that apportion the waters at Costilla Creek (amended), and between New Mexico and Texas (1948) that apportion the waters of the Pecos River.

The waters of the lower Rio Grande Valley are allocated on rights recognized in the Lower Rio Grande Valley Water Case (State of Texas, et al. v. Hidalgo County Water Control and Improvement District No. 18, et al., 443 S.W. 2nd 728) as approved by the Texas Supreme Court and on water rights in the middle Rio Grande Valley. A watermaster, employed by the Texas Water Rights Commission, is responsible for daily allocations of water to diverters holding rights to water from the Rio Grande in the lower Rio Grande Valley.

The Indians have some claim to the use of waters which are located on, or which flow through or along, the boundaries of Indian reservations. This reservation was established in the court case United States v. Winters, 207 US 564 (1908). There is some question in New Mexico whether Indian pueblos are reservations.

The water law discussion presented herein is necessarily brief but was presented to show the reader that water use within the region is rigidly and legally administered. All water problems and their potential solutions must be considered within the framework of existing legal institutions. These institutions should not be capriciously altered to fulfill a functional aspiration since they have been carefully developed over time to protect the national, State, and local interests.

Surface Flows

A discussion of surface flows within the Rio Grande Region must first convey three underlying concepts for reasonable understanding: (1) The region is arid and habitation relies on conservation for adequate water supply; (2) the region has developed formal institutions for the administration of water and the legal provisions pertaining thereto are rigidly enforced; and (3) there is no surplus water within the region for new uses or for expanding current uses.

Streamflows generally derive from mountain snowmelt in the northern portion of the region and from thunderstorms in the central and southern parts of the region. Hurricane rainstorms are a characteristic of the lower Rio Grande. Thunderstorm runoff carries large sediment loads into the Rio Grande and tributary streams, which create unstable stream channels in wide alluvial valleys.

Streamflows had been diverted for irrigation and domestic use even before European settlement. Diversions were significant before systematic streamflow measurements were initiated. Natural flow measurements have never been recorded for the Rio Grande. It also must be recognized that the Rio Grande, for 1,244 miles of its length, forms the boundary between the United States and Mexico and that 93,000 square miles of drainage area in Mexico contribute to the total flow at the mouth of the Rio Grande. The estimated average annual total available streamflow in the

United States is 4,813 mgd (5,400,000 acre-feet per year). However, all streamflow uses and estimates shown in this analysis are presented only for the reader's general understanding of the hydrologic status and are not to be considered in the same context as the legal estimates used for international and interstate streamflow administration.

Water diverted for irrigation accounts for the largest use of streamflow. The monthly and annual variation in streamflow requires storage to assure a dependable water supply to irrigate 1,984,000 acres in the United States and 1,100,000 acres in Mexico. The NF estimates normal surface storage in large reservoirs in the Rio Grande Region to be 2,534 billion gallons (7,779,000 acre-feet.) The reservoirs are all capable of providing annual hold-over storage to stabilize water supplies. With these conditions and the often less than precise field measurements, streamflow analysis requires an expertise that includes special knowledge of the situation. To illustrate the situation, the annual discharge for calendar year 1968 is related to the drainage area in the basin as shown in Figure 13-2. The discharge in Colorado emanating from snowmelt was over 650,000 acre-feet (579 mgd) before diversion to serve 333,600 acres of irrigation. At the Colorado-New Mexico State line the streamflow was depleted to only 320,000 acre-feet (285 mgd). After serving 319,000 acres in New Mexico and Texas, the streamflow was reduced to only 13,000 acre-feet (11.5 mgd) below El Paso, Texas. Inflow from the Pecos and other tributaries in the United States and Mexico increased the streamflow to 1,350,000 acre-feet (1,203 mgd). After serving approximately one million acres, the outflow at the mouth was roughly one million acre-feet (891 mgd). Figure 13-3 presents a similar analysis for the Pecos River.

The present average annual outflow of the Rio Grande from subregion 1301 (New Mexico-Colorado State line) is estimated to be 267 mgd (300,000 acre-feet per year). The total available streamflow is estimated to be 848 mgd (951,000 acre-feet per year). The figures are clouded by the estimated diversions to irrigate lands from which return flows enter a closed basin. There return flows are dissipated in the closed basin by evaporation and transpiration. The present estimated average annual outflow of the Rio Grande as it leaves subregion 1302 (El Paso, Texas) is 343 mgd (385,000 acre-feet per year). The total available streamflow is estimated to be 1,906 mgd (2,139,000 acre-feet per year). This does not represent total natural flow since stream evaporation uses by phreatophytes and other incidental losses are not estimated.

The phreatophytes (Salt Cedar) were introduced to the middle valley and have been rapidly expanding in recent years. If phreatophytic areas are allowed to increase, the natural modified flow will decrease.

The present estimated average annual outflow of the Pecos River as it leaves subregion 1304 (New Mexico-Texas State line) is 122 mgd (137,000 acre-feet per year). The total available streamflow is estimated to be 595 mgd (668,000 acre-feet per year).

The Pecos River, with a drainage area of 35,200 square miles, is tributary to the Rio Grande at the downstream boundary of subregion 1303.

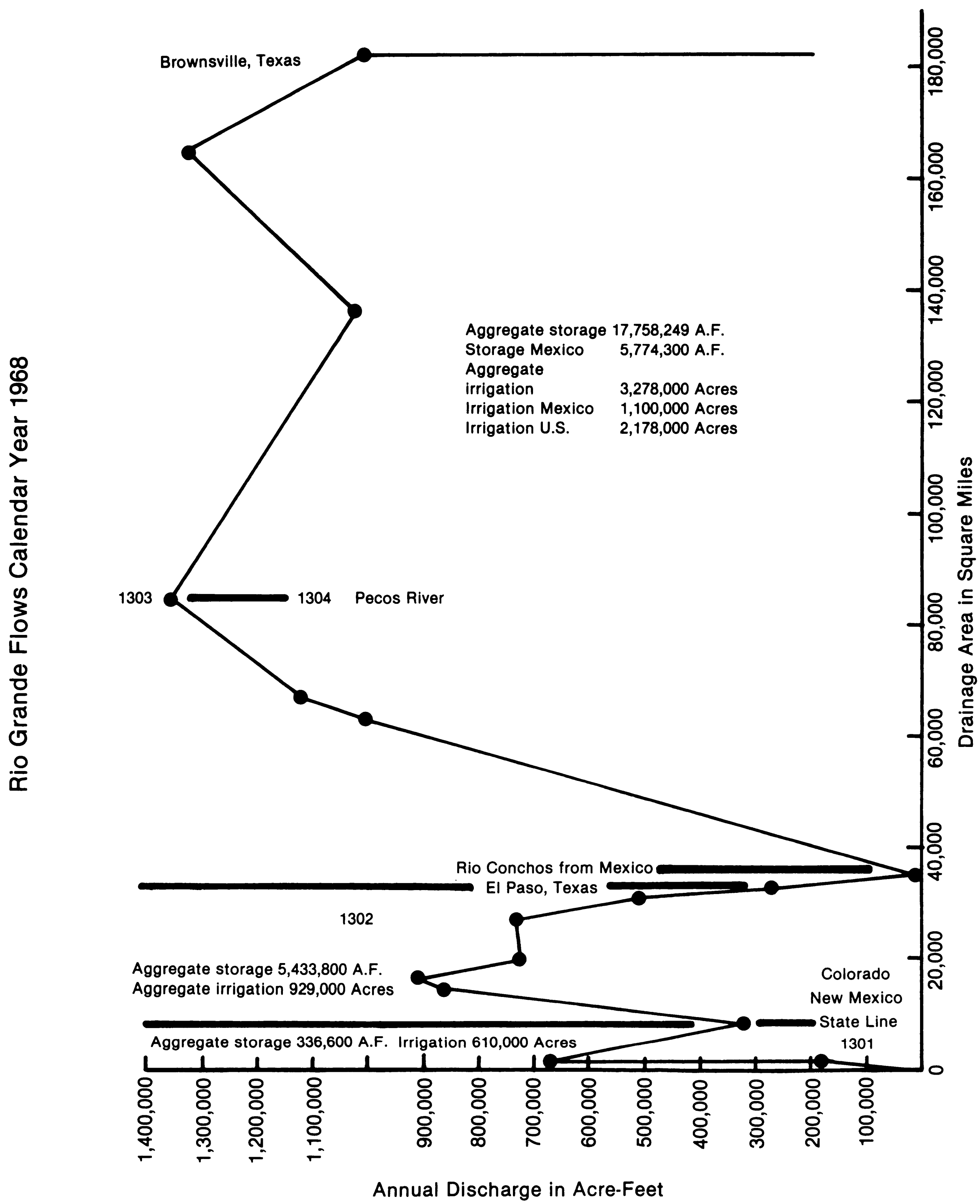


Figure 13-2. Rio Grande Flows

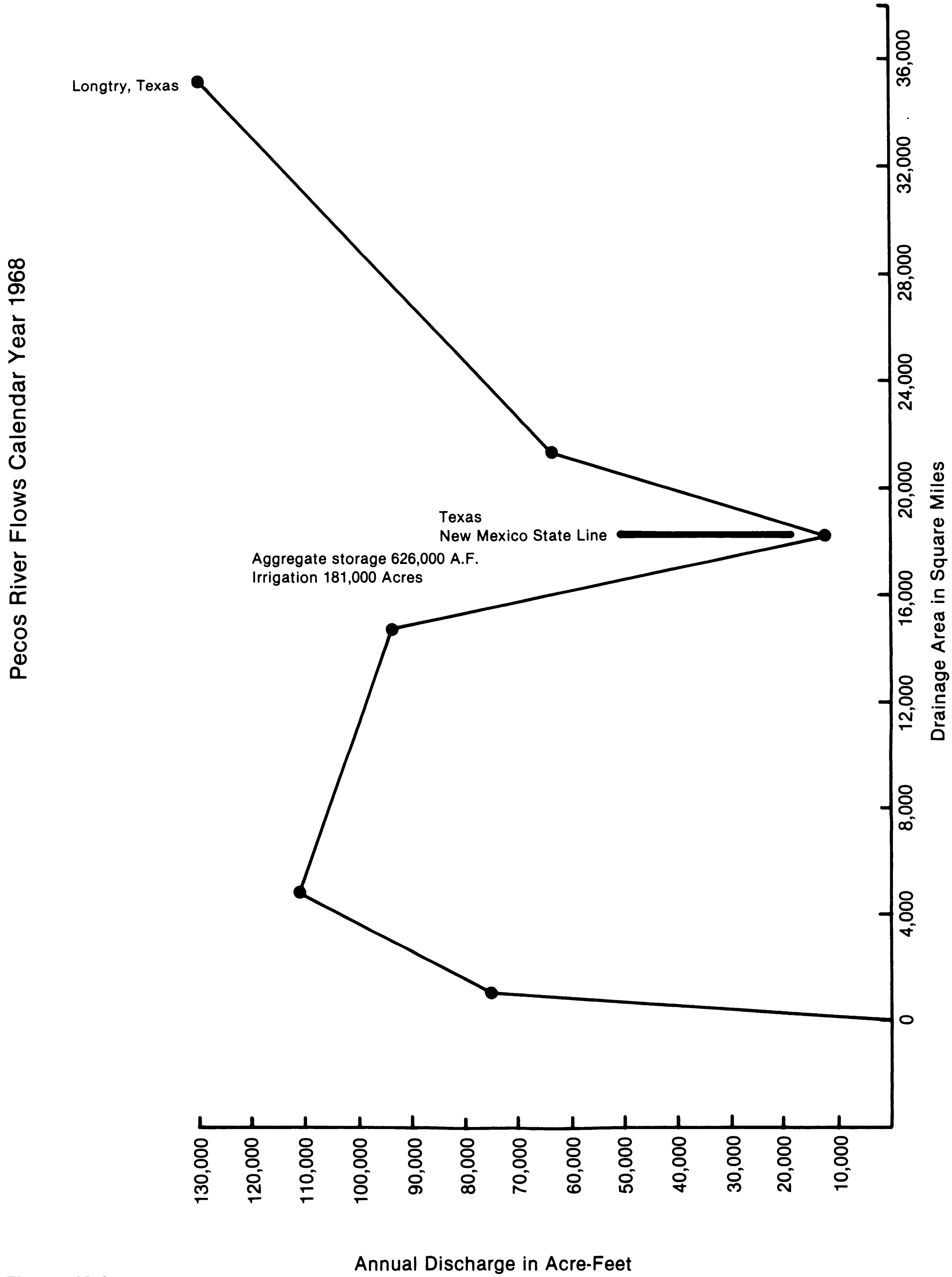


Figure 13-3. Pecos River Flows

This subregion contains 15,700 square miles of the Pecos River drainage area.

The present estimated average outflow of the Rio Grande at the downstream boundary of subregion 1303 is 582 mgd (652,000 acre-feet per year) which includes the flow of the Rio Conchas tributary from Mexico. The total available flow in the United States is estimated to be 2,958 mgd (3,319,000 acre-feet per year). The depletions in Mexico are not accounted for in the computation of the total flow, and any consideration of this figure should recognize the uncertainty of future depletions in Mexico and the effects of international treaties on availability of flow for offstream uses.

The present estimated average annual outflow from the region, represented by the records from the gaging station at Brownsville, is 1,230 mgd (1,380,000 acre-feet per year). The estimated total streamflow is 4,813 mgd (5,400,000 acre-feet per year). The International Boundary Commission shows the average recorded outflow to be 620.2 mgd (694,000 acre-feet per year) for the period 1954-1973, subsequent to Falcon Dam operation. Figure 13-4 depicts the streamflow and mean annual outflow for the entire region.

