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LOWER COLORADO RIVER BASIN

BY

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Contents

Illustrations

Tables

Lower Colorado River basin

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Description

The Lower Colorado River basin presents many strong contrasts in environment, culture, resources, and development. The physical geography is the main factor that has determined the course of development in the past and will continue to do so in the future.

That part of the Lower Colorado River basin lying in New Mexico is outlined on figure 1. Subbasins within this major drainage area

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are the Little Colorado River, San Francisco River, Gila River, and San Simon Creek (fig. 2). Counties and parts of counties included within the area are Hidalgo, Grant, Sierra, Catron, Valencia, and

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McKinley. Gallup is the only incorporated town in the area. Other communities of importance are Zuni, Reserve, Glenwood, Cliff, Redrock, and Rodeo.

Figure 1.--Drainage basins of New Mexico.

Figure 2.--Subbasins of the Lower Colorado River basin in New Mexico.

Drainage areas

The Little Colorado River subbasin in New Mexico has an area of some 5,165 square miles which includes three principle stream systems the Rio Puerco (of the west), the Zuni River, Carrizo Creek, and several minor systems. Only the Zuni is a perennial stream, it is formed by the junction of the Rio Nutria and Rio Pescado, both of which rise on the forested western slopes of the Zuni Mountains.

The San Francisco subbasin has an area of 1,905 square miles. The San Francisco river is perennial in most of its course in New Mexico, but the channel is sometimes dry in the reach immediately above Glenwood. In that area the valley is wide, the channel fill relatively thick, and the water disappears into the gravel, to reappear downstream. The river receives the flow of several perennial tributaries that rise in the Mogollon and Tularosa Mountains on the east side of the basin, and in the San Francisco Mountains and Blue Range on the west. The main perennial tributaries are the Tularosa River, Negrito Creek, Whitewater Creek, Apache Creek, and Saliz Creek. Jenkins Creek, Pueblo Creek, and Mule Creek drain a large area and have perennial flow in the upper part of their courses; they may contribute appreciable underflow to the San Francisco river through channel gravels in their lower reaches.

The Gila subbasin has an area of 3,490 square miles; the river normally is perennial from its source in the Gila Wilderness to the New Mexico-Arizona line but diversions for irrigation result in stretches of the river being dry at times. The Gila receives water from numerous small perennial creeks in the high country, the principal being Willow Creek, Beaver Creek, Taylor Creek, and Sapillo Creek. Mogollon Creek, Bear Creek, Duck Creek, Mangas Creek, and Blue Creek discharge water into the Gila by underflow through channel gravels. Each of these creeks has some perennial flow above the point of junction with the main stem of the Gila.

San Simon Creek subbasin has only 220 square miles in New Mexico. San Simon Creek, which flows to a junction with the Gila River in Arizona, is not perennial and has no tributaries of consequence in New Mexico. Flood flow from the west slopes of the Pelloncillo Mountains in New Mexico occasionally may reach the main channel. Tributaries, principally Cave Creek, rising in the Chiricahua Mountains in Arizona, may contribute some underflow to the San Simon Valley.

Topography and physiographic provinces

The contrasting environments of the Lower Colorado River basin in New Mexico result primarily from the diverse topography. The basin embraces parts of three sections in two physiographic provinces--the Navajo and Datil sections of the Colorado Plateaus province and the Mexican Highland section of the the Basin and Range province.

The Navajo section to the north is a young plateau country characterized by relatively low relief. Altitudes generally range from about 6,000 to 7,500 feet, above sea level, but, in places, reach 8,300 feet. The drainage ways are not deeply entrenched--canyons more than a few hundred feet deep are uncommon. Although the relief is not great, the topography is rough. Wide, flat-bottomed washes, bordered by step-cliffs of sandstone from 10 to 200 feet high rising to flat-topped table lands, are the conspicuous element of most of the region. Dissection of the broad Zuni uplift east and southeast of Gallup, locally, has produced a mountainous terrain. Young lava flows fill some of the wide shallow valleys. This is the transition zone between the Navajo Section and the Datil Section to the south.

The Datil Section of the Colorado Plateau Province is characterized by thick, widespread flows of volcanic rocks, remnants of flows, volcanic cones, and volcanic necks. Altitudes in much of the Datil Section range between 6,500 to 7,500 feet above sea level; in the Mogollon Mountains, near the southern margin of the section, altitudes reach nearly 11,000 feet.

The topography ranges from relatively level lava plains, having a relief of a few tens of feet, to canyoned plateaus and rugged mountains having relief of nearly 5,000 feet. The San Francisco and Gila Rivers originate in high plateaus and mountains and have cut deep canyons in their courses through the region. A part of these plateaus, mountains, and canyons are included in the Gila Wilderness and constitute one of the most beautiful and rugged areas to be found anywhere in the United States.

The small part of the Mexican Highlands province that lies in the Lower Colorado River basin consists entirely of aggraded desert plains. The Gila River is entrenched in these plains in the northern part of Hidalgo County and adjacent portion of Grant County. These plains also form the surface of San Simon Valley southwest of Lordsburg.

The plains are at an altitude of about 4,000 to 4,500 feet above sea level. The relief is low, abrupt variations of no more than 10 feet being the rule in San Simon Valley. The relief is greater in the areas bordering the Gila River. The Gila has cut sharply 300 to 500 feet into the plain and has developed a flat-bottomed inner valley up to one mile wide in the vicinity of Virden and Red Rock. Tributaries working headward into the plians from the inner valley have cut well-defined channels to a distance of 4 to 5 miles south from the river. The topography in this 4 to 5 mile wide strip along the river is moderately rough--some of the washes are bordered by gravel bluffs up to 100 feet high.

Topographic maps are available for all the area, though most of that north of 34°N. latitude is mapped at a scale of 1:250,000. Coverage at a scale of 1:24,000, 1:48,000 or 1:62,500 is available for the area south of latitude 33°N. Topographic maps at a scale of 1:125,000 are available for the area between latitudes 33° and 34°N. Published $