Streamflows in the region are used and reused for various purposes. The salts in the diverted flows are usually returned to the streams. There may also be additional salts in the return flows from leaching or from municipal and industrial effluents. Streamflows in some areas contain high concentrations of natural salts. Water quality of the surface flows is a problem that concerns the three States. The following information is presented to illustrate the general problem.

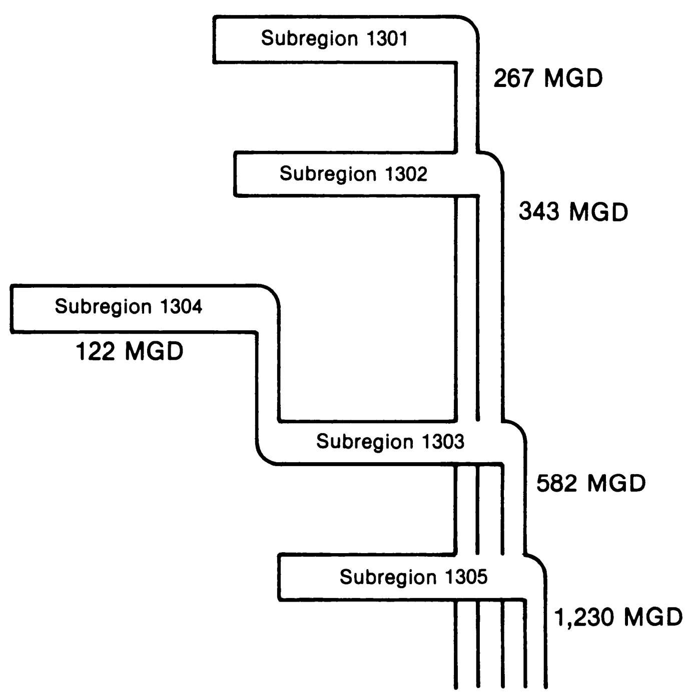


Figure 13-4. Streamflow

The records of quality analysis for 1968 show the weighted average dissolved solids of the Rio Grande at the Otowi, New Mexico, gaging station (D.A. 14,300 square miles) to be only 220 milligrams per liter (mg/l). The daily maximum for the period of record (1946-68) was 1,030 mg/l, and the minimum was 137 mg/l. At the Bernardo station (D.A. 19,230 square miles) the weighted average was 336 mg/l. The daily maximum for the period of record (1964-68) was 1,400 mg/l, and the minimum, 209 mg/l. At the El Paso station (D.A. 32,207 square miles) the indicated weighted average was 892 ppm. At the Ft. Quitman station (D.A. 34,475 square miles) the indicated weighted average was 2,905 ppm. However, the annual streamflow was less than 20,000 acre-feet. Below Amistad Dam the indicated weighted average was 553 ppm, and below Falcon Dam the average was 516 ppm. The concentration at the Rio Grande outflow at Brownsville was about 990 ppm. The maximum is about 2,620 ppm and the minimum 214 ppm. Salinity at the mouth of the Pecos River was about 1,490 ppm, but at Red Bluff (D.A. 19,540 square miles) the salinity was 10,300 ppm.

Suspended sediments carried in the Rio Grande system have long been a problem related to utilization and control of streamflow. Sediments aggrade stream channels and settle in canals and reservoirs. Extensive analysis would be required to portray drainage area yields, because the measured sediments are distorted by diversions and reservoir storage. The following information is presented to indicate the problem which is and has been more difficult and more serious than the measurements reflect.

The records for 1968 at the Rio Grande Otowi station show a load of 2,574,000 tons. The maximum daily concentration for the period of record (1947-68) was 43,500 ppm with a minimum of 11 ppm. The records for the station at San Marcial show an annual load of 3,703,000 tons, at El Paso, 101,000 tons, and Brownsville, 150,000 tons. The Pecos River at Artesia had a load of 248,000 tons. The maximum concentration was 21,300 ppm. The Pecos at the mouth yielded only 6,361 tons after storage and diversion.

Ground Water

Ground water is an important segment of the region's water supply. Average ground-water withdrawals are about 2,335 mgd (2,620,000 acre-feet per year). The average ground-water withdrawals (in mgd) in each subregion are as follows: 590 in subregion 1301; 611 in subregion 1302; 679 in subregion 1303; 400 in subregion 1304; and only 55 in subregion 1305. Subregion 1302 includes the large Tularosa and Estancia closed basins that depend almost entirely upon ground-water supply. Ground water within New Mexico and Colorado is rigidly administered under the prior appropriation doctrine. Nearly all of the Rio Grande Region has been designated a declared underground water basin administered by the States.

Though most of the region is within declared basins, ground-water withdrawals in New Mexico are predicted to expand by the year 2000. On a regionwide basis, ground-water withdrawals are expected to decline during this period; the greatest reduction is expected to occur in subregion

1303. Withdrawals in subregion 1305 are anticipated to decrease to a lesser extent. In subregion 1301 withdrawals are projected to remain constant.

Ground-water aquifers in the Rio Grande Basin consist of both valley fill and bedrock. Valley fill includes sediments that have been deposited along tributary streams and that have filled the Rio Grande Trough. These aquifers generally are stream-connected and are recharged mainly from surface flow. In the Rio Grande Trough the deposit is very thick and provides a reliable aquifer from which large quantities of water may be obtained. Legal restrictions on withdrawals recognize the interconnection with surface flows and the effects upon surface rights. The bedrock aquifers generally yield only small to moderate amounts of water. Aquifers in the Central Closed Basin may be grouped into two broad categories: bolson deposits and bedrock. Bolson alluvium is the more reliable aquifer, and water produced from this material probably exceeds that from all other aquifers combined. Generally, in the closed basins where ground-water sources have been developed, the supply is being mined; i.e., withdrawals exceed recharge. Ground-water quality in the Rio Grande Trough generally is of acceptable quality not exceeding 500 ppm dissolved solids. The quality, similar to that of surface water, becomes poorer in the downstream trough alluviums (see Figure 13-5).

Quality in the closed basins is highly variable, ranging from acceptable to brackish. Some waters exceed 2,000 ppm dissolved solids, and withdrawals of acceptable water must be carefully controlled to prevent encroachment of brackish water into the fresh-water pools. Large quantities of brackish water are available in the closed basins and are potentially available for use after desalinization.

Unconsolidated sand, gravel, limestone, and sandstone rocks form important aquifers in the Pecos Basin. The alluvian aquifers are generally stream-connected and are recharged by local precipitation and flood flows. There is a large artesian basin near Roswell, New Mexico. The artesian pressures have been declining, because withdrawals exceed recharge. The decline of artesian head has caused saline water to encroach into fresh-water portions of the aquifer. Generally, ground waters are of acceptable quality, but some withdrawals exceed 1,000 ppm of dissolved solids.

Some ground water is available in the lower Rio Grande Valley alluvium. The limited supplies that are available are generally too saline for municipal and industrial uses. Use of this marginal quality water for irrigation has resulted in severe soil salinity problems. Use of ground water in the lower valley, therefore, has been naturally restricted.

Water Withdrawals

Average withdrawals of water within the region from both ground and surface sources totaled 6,321 mgd (7,092,000 acre-feet per year) in 1975 base conditions according to NF estimates. By far the biggest user was irrigation with 90 percent of the total. Domestic use constituted about 4 percent of the total withdrawal; the other functional demands--manufacturing minerals, livestock, steam electric, public lands, and other--made up the remainder of the withdrawals.

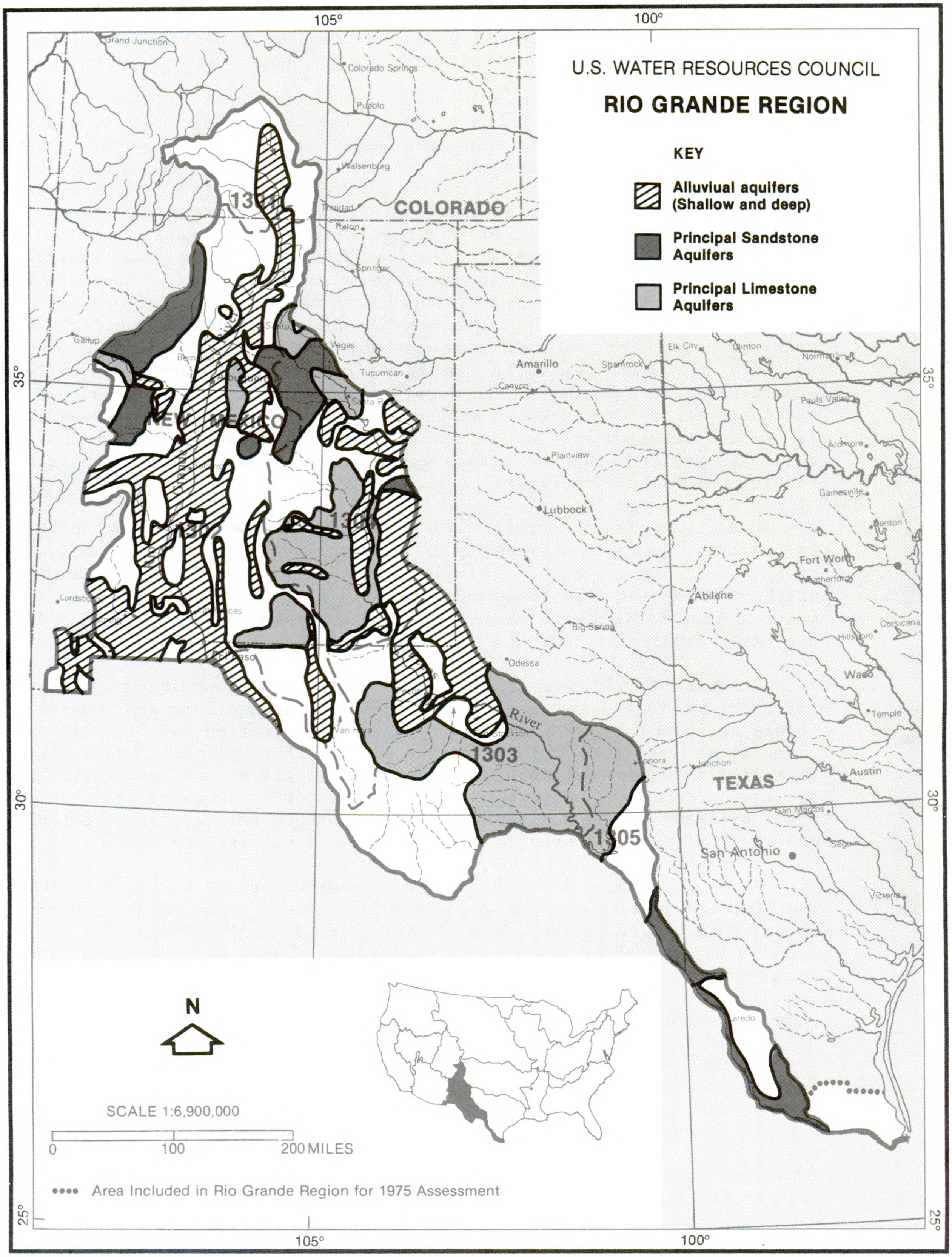


Figure 13-5. Major Aquifers

It is anticipated that withdrawals will decrease 11 percent by the year 2000. Irrigation use will decrease about 14 percent. It will only be 87 percent of the total in 2000. Domestic use is anticipated to command 6 percent of total withdrawals. All other uses will increase relatively at the expense of irrigation (see Figure 13-6).

Water Consumption

Average consumptive use of water within the region under 1975 conditions was 4,240 mgd (4,757,000 acre-feet per year). Sixty-seven percent of withdrawals was consumed. The dominant consumption was by irrigation, which accounted for 92 percent of all water consumed. Minerals consumed 2 percent and domestic users consumed 3 percent of the total; manufacturing, livestock, steam electric, public lands, and other uses individually consumed less than 1 percent of the total.

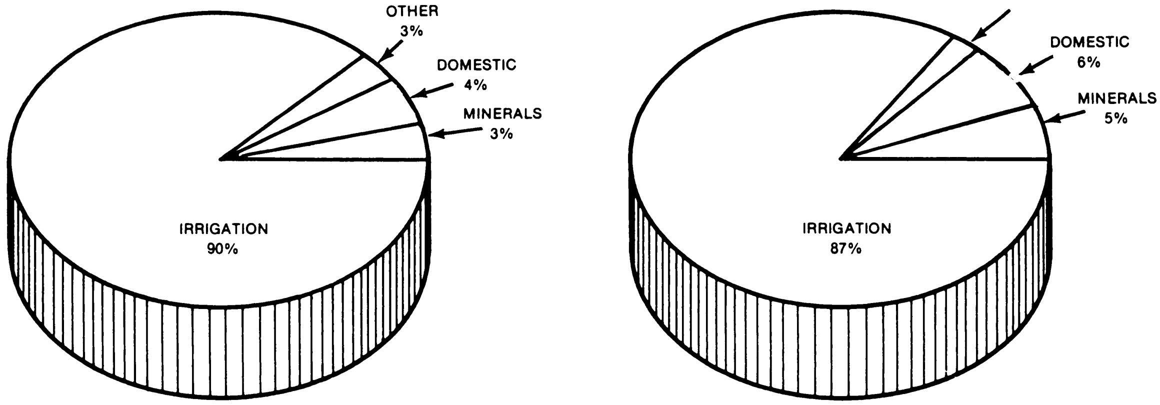
It is anticipated that consumptive use will decrease to 4,016 mgd (down 5 percent) by 2000 as ground-water mining declines. The projected improvement in efficiency of use is significant. In 2000 it is expected that 71 percent of the withdrawals will be consumed. Consistent with the withdrawals, a shift in consumption from irrigation to other uses is anticipated. Irrigation consumption is expected to decrease 8 percent and will account for 89 percent of the total in 2000. Domestic and mineral consumption will each represent 4 percent of the total, with manufacturing, livestock, steam electric, and other uses all showing relative increases (see Figure 13-6).

The most substantial increases in manufacturing will occur in subregion 1305, where consumption will increase from less than 1 mgd in 1975 to 17 mgd in 2000. There will be a dramatic increase in mineral consumption in both subregions 1302 and 1304 from 8 and 13 mgd respectively in 1975, to 40 and 38 mgd in the year 2000.

An element of total consumptive use within the region not included in the percentages above is the loss by evaporation. There are 2,534 billion gallons of reservoir storage available in large reservoirs within the region as derived from NF estimates. Existing surface storage is rarely filled. A significant increase in reservoir conservation storage is not projected. Since evaporation is related to the reservoir surface areas exposed in any year, the evaporation rate is expected to be about the same in 2000 as in 1975.

An element of consumptive use not specifically accounted for in these studies is the evapotranspiration by phreatophyte vegetation and closed basin sump areas. Salt cedar and other phreatophyte vegetation have invaded thousands of acres of Rio Grande and Pecos valley lands in New Mexico. While the use of this vegetation is often considered to be implicitly accounted for in water supply records, the use is increasing annually as the growth increases. This affects the averages derived from records. The estimates in these studies do not include the expected increase in non-beneficial cases in New Mexico and Colorado.

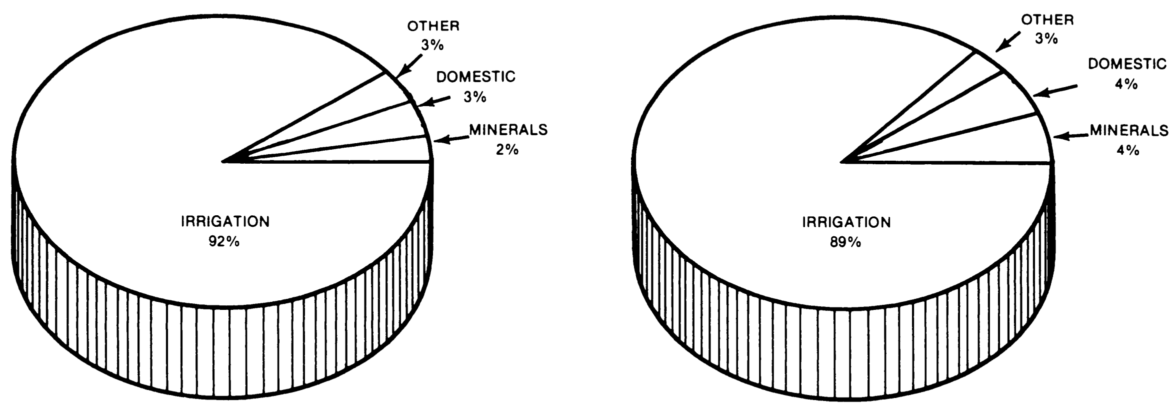
ANNUAL FRESHWATER WITHDRAWALS



1975
Total Withdrawals — 6,321 MGD

2000
Total Withdrawals — 5,633 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 4,240 MGD

2000
Total Consumption — 4,016 MGD

Figure 13-6. Withdrawals and Consumption

Instream Uses

Instream flow needs within the Rio Grande Region are related to fish and wildlife habitat, the environment, and esthetics. Pollution abatement and navigation are not recognized as requirements in the region. New Mexico water laws do not recognize instream use for fish and wildlife, environment, and esthetics as a specific beneficial use. Colorado and Texas do recognize these uses. While they are or are not legally recognized, impacts of new developments on instream flows are considered. These considerations apply to both private and public developments.

An issue in this region is the concept of Federal reserved rights to maintain esthetic values for national parks, national forests, and scenic rivers. These instream flow requirements have not been quantified and are issues to be cleared up on existing facilities. They should be a prerequisite for proposed authorizations.

Because either the State does not legally recognize instream flows as a right or because existing flows are appropriated, instream flow needs have not been quantified for this study as a need. Instream flow uses are incidental to meeting other existing or recognized beneficial uses. The instream flow approximation of 2,287 mgd cannot be met as long as offstream uses continue.

Water Supply and Demand

In the central and upper Rio Grande Region there are no surplus flows to meet new demands or to expand existing use. The existing supply is completely appropriated for existing demands and legal rights and treaties. All three States recognize water as a valuable resource, and rights to its use are negotiable; hence, uses are determined in the market place. Higher economic priority use will obtain a water supply from the uses with the lesser economic capability to retain rights to use. In these studies the transfer of uses has been recognized, which accounts for a decline in irrigation.

Shortages exist in meeting current uses, and those uses may only be fulfilled through conservation. Increased efficiency is anticipated and is recognized in the study by a higher percentage of withdrawals being consumed. Conservation of water by decreasing non-beneficial use are issues considered by both Texas and Colorado. These issues will be discussed as problems in the respective subregions. Texas (subregions 1303, 1305) shows increased demands that exceed existing reliable supplies. This study will not address the several possible alternatives to meet these demands. It is anticipated these issues would be objectives in the development of a comprehensive coordinated joint plan.

Comparative Analysis

Table 13-5 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water use in the Rio Grande Region. Comparisons of the State-Regional Future (SRF) with the National

Future (NF) illustrate that some functional use categories differ significantly because sources of data, as well as assumptions and criteria used in compiling the data, were different. In some cases the trends or magnitudes of the data reveal that there are potential problems relating to growth, recession, or magnitude of water requirements, even though there are differences in the basic estimates from the two sources.

Table 13-5.--Socioeconomic and volumetric data summary: the Rio Grande Region

Category	1975		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	1,695	1,868	1,780	2,678	1,875	3,630
Total employment	599	620	659	792	732	1,017
VOLUMERTIC DATA (mgd)						
-Base conditions-						
Total streamflow	4,813	NE	4,813	NE	4,813	NE
Streamflow at outflow point(s)	1,230	1,228	424	NE	707	NE
Fresh-water withdrawals	6,321	6,031	6,204	6,794	5,633	7,198
Agriculture	5,722	5,540	5,537	5,999	4,917	6,049
Steam electric	34	24	16	30	10	76
Manufacturing	19	24	42	31	32	42
Domestic	265	345	287	566	312	801
Commercial	62	a	65	a	68	a
Minerals	190	44	221	86	255	133
Public lands	22	11	27	14	28	14
Fish hatcheries	7	NE	9	NE	11	NE
Other	0	43	0	68	0	83
Fresh-water consumption	4,240	3,863	4,320	4,406	4,016	5,119
Agriculture	3,924	3,569	3,959	3,890	3,614	4,358
Steam electric	18	18	9	23	5	62
Manufacturing	5	10	15	13	24	20
Domestic	138	195	150	352	163	505
Commercial	30	a	31	a	32	a
Minerals	103	24	129	52	150	86
Public lands	22	12	27	16	28	16
Fish hatcheries	0	NE	0	NE	0	NE
Other	0	35	0	60	0	72
Ground-water withdrawals	2,335	1,722	NE	1,621	NE	1,538
Evaporation	730	606	764	623	785	616
Instream approximation Fish and wildlife	2,287	NE	2,287	NE	2,287	NE

NE - Not estimated.

[a] SRF domestic water use includes commercial and institutional requirements.

Problems

Pollution

Parts of Hinsdale and Mineral counties, Colorado, subregion 1301, are affected by pollution in the Rio Grande and tributaries. The hydrologic area is 844,000 acres of which 803,000 acres are in the Rio Grande National Forest. The population is estimated to be 5,120. Creede, Colorado, is the largest town in the area. The major industries are tourism, grazing, timber production, and mining. The area is a popular summer recreation spot with excellent stream fishing, hunting, and outdoor recreation facilities.

Willow Creek, a Rio Grande tributary, flows through the town of Creede and is polluted by mill effluent and sediment that washes into the stream during hard rains. Fish kills on Willow Creek and the Rio Grande have been noted. The unincorporated town of South Fork and the many homes located along the South Fork of the Rio Grande need a sewage collection system and treatment plant to alleviate the pollution of the South Fork and the Rio Grande.

Pollution of the type just described is an aspect of water quality, but it is a problem that can be solved. More serious is the salinity or dissolved solid facet of water quality, which is considered another form of pollution. The Alamosa River, Alamosa County, Colorado, subregion 1301, is polluted by acidic water and high concentrations of dissolved metals from tributaries of Iron Fork, Alum Creek, Bitter Creek, and Wightman Fork. The pollution is partly from natural sources and partly from mining operations. The Conejos River in adjoining Conejos County, Colorado, is polluted by high concentrations of dissolved heavy metals due to overflow from a mine tailings pond near the town of Platoro, Colorado.

The Rio Grande is a highly utilized stream, with the waters used and reused. Downstream users rely upon upstream return flows for water supplies. Waters diverted for various uses, as a minimum, are returned containing all of the dissolved salts in the diverted flows. In some instances additional leaching or chemical effluents are added to the natural salt burden. Downstream flows have higher concentrations of dissolved solids due to natural and man-impacted causes. Water quality of the Rio Grande below Caballo Reservoir approaches 890 ppm at El Paso and is 2,900 ppm at Ft. Quitman. The dissolved solid situation is currently a problem but can become more serious with increased non-beneficial upstream consumptive use.

Water quality is a major problem in surface supplies of the Pecos River below Santa Rosa, New Mexico (subregions 1303 and 1304). The natural discharge of saline springs downstream from Santa Rosa, near Roswell and south of Carlsbad, increases the salinity of surface flows. During periods of low streamflow, the saline content exceeds the tolerance of many irrigated crops. Irrigated lands in the Texas Pecos are centered along the river in Reeves, Pecos, Loving, and Ward Counties. A saline supply of surface water from Red Bluff Reservoir on the Pecos River (approximately 7,900 ppm) is used in small quantities, but ground water is the major source of irrigation supply in the area. However, the supply of ground water is declining. The ground water withdrawn is also becoming more saline as the result of natural saline water encroachment in the aquifer and the recycling of water used for irrigation. The area irrigated is declining, and has decreased by approximately 30 percent since 1958.

The Malaga Bend division of the McMillan Delta Project was constructed by the Bureau of Reclamation to alleviate the salinity problem. Brine is pumped from the Rustler Aquifer, which discharges into the Pecos River, and is disposed of in an off-channel evaporative reservoir. However, this project is not fully effective because of seepage from the evaporative reservoir, and the quality continues to deteriorate. Studies of new feasible means of reducing the natural brine emissions in all parts of the area are needed.

The Lower Rio Grande Valley (subregion 1305) includes Starr, Willacy, Hidalgo, and Cameron Counties, an area of 4,241 square miles. As previously discussed, this area, due to its favorable climate, supplies a significant portion of the Nation's winter vegetables, raised on irrigated lands. The water supply is derived from Falcon and Amisted reservoirs, constructed and operated jointly by the United States and Mexico. Although construction and joint system operation of these reservoirs has significantly enhanced the valley's water supply, channel losses and evapotranspiration losses significantly deplete the supply in the lower valley. Saline ground-water and irrigation return flows degrade the quality of river flows below Falcon Reservoir. Flows below Falcon are about 510 ppm and at the mouth (Brownsville) about 2,600 ppm. Recent completion of the Morrillo Drain Project in Mexico has partially alleviated adverse impacts; however, inferior water quality remains a critical problem in the lower valley.

Erosion and Sedimentation

The San Luis Valley (subregion 1301) in Colorado has light-textured soils that are subject to wind and water erosion. The estimated soil losses are about 164,000 tons annually.

The Rio Grande and Pecos River drainage in New Mexico (subregions 1302 and 1304) are subject to gully headcutting and sheet erosion. This erosion destroys range and cropland and adds sediment to the streams which affects irrigated crop production and livestock grazing capabilities. Downstream from the confluence of the Rio Puerco and the Rio Salado with the Rio Grande, heavy sediment loads result in siltation of canals, laterals, farm distribution systems, and reservoirs. Large sediment loads have also aggraded stream channels, resulting in high water tables which provide an excellent environment for phreatophyte growth. Land treatment measures are recommended to reduce sediment loads. The estimated average annual sediment delivery through streams in the region from all sources is about 45,000 acre-feet or about 89 million tons.

Flooding

Flooding is a problem on the Rio Grande in the vicinity of Alamosa, Colorado (subregion 1301). Estimated damages in the vicinity in 1975 were $118,041 urban, $1,945,377 agricultural, and $401,646 non-urban. Inundation of agricultural lands, farmsteads, roads, and irrigation systems from spring snowmelt and storm runoff occurs on a regular basis.

There are general flooding problems in subregion 1302 that damage urban and rural communities. Intense thunderstorms falling on steep, light-vegetative arroyo drainage produce high, short-peak flows that result in damage to diversion structures, bank-cutting, loss of irrigated cropland, and destruction of roads, bridges, powerlines, and other structures. Uncontrolled flooding has been a recent, severe problem in the Espanola Valley and in rural communities along the west side tributaries that enter Caballo and Elephant Butte reservoirs.

In the central and western portion of the Rio Grande in Texas (subregions 1302, 1303, and the upper part of 1305), ground and tree cover is sparse. Stream slopes vary from steep to moderately steep. During periods of intense rainfall, runoff is rapid, with high-peak flows, high stream velocities, and land inundation.

In the lower Rio Grande Valley (Cameron, Hidalgo, Starr, and Willacy Counties in subregion 1305) broad-crested floods move slowly and cause prolonged periods of inundation. The severe flooding problems are aggravated by inadequate drainage. Flooding can result from stream overflow, over-application of irrigation waters, or concentrated rainfall associated with hurricanes. Without massive drainage improvement in the lower Rio Grande Valley, limited use of productive agricultural land and flooding damages will continue. Flood damages (estimated at the time of damage) from Hurricane Beulah in 1967 amounted to $44,000,000 and from Hurricane Fern in 1971, $5,550,000.

Water Quantity

The Rio Grande Valley in Colorado (subregion 1301) has a withdrawal demand of 1,855.1 mgd (2,078,000 acre-feet), but supply is limited to an average of 848 mgd (951,000 acre-feet). Water is available to meet more than existing uses but must be bypassed to meet downstream needs as required by the Rio Grande Compact. The San Luis Valley Closed Basin area is 1,881,600 acres, which is about 38 percent of subregion 1301. The average annual natural flow into the closed basin is 237.5 mgd, and 293.7 mgd from the Rio Grande is diverted into the basin. It is estimated that 239.4 mgd is withdrawn annually from ground water. All irrigation return flows and surface flows settle in the low-lying areas in the southeastern part of the closed basin, where they are non-beneficially consumed by evaporation and by 371,800 acres of phreatophytes. A project has been authorized to construct a system of wells, pumping plants, and canals to salvage 90 mgd (100,800 acre-feet), of which 4.7 mgd would be made available to the Alamosa National Wildlife Refuge.

In subregions 1302 and 1304 in New Mexico, surface-water supplies are fully appropriated, mostly for irrigation purposes. Uses other than irrigation would require a transfer of use from irrigation. Any new use, whether manmade or natural, depletes present uses. Phreatophytes are invading poorly-drained areas, stream channels, and reservoir delta areas and are depleting supplies committed to present uses. Environmental interests are concerned that clearing of phreatophytes will affect wildlife habitat and are therefore opposed to clearing programs.[1]

In subregions 1302 and 1304 ground water is being withdrawn from wells at a rate that exceeds recharge, and ground-water levels are being lowered. In the Roswell Artesian Basin in Chavez and Eddy Counties, ground-water withdrawal has exceeded recharge for many years. The artesian head, the shallow water table, and the base flow into the Pecos River have been declining. This decline has caused saline waters to encroach into the fresh-water portion of the aquifer east and north of Roswell.

Other areas where ground water is being mined are the Sunshine Valley in Taos County, Estancia Basin in Santa Fe and Torrance Counties, near Carrizozo in Lincoln County; the Nutt-Hockett area in Dona Ana, Luna, and Sierra Counties; and the Mimbres Underground Water Basin in Luna County. In these areas, 210,000 acres are irrigated from ground waters, and the annual net depletion is estimated to be 347 mgd (389,000 acre-feet). Except for the Estancia and the Roswell artesian basins, ground-water storage is probably sufficient to last through 2000. In the Estancia Basin 5,900 acres are estimated to go out of production by 2000. Elsewhere irrigated lands will be reduced shortly after 2000. In the Roswell Basin, the Pecos Valley Artesian Conservancy District has been purchasing and retiring irrigated acreage. About 3,300 acres have been retired under this program.

In subregion 1303, the Trans-Pecos region of Texas, irrigated lands are centered largely along the Pecos River in Reeves, Pecos, Loving, and Ward Counties. A saline supply of surface water from Red Bluff Reservoir on the Pecos River is used in small quantities, but ground water is the principal source of water supply in the area. The supply of ground water is declining, because pumpage exceeds recharge to the aquifers. The ground waters are becoming more saline because of saline water encroachment, lowering of the fresh-water level, and recycling of water applied for irrigation. The total area irrigated was 250,000 acres in 1958, 174,000 acres in 1969, and 177,000 acres in 1974.

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[1]The subject of water use by riparian vegetation, the water savings subsequent to clearing projects, and the use of the word phreatophyte are extremely controversial. Most of the studies conducted to support arguments for phreatophyte control have been repudiated by other studies which demonstrate that no gains in water salvage result from clearing and that water losses may be greater immediately after the riparian vegetation has been removed. The most recent of these studies and the strongest statement thus far on the subject is a 1977 draft report by the U.S. Geological Survey.

There are four major sources of fresh water in El Paso County, Texas (subregion 1302). Three are ground-water sources and consist of (1) the Hueco Bolson deposits in which fresh ground water occurs just east of the Franklin Mountains; (2) the La Mesa Bolson deposits which underlie the Texas portion of the Mesilla Valley west of the Franklin Mountains; and (3) the Rio Grande alluvium which overlies the Hueco and La Mesa Bolson deposits in the El Paso and Mesilla valleys. The fourth source of water is the Rio Grande, with water being provided for irrigation and a small quantity for public water supply. The city of El Paso is a large user of ground water, with the Hueco Bolson deposits as the primary source and the three aquifers in the La Mesa Bolson deposits and the Rio Grande alluvium as secondary sources. The city also obtains some water from the Rio Grande.

The city of Juarez in Mexico also draws on Hueco Bolson deposits for its water supply. Several large industrial users in the area draw on the ground-water supply. Total pumpage for municipal and industrial use is about 90 mgd. Ground water from the Hueco Bolson deposits is being mined, and it is estimated only 9.84 million acre-feet will be left in storage by 1990. Problems are expected with (a) vertical leakage from the alluvium and encroachment of saline waters, (b) declining well yields, and (c) increasing pumping costs. The El Paso area is facing an impairment of the quality and quantity of its ground-water supply.

Water supplies available to the lower Rio Grande Valley include a small quantity of ground water in the Rio Grande alluvium and the flow of the Rio Grande, most of which is available from storage in Falcon and Amistad reservoirs. Municipal and industrial use is about 65 mgd, and the irrigation requirement for approximately 800,000 acres is about 893 mgd. Operation studies indicated that some shortages will be experienced 70 percent of the time, although substantial shortages occur less than 30 percent of the time. The average annual shortage to be expected is 226 mgd. While not a current problem, the lower valley contains approximately 500,000 acres of additional irrigable land that could be brought into citrus, truck farming, cotton, and sugar cane production if additional water were imported into the area to relieve existing shortages.

The Texas Water Development Board appraised public water supply systems and found that many could not comply with the Environmental Protection Agency's (EPA) Interim Primary Drinking Water Standards of the Safe Drinking Water Act of 1974 (Public Law 93-523). Many of the systems that do not meet the standards are in the lower valley. In addition, approximately 42 communities, about 20 percent of the valley's population, are not served by public water supply systems. Many of the communities are currently ineligible for loans or grants from the Federal Government. The State of Texas cannot directly assist these water systems. In-migration to the sun-country environment is anticipated to increase the already existing serious problem. If the current migration continues, the problem will be of serious national concern.

Water Surface

Currently a large need for water surface area exists in subregions 1302 (82,000 acres), 1303 (7,000 acres), and 1305 (40,000 acres). While water surface area needs equal 129,000 acres, only 2,000 acres are intensively utilized. Utilization of presently available waters could be improved by providing additional access (roads and camps). It is projected that by 2000 the demand will increase to 160,000 acres, which, with current water supply outlook, will not be met within the region.

Recreation

In subregion 1301 the expanding use of off-road recreational vehicles and hiking on mountain trails is creating an erosion and sedimentation problem that should be addressed. There is a need for additional campgrounds, picnic areas, hiking and skiing trails, and roads for four-wheel drive vehicles to meet the growing demand for these recreational facilities.

The Rio Grande from Presidio, Texas, to Amistad Reservoir (191.2 river miles) has unique values for designation as a Wild and Scenic River under Public Law 90-542. A minimum of 9,600 acres of land adjacent to the river, excluding Big Bend National Park, is proposed for a Wild and Scenic River to protect the scenic, historic, and archeologic values. The Rare Plant Study Center at the University of Texas identified five plant species as acutely endangered in this area. These include the Shiner's brickellia, cliff thistle, cliff bedstraw, Maravillas milkwort, and Emorya suaveolons. Correspondingly, numerous animal species occurring in the canyons are listed as endangered or threatened by the U.S. Fish and Wildlife Service. The endangered species are the Big Bend gambusia, American peregrine falcon, and Mexican wolf. Threatened species are the Mexican stoneroller, Big Bend turtle, Chihuahua shiner, bluntnose shiner, and Concho River pupfish.

Without protection and management of lands adjacent to the river, overgrazing, proliferation of private camps, and possible development of vacation home subdivisions will intensify. Overall, without adoption of the proposal, many of the natural, scenic, and recreational attributes of the Rio Grande Wild and Scenic River could be lost.

Institutional

The Rio Grande Region includes many Federal and Indian lands. Reserved water rights to permit the reasonable use of these lands for the general public is a regional issue. Recognizing that available water suplies are committed, additional water use on Federal lands will require a transfer from existing uses. Early resolution of water rights reserved for Federal lands is needed to facilitate the solution of the region's water problems.

Individual Problem Areas

The Rio Grande Coordinating Committee identified specific areas with urgent problems concerning water and related land resources. The problems for each area were described and evaluated. The problem areas are:

1301. Rio Grande Headwaters.
   1. San Luis Valley Closed Basin
   2. Hinsdale, Rio Grande, and Mineral Counties
   3. Del Norte, Colorado, to Colorado-New Mexico State line

1302. Middle Rio Grande.
   4. Rio Grande Basin, New Mexico
   5. Albuquerque, Carlsbad, Las Cruces, Roswell, and Santa Fe, New Mexico
   6. Espanola Valley and Rio Grande west side tributaries, New Mexico
   7. El Paso area
   8. Roswell Artesian Basin, Sunshine Valley, Estancia Basin, Carrizozo, Nutt-Hockett area, and Mimbres Underground Basin

1303. Rio Grande-Pecos.
   9. Trans-Pecos region of Texas
   10. Rio Grande Canyons, Texas

1304. Upper Pecos.
   4. Rio Grande Basin, New Mexico
   5. Albuquerque, Carlsbad, Las Cruces, Roswell, and Santa Fe, New Mexico
   8. Roswell Artesian Basin, Sunshine Valley, Estancia Basin, Carrizozo, Nutt-Hockett area, and Mimbres Underground Basin
   11. Pecos River downstream from Santa Rosa, New Mexico

1305. Lower Rio Grande.
   12. Lower Rio Grande Valley

Regionwide in Texas
   13. Small Cities and Rural Communities, Texas
   14. Texas Statewide: Flood Problems and Hurricanes

The dominant regional or national problem in the Rio Grande Region relates to limited and erratic water supplies in the three States. The limited and precious water supplies are depleted by nonbeneficial consumptive uses as well as by irrigation, municipal, industrial, fish and wildlife, and other uses in all three States. Furthermore, the consumption of water and the natural inflow of salts create salinity problems which gravely intensify the water supply problems of the region. The map shown in Figure 13-7a shows the location of the problem areas. Figure 13-7b presents a tabulation of problem issues by subregion.

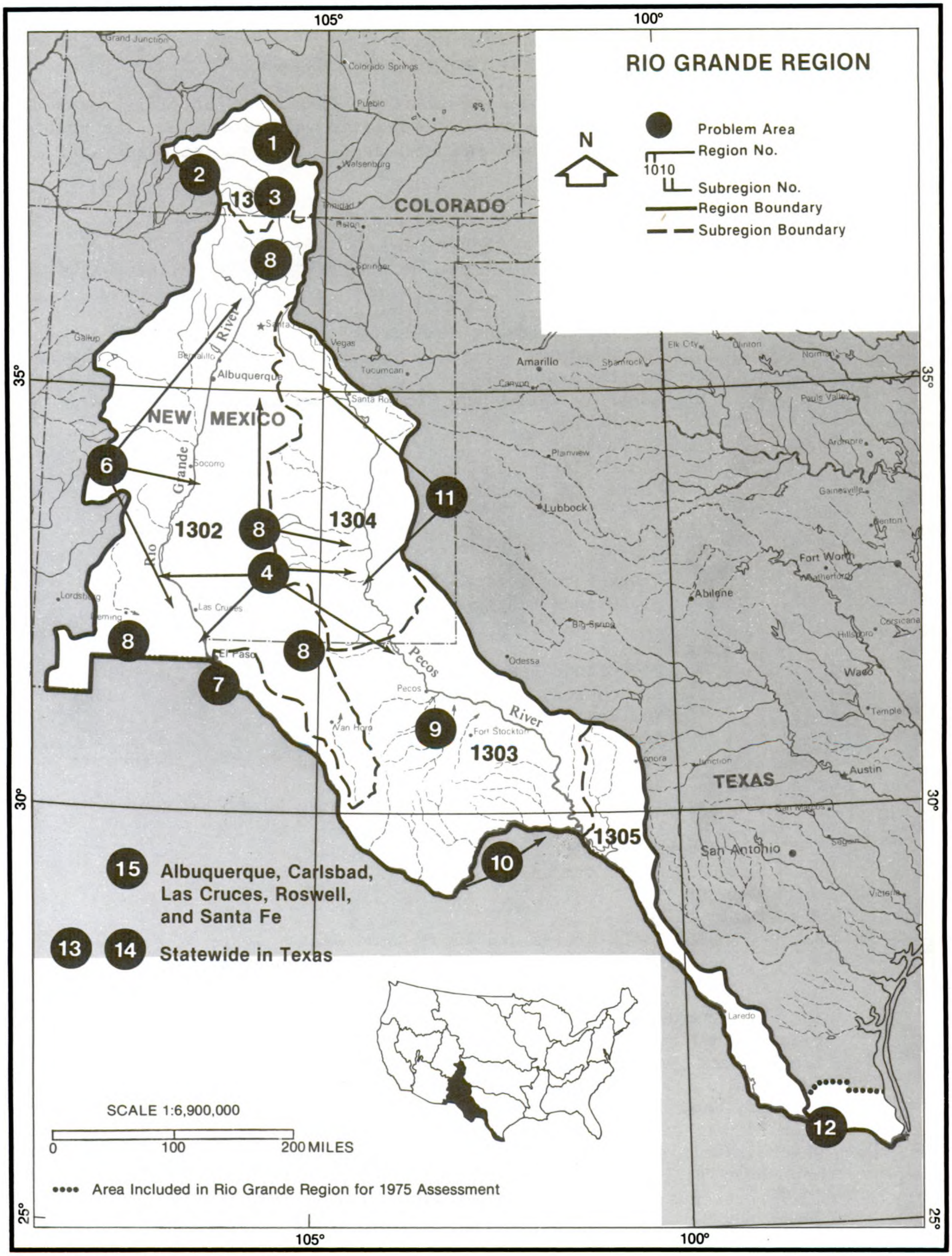

Figure 13-7a. Problem Map

RIO GRANDE REGION (13)

PROBLEM MATRIX

Problem issues: O= Identified by Federal Agency Representatives; X= Identified by State-Regional Representative

Problem area: No. on map	Problem area: Name	Water quantity: Fresh surface	Water quantity: Ground	Water quantity: Marine and estuarine	Water quantity: Surface/depth	Water quality: Fresh surface	Water quality: Ground	Water quality: Marine and estuarine	Water quality: Surface/depth	Related lands: Flooding	Related lands: Drainage	Related lands: Erosion and sedimentation	Related lands: Dredge and fill	Related lands: Water related use conflicts	Other
Subregion 1301	Rio Grande Headwaters	O	O							O					O
Area 1	San Luis Valley Closed Basin	X												X	X
2	Hinsdale, Rio Grande, & Mineral Counties					X								X	
3	Del Norte, Colorado, to Colo.-N. Mex. State Line	X				X				X				X	
Subregion 1302	Middle Rio Grande	O	O			O	O			O					O
Area 4	Rio Grande Basin, New Mexico	X	X		X					X		X		X	
5	Albuquerque, Carlsbad, Las Cruces, Roswell and Santa Fe, New Mexico	X	X												X
6	Espanola Valley & Rio Grande West Side Tributaries									X		X			X
7	El Paso Area		X				X								
8	Roswell Artesian Basin, Sunshine Valley, Estancia Basin, Carrizozo, Nutt-Hockett Area, and Mimbres Underground Basin		X				X								
Subregion 1303	Rio Grande-Pecos	O	O			O	O								O
Area 9	Trans-Pecos Region, Texas	X	X			X	X								
10	Rio Grande Canyon, Texas														X
Subregion 1304	Upper Pecos	O	O			O	O								O
Area 4	Rio Grande Basin, New Mexico	X	X		X					X		X		X	
5	Albuquerque, Carlsbad, Las Cruces, Roswell and Santa Fe, New Mexico	X	X												X
8	Roswell Artesian Basin, Sunshine Valley, Estancia Basin, Corrizozo, Nutt-Hockett Area, and Mimbres Underground Basin		X				X								
11	Pecos River downstream from Santa Rosa, N. Mex.					X							X		X
Subregion 1305	Lower Rio Grande	O	O			O	O	O		O					O
Area 12	Lower Rio Grande Valley	X				X									
Regionwide in Texas															
Area 13	Small Cities & Rural Communities, Texas	X	X			X	X								
14	Texas Statewide: Flood Problems & Hurricanes									X					

Figure 13-7b. Problem Matrix

Problems are tabulated by subregion and by State as follows:

STATE	1301	1302	1303	1304	1305	Regionwide	Total
Colorado	3						3
New Mexico		3*		3*		1	5
Texas		3+	4+		3+	2	5
Totals	3	3	2	2	1	3	14

* One New Mexico regionwide problem included.
\+ Two Texas regionwide problems included.

Problem Area 1, Subregion 1301

The problem area is the closed basin of the Rio Grande headwaters in parts of Saguache and Alamosa Counties in Colorado. The area lies north of the Rio Grande River and, as the name implies, the surface runoff does not flow to the river. The hydrologic area is 1,882,000 acres, approximately 36 percent of which are in the national forests in the area and 14 percent are on Bureau of Land Management lands. The population is 8,700 and is engaged primarily in farming and ranching. There are a few mineral mines in Saguache County. Timber is harvested in the Rio Grande National Forest. There are 338,750 acres of irrigated cropland, irrigated meadowland, and pastureland in the area.

The average annual streamflow into the basin is 237.5 mgd. An average of 293.7 mgd is diverted annually into the basin from the Rio Grande for irrigation uses. It is estimated that 239.4 mgd annually are withdrawn from the ground water for irrigation. All irrigation return flows and surface flows settle in the low-lying areas in the southeastern part of the closed basin where it is nonbeneficially consumed by evaporation and by 371,800 acres of phreatophytes.

Water Issues

During late season streamflow and drought periods, the water supply is insufficient to meet irrigation requirements. During an average irrigation season, the total water withdrawn amounts to 724.9 mgd for irrigation. The average annual requirement is 858.0 mgd, leaving an average annual shortage of 133.1 mgd. The low flows in fall are less than the amount required to satisfy minimum flows for fish and wildlife.

The water that collects in the low area of the closed basin has high concentrations of salts as a result of the salts in the irrigation return flows reaching the area, and mine-tailing ponds on Kerber Creek pollute the stream with high concentrations of minerals and acids.

Related Land Issues

The lower part of the closed basin has high water tables that have encroached upon croplands and encouraged the growth of phreatophytes. There are an estimated 371,800 acres of phreatophytes which nonbeneficially consume 415.0 mgd annually. These lands need to be drained in order to return the formerly cropped lands to production and to salvage water that is now being nonbeneficially consumed by the phreatophytes and by evaporation.

Land use practices need to be improved in order to reduce damages on croplands and over-grazed pastureland from wind erosion and from gullying caused by storm runoff. These natural events cause sediment damages to fields and irrigation systems.

Institutional Issues

There is a need to settle the issue of Federal claims for water rights on public lands with the date of priority as date of problem land withdrawals. These claims should be quantified in order to determine their effect on present water users.

Modification of the administration of the Rio Grande Compact is needed to permit the better use of Colorado's allotment of water for irrigation.

Financial Issues

Additional Federal, State and local funds are needed to accelerate the implementation of the San Luis Valley resource conservation and development programs. Although $300,000 have been appropriated for preconstruction planning of the authorized Closed Basin Project for salvage of closed basin waters, assurance is needed that adequate and regular construction funds are appropriated to complete the project as soon as possible.

Problem Area 2, Subregion 1301

This area encompasses the Rio Grande watershed above the stream gage six miles west of Del Norte in parts of Hinsdale, Rio Grande, and Mineral Counties. The hydrologic area is 844,800 acres, of which 803,000 acres are in the Rio Grande National Forest. The population is estimated to be 5,120. Creede, with a population of about 625, is the largest town in the area. The major industries are tourism, stock production, timber production, and mining. The area is a popular summer recreation spot with its excellent stream fishing, hunting, and outdoor recreation facilities. The only irrigation in the area is on about 2,600 acres of meadow land. The average annual runoff of the Rio Grande at the Del Norte stream gage is 578.6 mgd, about 24 percent of the surface inflow into subregion 1301.

Water Issues

Willow Creek, a tributary of the Rio Grande, flows through the town of Creede and is polluted by mill effluent and large amounts of sediment that wash into the stream during hard rains. Fish kills on Willow Creek and the Rio Grande below have been noted following a period of hard rains. The unincorporated town of South Fork and the many homes located along the south fork of the Rio Grande need a sewage collection system and treatment plant to alleviate the pollution of the South Fork and the Rio Grande.

Related Land Issues

The expanding use of recreation vehicles and hiking on mountain roads and trails are creating an erosion and sedimentation problem which must be resolved in some manner. There is a need for additional campgrounds, picnic areas, hiking and skiing trails, and roads for four-wheel drive vehicles to meet the growing demand for these recreational facilities.

Institutional Issues

Same as for Problem Area 1.

Financial Issues

Increased and regular Federal and State funds are needed to meet the growing demand for recreational facilities.

Problem Area 3, Subregion 1301

This area encompasses the drainage of the Rio Grande and its tributaries from the stream gage on the river near Del Norte to the Colorado-New Mexico State line. The area is in Conejos and Costilla Counties and in parts of Rio Grande and Alamosa Counties. The total area is 2,273,600 acres, of which 323,100 acres are in national forests and 176,000 acres are Bureau of Land Management lands. The population is 28,195. The principal trading centers are Del Norte, Monte Vista, and Alamosa, all located near the Rio Grande.

Agricultural production and processing of agricultural products are major industries. Tourism and timber production are also important sources of income in the area. There are 270,000 acres of irrigated cropland, meadowland, and pastureland. The average annual withdrawal of water for irrigation has been 640.6 mgd of surface water, and 135.6 mgd of ground water, or a total of 776.2 mgd. The average annual surface water flow into the area is 578.6 mgd in the Rio Grande at Del Norte, and 592.0 mgd in tributary streams, or a total of 1,170.6 mgd.

Water Issues

There is a shortage of water to satisfy irrigation requirements. The average annual withdrawal requirements for irrigation are 952.1 mgd, and the average annual withdrawal has been 776.2 mgd, thus leaving an annual shortage of 175.9 mgd (197,060 acre-feet). Irrigation diversions reduce the flow in the Rio Grande and Conejos Rivers frequently to near zero flows in the lower reaches of the rivers during the irrigation season. The low flows cause the Rio Grande to become polluted below Alamosa where the Alamosa lagoons contribute approximately one-fifth of the total river flow during these low flow conditions. During the summer and the late fall, almost the entire flow in the Rio Grande below Monte Vista is derived from irrigation return flows, which carry high concentrations of dissolved solids and moderate concentrations of sulfates, nitrates and nutrients.

The Alamosa River is polluted by acidic water and high concentrations of dissolved metals from the tributaries of Iron Fork, Alum Creek, Bitter Creek, and Wightman Fork. The pollution appears to be from natural sources except on Wightman Fork where at least some of the high concentrations come from mining operations. The Conejos River is polluted by high concentrations of dissolved heavy metals from a small amount of overflow from a mine tailings pond near the town of Platoro.

Related Land Issues

The communities of Monte Vista and Alamosa on the Rio Grande are subject to damaging floods. The communities of Capulin, Guadalupe, La Jara, and San Luis are subject to flooding from tributary streams. Inundation of agricultural lands, farmsteads, roads, and irrigation systems from spring snowmelt and storm runoff occurs on a regular basis.

Damaging wind erosion, and erosion and sediment damages from storm runoff occur on unprotected cropped lands and overgrazed pasturelands. Wind erosion damages are particularly severe in Costilla County.

Institutional and Financial Issues

Same as in Problem Areas 1 and 2.

Problem Area 4, Subregions 1302 and 1304 (New Mexico)

The Rio Grande Region in New Mexico includes subregion 1304 (entirely in New Mexico) and subregion 1302 (includes two counties in Texas). Counties in subregion 1304 are generally located in the Pecos River Basin and those in subregion 1302 are generally in the Rio Grande Basin.

In national and regional planning studies concerning New Mexico, all of the area east of the Continental Divide and extending to the Arkansas-White-Red River and Texas Gulf basins is considered part of the Rio

Grande Basin. The Pecos River is a tributary of the Rio Grande and joins the Rio Grande near Comstock, Texas. In national and regional planning, the Pecos River drainage is included as a sub-basin of the Rio Grande. In New Mexico, however, the Pecos River Basin is separate and distinct from the Rio Grande and for State planning purposes, the basins are considered separately.

The Pecos River and Rio Grande basins as defined by surface drainage boundaries in New Mexico were described during Activity 2, Phase II of the national assessment. These descriptions are found at pages 11-35 and 114-125 in "Technical Memorandum - State Regional Futures and Problem Lists" (Activity 2, Phase II) for the Rio Grande Region published by the Bureau of Reclamation in January 1977 and are not repeated here.

During Activities 1 and 2, a number of similar problems were identified throughout both river basins in New Mexico. These problems are common to the area shown as No. 4 in New Mexico on the problem area map and are as follows:

1. Surface-water supplies are limited and in most of the area these supplies are fully appropriated or committed, mostly for irrigation purposes. Uses of these supplies for other than irrigation would require a transfer of use.

2. Throughout much of the area, yields from ground-water aquifers are low to moderate and the quality of water is generally poor. Where these conditions exist, the supplies are not adequate to meet projected increased municipal and other uses.

3. Surface-water runoff results in flood damage in urban and rural communities. Uncontrolled flooding along stream channels results in damage to diversion structures, bank-cutting, loss of irrigated cropland, and destruction of roads, bridges, powerlines, and other structures.

4. Headcutting and sheet erosion destroy range and cropland, add sediment to streams, and affect crop production and livestock grazing capabilities.

5. A study by the U.S. Bureau of Outdoor Recreation indicates large deficiencies in surface-water supplies required for projected recreation demands in the Rio Grande Region.

6. Quantification of Indian and Federal water rights is needed.

Problem Area 5, Subregions 1302 and 1304

Urban sprawl is a problem in cities that are experiencing rapid growth. Cities showing major population increases between 1970 and 1975 are Albuquerque, Carlsbad, Las Cruces, Roswell, and Santa Fe.

Except in Santa Fe, housing, commercial, and industrial developments are extending onto prime agricultural lands. Water supply for municipal and industrial purposes are limited except as supplies can be obtained by retirement of irrigation and transfer of that water to municipal and industrial uses.

Problem Area 6, Subregion 1302

Uncontrolled flood flows in the Rio Grande drainage can result in major damage in Espanola Valley and in rural communities along the west side tributaries that enter Caballo and Elephant Butte reservoirs.

Quality of water in the Rio Grande decreases progressively downstream. Below the confluences of Rio Puerco and Rio Salado with the Rio Grande, heavy loads of sediment cause siltation of canals, laterals, and farm distribution systems and decrease storage space in reservoirs. Suspended sediments are deposited on irrigated lands which affect productivity. Headcutting and sheet erosion occur throughout the area and enter the stream system during periods of runoff.

High water tables under irrigated lands in parts of the middle and lower valleys require drainage and continued maintenance. Phreatophytic growth invades poorly-drained areas, stream channels, and reservoir delta areas. These plants consume large quantities of water and contribute to the quality deterioration of water supplies.

Problem Area 11, Subregion 1304

Water quality is a major problem in surface supplies of the Pecos River, especially downstream from the city of Santa Rosa. The natural discharge of saline springs downstream from Santa Rosa, near Roswell and south of Carlsbad, increases the salinity of surface flows. During periods of low streamflow, the saline content of surface water exceeds the tolerance of many irrigated crops.

Large sediment loads have silted stream channels and greatly reduced the capacity of reservoirs. This problem will be partly alleviated by sediment storage in authorized reservoirs; but land treatment and other conservation measures are required to reduce sediment loads. Phreatophyte growth invades stream channels and reservoir areas.

Problem Area 8, Subregions 1302 and 1304

In areas where ground water is being mined, pumping from wells exceeds recharge and ground-water levels are being lowered.

In the Roswell Artesian Basin in Chaves and Eddy Counties, the natural and manmade discharge from the basin has exceeded the recharge for many years. The artesian head, the shallow water table, and the base inflow into the river have been declining. The continuing general decline of head in the artesian aquifer has caused saline water which formerly discharged naturally to the Pecos River to encroach into the fresh-water portion of the aquifer east and north of Roswell.

Other areas shown on the regional map where ground water is being mined are Sunshine Valley in Taos County; Estancia Basin in Santa Fe and Torrance Counties; near Carrizozo in Lincoln County; the Nutt-Hockett area in Dona Ana, Luna, and Sierra Counties; and the Mimbres Underground Water Basin in Luna County. Most of the ground-water supplies in these areas are used for irrigation.

Throughout the basin, most of the ground-water supplies are within boundaries of underground water basins as declared by the State engineer. In these areas, new appropriations cannot be made if such appropriations will impair an existing right.

Ground-water supplies used for irrigation and other purposes in the Rio Grande Region in New Mexico are furnished from multiple-aquifer sources. Sources, static water levels, and yields vary throughout the region.

Table 13-6 shows acreage irrigated from ground-water supplies in 1975 and the withdrawals and depletions from this source. Part of the acreage received supplies from both surface and ground water; however, withdrawals and depletions furnished from surface-water sources are not included as part of this tabulation.

Table 13-6.--Ground water supplies used for irrigation in 1975 in Problem Area 5 in New Mexico

		1,000 Acres	1,000 Acre-Feet	
Area	County	Irrigated	Withdrawals	Depletions
Sunshine Valley	Taos	3.4	7.8	4.4
Estancia Basin	Santa Fe-Torrance	28.4	65.5	35.9
Near Carrizozo	Lincoln	0.8	2.8	1.6
Tularosa-Alamogordo	Otero	5.9	18.2	10.1
Salt Basin	Otero	4.4	18.2	10.0
Nutt-Hockett	Dona Ana-Luna-Sierra	10.4	31.1	17.5
Mimbres Underground Water Basin	Luna	40.0	120.0	69.9
Roswell Artesian Basin	Chaves-Eddy	116.9	364.3	239.2

Except for Estancia and the Roswell Artesian Basins, ground water in storage is probably sufficient to last through the period 1975-2000. In Estancia Basin, about 5,900 acres are estimated to go out of production by 2000. Elsewhere because of dwindling ground-water supplies, irrigated lands will be reduced commencing shortly after the year 2000.

In the Roswell Artesian Basin, the Pecos Valley Artesian Conservancy District has an ongoing program of purchasing and retiring irrigated acreage. This program will assist in bringing the basin into balance and alleviate saline water intrusion into fresh-water supplies. About 3,300 acres have been retired under this program.

Problem Area 9, Subregion 1303

Irrigation Water Supply and Quality Problems in the Pecos Valley and Adjacent Areas

Irrigated lands in the Trans-Pecos region of Texas are centered largely along the Pecos River in Reeves, Pecos, Loving, and Ward Counties. A saline supply of surface water from Red Bluff Reservoir on the Pecos River is used in small quantities but ground water is the principal source of irrigation water supply in the region.

The supply of ground water in the Trans-Pecos region is declining. Pumpage exceeds natural recharge to the aquifers. The ground water pumped for irrigation is also becoming more saline as the result of natural saline water encroachment in the aquifer, and possibly as a result of the recycling of water applied for irrigation.

The total area irrigated was 250,000 acres in 1964, 284,000 acres in 1964, 174,000 acres in 1969, and 177,000 acres in 1974.

A number of areas along the Pecos River in Reeves County are no longer cultivated because of poor quality and inadequate amounts of water in most years.

The ground water used in Reeves County is high in soluble salts, averaging four tons per acre-foot. Heavy water applications, salt-tolerant crops such as cotton, and the moderate permeability of the soils permit the use of this water for irrigation.

Deterioration of water quality of the Pecos River, largely from natural brine emissions in New Mexico, has virtually precluded its use for irrigation purposes despite operation of the Malaga Bend Division of the McMillan Delta Project. The objective of this project, operated by the Bureau of Reclamation, is to alleviate the salinity problems, which result from the artesian discharge of brine from the Rustler Aquifer into the Pecos River by pumping the aquifer to reduce the artesian pressure. Brine pumped from the aquifer is disposed of in an off-channel natural depression where it evaporates. However, renewed studies of more feasible ways of reducing the natural brine emissions in all parts of the area are needed.

Additional problems in the area have resulted from the increased cost of energy used to pump irrigation water. At the present time, the primary fuel used for pumping is natural gas. Within the last three years, natural gas prices have increased from $0.35 per thousand cubic feet (mcf) to $1.85 per mcf. This fivefold increase in price coupled with large pumping lifts and a requirement of up to 44 inches of water which must be applied just to leach the salts from the land have made it impossible for many farmers in the area to produce at a profitable level.

The effects of not solving water supply and water quality problems could result in the area not attaining its full economic potential, which will directly influence the more than 42,000 persons projected to reside in the area by 2000 (Table 13-7). Over 17,000 of these persons are projected to be employed, since the economic activity within the area would be sufficient to generate this number of jobs without solving the water supply and water quality problems.

Table 13-7.--Projected population, employment and per capita income in Loving, Pecos, Reeves, and Ward Counties

	1975	1985	2000
Population	43,238	42,836	42,600
Employment	15,783	16,806	17,242
Per capita income	$5,025	$7,047	$10,975

In addition to the impacts of water supply and quality, problems in the area will be affected by the increased costs of the energy required for pumping irrigation water. Recent studies have indicated that the high prices of natural gas along with increased costs of other farm inputs associated with irrigation may preclude crop production in the area. Major adjustments in the agricultural economy of the area could include a change from irrigated crop production to livestock production. Such adjustments would have serious regional implications through probable default in land payment. Financial institutions would be adversely affected as borrowers default and land values decline. In turn, this situation can produce impacts throughout the region as well as the State by adversely affecting the economic base, employment, population, earnings, etc.

Problem Area 10, Subregion 1303

The U.S. Congress, in response to recreational demand for less crowded natural and scenic areas, passed the 1968 National Wild and Scenic Rivers Act, Public Law 90-542. This Act recognized the necessity for the preservation of natural, free-flowing waterways. The Act provides for the inclusion of rivers or sections of rivers of national significance in the Wild and Scenic Rivers System. The only Texas river segment specifically listed for possible inclusion was the Rio Grande upstream from Amistad Reservoir. A study of the Rio Grande from Presidio to Amistad Reservoir was made to determine if this segment should be included in the wild and scenic rivers system. The study was directed by the U.S. Department of the Interior, Bureau of Outdoor Recreation. Other agencies involved in this analysis included the U.S. Forest Service, National Park Service, International Boundary and Water Commission, and the Texas Parks and Wildlife Department. In May 1976, the final environmental statement was released proposing inclusion of a portion of the Rio Grande in the

National Wild and Scenic Rivers System.

The proposed Rio Grande segment (191.2 river miles) is bounded on the west by the Chihuahua-Coahuila State line in Mexico, and on the east by the Terrell-Val Verde county line in Texas. A minimum 9,600 acres of adjacent land, excluding Big Bend National Park, is proposed for inclusion to protect the scenic, historic, and archeological values of the river segment.

The canyons of the proposed Rio Grande Wild and Scenic River lie within the Chihuahua Desert biotic region, which is characterized by low annual rainfall (8-10 inches), daily and annual temperature extremes, relatively sparse vegetation, and desert fauna. The Rare Plant Study Center at the University of Texas identified five plant species as acutely endangered in this area. These include the Shiner's brickellia, cliff thistle, cliff bedstraw, Maravillas milkwort, and Emorya suaveolens. Correspondingly, numerous animal species occurring in the Rio Grande canyons are listed as endangered or threatened by the U.S. Fish and Wildlife Service. Those species listed as endangered include: the Big Bend gambusia, American peregrine falcon, and Mexican wolf. Threatened species are listed as: the Maxican stoneroller, Big Bend turtle, Chihuahua shiner, bluntnose shiner, and Concho River pupfish.

Without protection and management of lands adjacent to the river, over-grazing, proliferation of private camps, and possible development of vacation home subdivisions will intensify. These factors will adversely affect rare plants and wildlife habitat, resulting in loss of vegetation, increased siltation, soil loss, and soil compaction in high use areas.

The canyons of the Rio Grande contain numerous historical and archeological sites which constitute a non-renewable source of data concerning man's presence in the region over the last 10,000 years. Archeological sites range from those of paleo-American hunters and neo-American hunters and gatherers, to Coahuiltecan Indians and Apaches. Typical historical sites include evidence of presidios, trails, candelilla wax plants, villages, railroad construction camps, mines, and ranching. Lack of adequate protection for these archeological and historic sites will result in increased disturbance and/or destruction of an irreplaceable resource. Overall, without adoption of the proposal, many of the natural scenic and recreational attributes of the Rio Grande Wild and Scenic River would be lost.

Problem Area 12, Subregion 1305

Water Supply and Related Problems in the Lower Rio Grande Valley

The lower Rio Grande Valley of Texas includes Starr, Willacy, Hidalgo and Cameron Counties, encompassing 4,241 square miles. This area, due to its favorable climate, unique recreational and retirement potential, and port facilities, has the capacity for significant economic growth and improvement in the quality of life of its residents. Although the economy is heavily agriculturally oriented, other economic sectors have gained significantly in recent years, most notably textiles, food processing and packaging, petroleum refining, and petrochemical production. The port of Brownsville consistently ranks near the top among the Nation's ports in value of fishery products landed, principally shrimp. The most important industries in the valley are irrigated agriculture, petroleum refining and petrochemical production, synthetic textile production, and food processing, all of which are intensive water-using sectors of the economy.

Water supplies available to the lower Rio Grande Valley include a small quantity of ground water in the Rio Grande alluvium and the flow of the Rio Grande, most of which are available from storage in International Amistad and Falcon reservoirs. Ground water in the Rio Grande alluvium is generally too saline for municipal and most industrial uses. The limited supplies which are available are principally for irrigation (only about 5,000 acre-feet of ground water is used annually for municipal and industrial purposes). Widespread use of this marginal-quality water has resulted in severe and widespread agricultural soil salinity problems. Overapplication of irrigation water has resulted in local drainage problems.

Currently, municipal and industrial water use in the four-county area approximates 65 million gallons per day (72,809 acre-feet per year), with existing steam electric power plants consuming an additional 5,000 acre-feet of water annually. In addition to individual industries which have developed independent water supply systems, there are approximately 39 purveyors of municipal, domestic, and "light" industrial water supplies to approximately 102 water-using entities in the four-county area. Several irrigation districts also supply water to a number of small cities and communities, frequently on a temporary basis, through irrigation diversion and conveyance facilities. Of approximately 144 cities, incorporated and unincorporated communities, water supply corporations, and entities in the area, 42 communities, representing about 20 percent of the valley's population, are not served by public water supply systems. Inferior water quality (high dissolved solids concentrations and excessive hardness) and problems of insufficient plant capacity plague much of the valley population.

Currently, over 7,000 operating units, served by 33 active irrigation districts as well as individual and cooperative irrigation systems, use approximately 1,000,000 acre-feet annually to irrigate more than 800,000 acres of land in the Rio Grande Valley. More than 500,000 acres of additional potentially highly productive irrigable lands exist in the valley which could be put into production if water were available.

Water available to the valley from the Rio Grande is subject to provisions of the International Treaty of 1944 between the United States and Mexico and the supply available in storage in Amistad and Falcon reservoirs. Allocations of this supply are based upon water rights recognized in the Lower Rio Grande Valley Water Case (State of Texas, et al. v. Hidalgo County Water Control and Improvement District No. 18 et al., 443 S.W. 2nd 728) as approved by the Texas Supreme Court.

Falcon and Amistad reservoirs, constructed jointly by the United States and Mexico for flood control and water supply, are operated by the International Boundary Commission, with the United States' share of conservation storage administered by the Texas Water Rights Commission under rules and regulations established pursuant to provisions of the above-described court order. A watermaster, employed by the Texas Water Rights Commission, is responsible for daily allocations of water to divertors holding rights to water from the Rio Grande. Although construction and joint system operation of these reservoirs has significantly enhanced the valley's water supply, channel losses and evapotranspiration losses significantly deplete facilities in the lower valley. Saline ground water and irrigation return flows degrade the quality of river flows below Falcon Reservoir. Recent completion of the Morrillo Drain project in Mexico has partially alleviated adverse impacts of irrigation return flows from Mexico on river flows; however, inferior water quality remains a critical problem in the valley.

The lower Rio Grande Valley suffers severe constraints against reaching its full economic potential due to the quantity and quality of the area's water supply. The principal problems which have plagued the valley and which will become increasingly severe by 2000, are (1) inadequate ground- and surface-water supplies to meet current levels of irrigated agriculture during critical drought periods, (2) insufficient water supplies for expansion of industry and irrigated agriculture or for an expanding population, (3) impaired water quality, and (4) low per capita income (Table 13-8).

Table 13-8.--Present and projected population, employment, and per capita income in Starr, Hidalgo, Willacy, and Cameron Counties

	1975	1985	2000
Population	374,799	425,473	484,100
Employment	112,031	137,210	163,657
Per capita income (in 1975 dollars)	$5,025	$7,047	$10,975

By 2000, municipal and industrial water requirements in the four-county area will reach approximately 132,500 acre-feet annually (118 mgd), while consumptive use for steam electric power plant cooling is expected to increase to at least 11,800 acre-feet annually. Operation studies of the Rio Grande reservoir system for the 70-year period from 1900 to 1970 indicate that water shortages for the 750,000 acres of land allotted irrigation water rights by the court order arising from the Lower Rio Grande Valley Water Case would occur 70 percent of the time, with the average annual shortage approximately 253,000 acre-feet. Thus, maintaining the current level of irrigated agricultural acreage in the valley, as well as providing vitally-needed supplies for additional prime irrigable lands, requires supplemental supplies over and above Rio Grande supplies which are fixed by International Treaty and court adjudicated decree.

Additionally, existing water quality problems, storage and conveyance system inadequacies, and drainage problems must be resolved.

Problem Area 13, Subregion 1302 (Texas), 1303 and 1305

Water Supply and Quality Problems in Small Cities and Rural Communities as a Consequence of Implementing the 1974 Safe Drinking Water Act; (Public Law 93-523).

An assessment was made by the Texas Water Development Board of all of Texas' public water systems which could not comply with the Environmental Protection Agency's (EPA's) Interim Primary Drinking Water Standards of the Safe Drinking Water Act of 1974 (Public Law 93-523). This assessment used water qualty information obtained from the records of the Texas Department of Health Resources as of May 14, 1976. Results of the assessment indicated that a total of approximately 600 public water systems in the State will be in violation of the EPA Interim Primary Standards with the majority of these being unable to meet the maximum standards set for the contaminant fluoride, with many in noncompliance due to excessive nitrates or both. Compliance with the EPA Interim Primary Standards is mandatory and many of the water systems will encounter financial difficulties in providing and operating the necessary treatment facilities or alternative sources of supply to meet the proposed standards. A significant portion of the population of Texas (an estimated 6 percent, or 734,000 persons) resides in areas where the current water supply system cannot meet the EPA Primary Standards of the 1974 Safe Drinking Water Act. These areas vary in density from a few people per residence to somewhat higher concentrations.

The relatively small size of these systems and the low density of customers create financial problems of recapturing fixed costs of investments in facilities required to meet the new standards. In addition, rising costs of electricity, labor, and other impacts have significantly increased overall plant operating costs and will continue to impose sometimes insurmountable obstacles in meeting the new Federal standards.

The Safe Drinking Water Act requires continuous monitoring through tests performed by the Texas Department of Health Resources. Water quality must satisfy the tolerances established by the Act and reflected in the tests. Increases in fixed costs for the mandatory facilities are anticipated along with increases in variable operating costs. These increased costs will result in increased per-connection costs to users which are in many instances below the poverty level income.

An estimated 504 Texas systems (serving populations below 2,500) are deemed economically infeasible for improvement under requirements of the Interim Primary Standards. Almost all of the systems in need of improvement do not comply with the fluoride requirements. A large number of systems suffer from nitrate contamination. The population served by the above systems was estimated to be 500,000 persons.

If the contaminants cannot be removed through the installation of equipment financed through local taxes or revenue, some form of public assistance will be required. Many of the systems in need of treatment facilities are currently ineligible for loans and grants from the Federal government. At present, the State cannot directly assist private water systems. Populations served by the non-complying systems are in danger of water supply loss. The severity of the problems associated with the Safe Drinking Water Act are also increasing since many rural areas are gaining from out-migration from urban areas.

Problem Area 14, Subregions 1302 (Texas), 1303 and 1305

Flood Problems and Hurricanes

Flooding occurs when streamflow exceeds channel capacity. Historically throughout the State of Texas, floods have resulted in the loss of human life, as well as caused serious economic damages to urban areas, to agriculture, and to transportation and utilities industries. Because of the wide variations in climate and physioigraphy of Texas, the magnitude and character of floods differ widely, both within and among the major river basins.

In the central and western portions of the Rio Grande in Texas (subregions 1302, 1303, and the upper part of 1305), ground and tree cover is sparse. Stream slopes vary from steep to moderately steep. During periods of intense rainfall, runoff is rapid, with high peak flows, high stream velocities, and shorter periods of land inundation. Flood frequency and estimated damages are documented by the U.S. Corps of Engineers.

Estimated flood damages in the Rio Grande Basin in Texas since 1950 are itemized in Table 13-9; specific damages for the farm-county area in subregion 1305 from hurricanes Beulah and Fern are given in Tables 13-10 and 13-11, respectively.

In the lower reaches of the Rio Grande (subregion 1305) broad, flat, crested floods move slowly and cause prolonged periods of inundation. The lower Rio Grande Valley (Cameron, Hidalgo, Starr, and Willacy Counties) has severe flooding problems caused by inadequate drainage. Flooding can result from stream overflow, overapplication of irrigation waters, or concentrated rainfall associated with hurricanes. Without massive drainage improvement in the lower Rio Grande Valley, limited use of productive agricultural land and flooding damages will continue. Flood-plain management and/or structural controls are necessary to alleviate flood damages in the upper region of subregion 1305, and in subregions 1302 and 1303.

Table 13-9.--Estimated flood damages in the Rio Grande Basin in Texas, 1950 to present

Year	Watershed	Damage category	Dollars (value at time of damage)
1950	Rio Grande (city of El Paso)	Total	$ 450,000
1954	Devil's River (cities of Ozona, Juno, Lake Walk)	Agriculture	1,033,000
		Urban/suburban	3,700,000
1955	Rio Grande (city of El Paso)	Urban/suburban	1,680,000 (1972 dollars)
1958	Rio Grande & Cibolo Creek (city of Presidio)	Agriculture	1,800,000
		Urban/suburban	200,000
1958	Rio Grande (city of El Paso)	Agriculture	5,000
		Urban/suburban	2,200,000
1962	Rio Grande (city of El Paso)	Agriculture	5,000
		Urban/suburban	1,678,000
1963	Rio Grande (city of El Paso)	Total	55,000
1965	Sanderson Canyon (city of Sanderson)	Agriculture	4,000
		Urban/suburban	2,660,000
1966	Rio Grande (city of El Paso)	Total	144,000
1967	Rio Grande (city of El Paso)	Total	585,000
1968	Rio Grande (city of El Paso)	Total	539,000
	Rio Grande (city of Presidio)	Total	560,000
1974	Rio Grande & Cibolo Creek	Agriculture flood control structures and railroads	2,447,000

Table 13-10.--Flood damages from Hurricane Beulah, 1967

County	Damage category	1975 dollars (value at time of damage)
Cameron	Total	$16,404,000
Hidalgo	Total	20,700,000
Starr	Total	4,700,000
Willacy	Agriculture	504,000
	Urban/suburban	2,296,000
Total		$44,604,000

Table 13-11.--Flood damages from Hurricane Fern, 1971

County	Damage category	1975 dollars (value at time of damage)
Cameron	Agriculture	$ 447,000
	Urban/suburban	40,000
Hidalgo	Agriculture	2,302,000
	Urban/suburban	192,000
Starr	Agriculture	1,348,000
	Urban/suburban	154,000
Willacy	Agriculture	240,000
	Urban/suburban	830,000
Total		$ 5,553,000

Problem Area 7, Subregion 1302

Water Supply and Related Quality Problems in the El Paso Area

There are four major sources of fresh water in El Paso County. Three are ground-water sources and consist of (1) the Hueco Bolson deposits in which fresh ground water occurs just east of the Franklin Mountains in a trough-shaped subsurface zone extending from the Texas-New Mexico State line southward to the Rio Grande into Mexico; (2) the La Mesa Bolson deposits which underlie the Texas portion of the Mesilla Valley west of the Franklin Mountains; and (3) the Rio Grande alluvium which overlies the Hueco and La Mesa Bolson deposits in the El Paso Valley and Mesilla Valley, respectively.

The fourth source of water for El Paso County is the Rio Grande, with water being provided for irrigation and a small quantity of public supply by the Bureau of Reclamation's Rio Grande Project of New Mexico and Texas from storage in Elephant Butte Reservoir in New Mexico.

The city of El Paso is the largest user of ground water in the county. The major source of the city's water supply is the Hueco Bolson deposits. The three aquifers in the La Mesa Bolson deposits and the Rio Grande alluvium in the Mesilla Valley are secondary sources. A third source of the city's water supply is surface water from the Rio Grande obtained through contracts with the El Paso County Water Improvement District No. 1 which in turn receives its water allotments from the Rio Grande Project. Other municipal and industrial users of ground water in El Paso County include Fort Bliss, an electric utility, a natural gas company, two oil refineries, a copper refinery, several golf courses, and a dairy.

The city of Juarez just across the Rio Grande from El Paso in Chihuahua, Mexico, is the second largest user of ground water for municipal and industrial purposes in the El Paso area. Their source of ground water is the Hueco Bolson deposits which, as indicated previously, are the primary source of water for the city of El Paso.

Total ground-water pumpage for municipal and industrial supplies in El Paso County amounted to about 101,074 acre-feet in 1974. About 80 percent of this amount was pumped by municipalities, primarily the city of El Paso, and about 20 percent was pumped by various industries. In 1974, Juarez pumped about 37,133 acre-feet of ground water from the Hueco Bolson deposits for municipal and industrial use.

The major use of surface water in El Paso County is for irrigation of 55,000 to 58,000 acres in El Paso and the valleys in the El Paso County Water Improvement District No. 1.

During periods when surface water deliveries from Elephant Butte Reservoir to these valleys are low, ground water from the Rio Grande alluvium is used as a supplementary water supply. In 1974, approximately 173,502 acre-feet of Rio Grande Project surface water was used to irrigate 55,195 acres in the two valleys. In 1964, during a period of low surface water delivery, 120,303 acre-feet of ground water was pumped while only 20,378 acre-feet of project surface water was used.

Ground water from the Hueco Bolson deposits is being mined in El Paso County and the Juarez area. It has been estimated, through the use of an aquifer model, that in 1903, about 11.45 million acre-feet of fresh ground water was in storage in the Hueco Bolson deposits in El Paso County. In 1973, the amount in storage had been reduced to 10.64 million acre-feet. One application of the model indicates that by 1990 storage will be decreased to about 9.84 million acre-feet. Depletions in storage are causing saline water encroachment from aquifers and degradation of ground-water quality. The amounts of fresh to slightly saline water that can be removed under "safe yield" conditions have not as yet been determined. In 1974, about 99,700 acre-feet of water was pumped from the Hueco Bolson deposits in El Paso County and by the city of Juarez in Mexico. Studies indicate that the aquifer received about 6,000 acre-feet per year of natural recharge and about 21,000 acre-feet per year of water from induced recharge (leakage) from the Rio Grande alluvium. Induced recharge or leakage from the alluvium is slowly degrading the quality of ground water pumped from the Bolson deposits. Water quality degradation will also occur due to lateral and vertical encroachment of saline water from adjacent saline water sands in the Bolson deposits as the fresh to slightly saline water in storage is depleted.

The El Paso area has surface-water supply and quality degradation problems also. In the last 20 to 30 years, Elephant Butte Reservoir has been able to deliver about 65 percent of the water originally planned for the Rio Grande Project. At the El Paso gaging station, the rate of annual depletion in discharge of the river averaged about 16,400 acre-feet over a 65-year period (1907-1972). These types of water shortages coupled with agricultural, municipal, and industrial return flows have caused and will continue to cause water quality degradation in the area.

Summary

The Rio Grande Region has a total drainage area of 230,000 square miles of which 93,000 square miles are in Mexico. Forty-eight thousand square miles drain into closed basins. Elevations in the region vary from 14,000 feet to sea level. Most of the economic activity lies within the valley areas. The region has a semiarid to arid climate with low humidity and erratic rainfall. Average annual precipitation varies from 30 inches in the high mountains and lower Rio Grande Coastal Plain to only 8 inches in the middle valley area, where most of the precipitation occurs as intense thunderstorms. Average annual temperatures vary from about 42°F in the north to 74°F in the lower valley. Growing seasons vary from less than 100 days annually in the northern mountain valleys to more than 310 days in the lower valley.

The 1975 population was estimated to be 1,695,000, according to national estimates. The regional population is projected to reach 1,875,000 by 2000, with 75 percent of the increase to occur in New Mexico.

The region's per capita income is only $4,761 and ranks in the bottom 10 percent nationally. Eighty percent of the employment is in the non-product sector, such as trades and services. Of the remaining 20 percent, 10 percent is employed in manufacturing, 7 percent in agriculture, and 3 percent in mining. There are 87,222,000 acres of land within the region. Seventy percent of the lands are in private, State, or municipal ownership; 27 percent in Federal ownership; and 3 percent are Indian lands. Of the 27 percent federally-owned lands, 13 percent are national resource lands, 9 percent national forest lands, and 5 percent other, including national parks, national defense, wildlife refuges, and Bureau of Reclamation lands. Seventy-two percent of the lands are used for pasture and range. Forest and grazed woodlands constitute 17 percent of the total land. Only 3 percent is used for cropland cultivation, with most of the croplands irrigated. Only 1 percent of the lands is devoted to urban and built-up areas. About 6 percent of the lands are used for parks, military, wildlife refuges, and water resource developments.

There are 15,048,000 acres of timberlands, but the industry contributes less than 5 percent of the region's total earnings. The region leads the Nation in uranium and potash production. Petroleum and natural gas are the region's leaders in mineral production. The energy base (uranium, petroleum, natural gas, and coal) holds promise for industrial potential.

There were 10,733 gWh of electric energy generated within the region in 1975, of which less than 2 percent was hydroelectric. It is expected that electric energy generation will be 2.5 times that of 1975 in 2000. There is sufficient energy within the region's environs to meet foreseeable demands, if properly developed.

Water is a vital necessity for human habitation within the region and is carefuly administered. All waters are legally administered through the appropriation doctrine, international treaties, and interstate compacts. Currently, all waters are legally committed to use. Indians in the region have water rights, and these rights are protected by the Federal Government.

The estimated average outflow of the Rio Grande at the mouth is 1,230 mgd. The estimated total available flow is 4,813 mgd. The difference would indicate a stream depletion of 3,583 mgd, but there is a question concerning depletions from 1,100,000 acres of irrigation in Mexico and uncertainties regarding closed basins and phreatophyte uses in computing the total available flow. The erratic flows of the Rio Grande and tributaries are somewhat regulated by a regional storage capacity of almost 8 million acre-feet.

Total consumptive use in the region in 1975 was 4,240 mgd. Sixty-seven percent of withdrawals were consumed. Irrigation consumed 92 percent, domestic uses consumed 3 percent, and all other uses consumed less than 6 percent. Ground water is an important segment of the region's water supply with 2,335 mgd withdrawn. Evaporation from large reservoirs and small ponds in the region is estimated at 730 mgd. It is estimated that consumptive use will decrease to 4,016 mgd by the year 2000. It is expected that consumption will increase from 67 percent in 1975 to 71 percent of withdrawals in 2000. Shifts in use will be from irrigation to other uses, with irrigation consuming 89 percent of the water withdrawn in 2000.

Shortages exist in meeting current uses, and those uses may only be fulfilled, if at all, through conservation. The instream flow approximation of 2,287 mgd cannot be met as long as existing offstream uses continue. Some retirement of irrigation in the region is anticipated to help balance the withdrawals and recharge. In addition, large blocks of water will be transferred from irrigation to other uses.

Water in the basin is used and reused. Each use adds to the salinity, as the salts, in general, must be returned to the stream system. Water quality is a serious problem in the lower Rio Grande Valley and precludes or inhibits expanded use of the valley under present conditions.

Organic pollution is a minor problem within the region, the major problem being dissolved solids and suspended solids. Colorado mill effluents and sediments should be controlled. In both the Pecos and the Rio Grande, quality of both ground waters and streamflows is becoming a serious problem, and feasible means of improving qualty need to be found. Soils in the region are relatively unprotected by vegetative cover and are subject to gullying and erosion during storm runoff periods. Erosion produces large sediment loads that result in siltation of canals and reservoirs and aggrade stream channels.

Flooding affects all portions of the region but is most severe in Texas. The El Paso area is particularly affected. In the lower valley, flooding problems are aggravated by inadequate drainage. Flooding can result from streamflow, overapplication of irrigation waters, or concentrated rainfall associated with hurricanes. Flood damages (estimated at the time of damage) from Hurricane Beulah in 1967 amounted to $44,000,000 and from Fern in 1971, $5,550,000.

Texas also has a problem in providing satisfactory domestic water supplies under the 1974 Safe Drinking Water Act. Many communities will have to have improved systems, which they are unable to finance. In addition, 20 percent of the lower valley population is not served by public water supply systems. This situation is likely to be aggravated by the increasing population in that area.

The primary problems in the region are associated with providing a water supply to accommodate an increase in population from 1,695,000 people in 1975 to 1,875,000 by 2000. No additional water supply is currently available for the majority of this population increase. Industrial expansion is anticipated to provide the economic base for the population expansion, which means transfers of water from irrigation and increased conservation. Reduction of nonbeneficial uses through phreatophyte control is a key issue. Basically, problems in the Rio Grande are related to water management and control.

Conclusions and Recommendations

General

Water supplies are limited in the Rio Grande Region. Shortages occur frequently. Even though regional water supplies for beneficial uses are limited, excess waters often produce flooding, erosion, and sedimentation problems largely due to concentrated thunderstorms on erodible soils, which are barren or sustain only a sparse arid-type vegetation.

Reservoir projects and regulating works constructed in the past have been storing and continue to store water during wet periods for use in dry periods. This is necessary for sustaining the regional agricultural economy, municipal and industrial water supplies, and other functions and uses.

Water supplies could be further stabilized by additional storage and regulation. In the long run, there is a definite need also to reduce nonbeneficial consumptive uses by phreatophytes to help meet the growing water needs of the people of the region. Without augmentation of water supplies, municipal and industrial (M and I) growth needs will probably be met through the year 2000 and beyond by transferring irrigation water rights to M and I through open market transactions.

The serious salinity problems in the region, particularly those on the Rio Grande in the El Paso area and on the Pecos River in New Mexico and Texas, will continue to plague the region unless a comprehensive water quality improvement program is undertaken. It is recommended that such a program be authorized at the earliest practicable time by the Congress for initiation by the United States in cooperation with New Mexico, Texas, and the U.S. Section of the International Boundary and Water Commission.

The monitoring of water supplies and analysis of existing and pending problems rely upon an array of basic data, as summarized in the SRF reports. The National Future data have been summarized on hydrologic boundaries. Water administration relates to State boundaries. Much of the data presented in the modified Central Case Studies (NF) is of little value in State planning and implementation. The summarization and analysis of these data are a State and national issue. The States of the Rio Grande Region recommend that data be related to both hydrologic and State boundaries.

The region supports a comprehensive and related land resources development program. Developments must be planned and implemented in balance with evaluations of environmental values. An existing impediment to objective analysis is the prevalent confusion surrounding environmental concerns. Uncertain and vacillating administration of environmental programs is hindering progress in meeting the people's essential water and related land needs within the region. Streamlining of Federal procedures is recommended so decisions may be expeditiously reached on both public and private developments relating to the utilization, conservation, development, and control of the region's water and related land resources.

Level B Studies in the Rio Grande Region under sponsorship of the Water Resources Council are not recommended at this time by representatives of the States of Colorado, New Mexico, and Texas. Specific conclusions by each of the three States follow.

Colorado

The Rio Grande headwaters (subregion 1301) are experiencing problems related to a lack of dependable water supply for irrigation and other uses. A great quantity of water is being nonbeneficially consumed by evaporation and by the phreatophyte growths in the sump area of the closed basin due to lack of drainage to the Rio Grande. In addition, the river basin has many significant water and related land resource problems, including water quality, drainage of wetlands, flooding, erosion and sedimentation from storm runoff, and wind erosion. The environment of the forest is being adversely affected by a demand for outdoor recreation facilities in excess of supply. There is a lack of jobs for the unemployed farm labor force.

The Rio Grande headwaters are currently experiencing severe water related land use problems. Although many studies have been made of the problems, the objectives have generally been agency oriented, single purpose in scope, limited geographically, and not sufficiently oriented. For these reasons, we conclude that the Resource Conservation and Development (RC&D) and U.S. Department of Agriculture cooperative river basin studies in the Rio Grande headwaters (subregion 1303), when completed, will be beneficial to the State of Colorado, because they will define the problems and needs in greater detail and recommend plans for their resolution. The planned Closed Basin Project is a major solution for meeting the Rio Grande Compact Commitment and for providing additional water for irrigation, as well as providing drainage for the wetlands.

New Mexico

Federal and State data used in the study

In general, the National Future (NF) data provided by WRC were compiled for subregions which in most cases do not follow State boundaries or hydrologic areas within States. In the Rio Grande Region, subregion 1302 includes parts of Texas and New Mexico, and comparisons of SRF and NF data in New Mexico cannot be made. Thus, differences cannot be identified. Although subregion 1304 lies entirely within New Mexico, comparisons of NF and SRF data in this subregion did not show general agreement, partly because subregion 1304 does not include parts of some counties which contribute both to the economy and natural resources of the Pecos River Basin. For the most part NF data is of limited usefulness to New Mexico in providing economic, water, and related land resource statistical information.

Existing laws, regulations, and compacts that regulate and control water use within States or between States appear to be ignored by the NF data. State laws, interstate compacts, and court decrees affect present and future use of water supplies and must be considered in determining the availability of supplies for various uses at various locations.

The State recommends that: (1) data used in future studies, either based on State or hydrologic boundaries, be disaggregated by State boundaries so that data breakdowns and study results may be readily applicable for State purposes; and (2) such studies fully consider and apply the several legal constraints which affect the multiple use and reuse of the available water supplies.

Problems in the Rio Grande Region in New Mexico

Common problems throughout the Rio Grande Region in New Mexico are as follows: (1) limited surface water supplies; (2) in much of the State area, yields from ground-water aquifers are low to moderate and the quality of water is generally poor; (3) surface water runoff results in flood damage in urban and rural areas; (4) headcutting and sheet erosion destroy range and cropland, add sediment to the streams, and affect crop production and livestock grazing capabilities; (5) a study by the U.S. Bureau of Outdoor Recreation indicates large deficiencies in surface water required for projected recreation demands; (6) quantification of Indian and Federal water rights is lacking and is needed.

In the Rio Grande Region of New Mexico, surface-water supplies are fully appropriated or committed, mostly for irrigation purposes. Uses for other than irrigation of these supplies would require a transfer of use from irrigation. Increased demands for uses other than irrigation could result in drying up large, irrigated acreages and would have an adverse impact upon economic, social, and environmental conditions in the region.

Problems of ground-water quality and quantity, flooding, erosion, siltation, and sedimentation are being addressed by several existing studies and programs at the local, State, and Federal levels. The State recommends that ongoing watershed programs that encourage and utilize beneficial soil, water, and vegetative management practices be expedited.

Urban sprawl problems are in evidence in cities that are experiencing rapid growth. Water supply for municipal and industrial purposes is limited. Augmentation is possible if supplies can be obtained by retirement of irrigated agriculture and the transfer of water used for that purpose to municipal and industrial uses.

In the Rio Grande drainage, uncontrolled flood flows could result in major damage in parts of the basin. Quality of water in the Rio Grande decreases progressively downstream. High water tables under irrigated lands in parts of the middle and lower valleys require drainage for adequate crop production. High water-use phreatophytic growth invades poorly drained areas, stream channels, and reservoir delta areas.

In several areas of the region, ground water is being mined; that is, pumping from an aquifer exceeds recharge and ground-water levels are being lowered. This situation has affected the base flow of the Pecos River and has caused saline water to encroach into the fresh-water portion of the aquifer in the Roswell Artesian Basin in Chaves and Eddy Counties.

In Estancia Basin, Tularosa Basin, Salt Basin, Mimbres Basin, the Nutt-Hockett area, and Sunshine Valley ground water is used extensively for irrigation and also supplies municipal and other uses. The supplies are pumped from ground water in storage at a rate that exceeds recharge, and water levels are being lowered. The ground water in storage is limited and it is only a matter of time until pumping will become uneconomical for irrigation and extensive works will be required to supply municipal and other uses.

Except for Estancia and Roswell Artesian Basin, ground water in storage is probably sufficient to last through the period considered (1975-2000). In Estancia Basin, about 5,900 acres are estimated to go out of production by 2000. Elsewhere, because of dwindling ground-water supplies, irrigated lands will be reduced, commencing shortly after 2000.

In the Roswell Artesian Basin, the Pecos Valley Artesian Conservancy District has an ongoing program of purchasing and retiring irrigated acreage. This program will assist in bringing the basin into balance and may reduce the saline water intrusion into fresh-water supplies. About 3,300 areas have been retired under this program.

Texas

A problem of major concern to Texas is the water supply situation in the lower Rio Grande Valley. Starr, Willacy, Hidalgo, and Cameron Counties define the area of concern. The climate is subtropical and provides an excellent growing condition for high yielding winter vegetable crops, cotton, and citrus. Increasing appreciation of the sunny environment and associated amenities by people outside has induced a surge of in-migration to the area. Population is conservatively projected to increase 35 percent by 2000. Over 750,000 acres are irrigated and the water supply for all purposes is short of meeting requirements 70 percent of the time. The problem will get worse as the population and industry increase their demands. Inventories show there are over 500,000 acres of additional lands suitable for irrigation. Texas has found that meeting the future water needs and an additional potential for winter food crops are problems of national concern and recommends Federal assistance in addressing the problems.

The lower Rio Grande is subject to periodic flooding often associated with hurricane storms. Contributing to the problem is inadequate drainage. Proposals to correct the drainage condition have not adequately considered environmental problems. It is recommended that a program be developed that will satisfactorily consider all issues. The environmental concerns are of national significance; Federal participation should contribute to the resolution of the problem.

The El Paso SMSA and Juarez in Mexico anticipate a growing water need that exceeds a sustainable supply. The Bureau of Reclamation has instituted a basin-wide interagency study of potential solutions. The problem is of national and international concern. It is recommended that the study be pursued to a conclusion and potential solutions implemented as soon as possible.

Texas recommends that a reach of the Rio Grande previously proposed be included in the Wild and Scenic Rivers System. Without adoption of the proposal, many of the natural and scenic recreational attributes of the Rio Grande Wild and Scenic River would be lost.

Texas recognizes the need to achieve a balance between development and environmental concerns. However, water resource development for strong economic needs has been unnecessarily delayed or obstructed by uncertain and vacillating administration of environmental programs. Texas recommends that environmental programs and water resources developments proceed expeditiously in partnership in a mutually responsive manner to meet the demonstrated needs of the people.

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The United States Water Resources Council was established by the Water Resources Planning Act of 1965 (Public Law 89-80). The purpose of the Council is to encourage the conservation, development, and utilization of water and related land resources on a comprehensive and coordinated basis by the Federal government, States, localities, and private enterprises with the cooperation of all affected Federal agencies, States, local government, individual corporations, business enterprises, and others concerned.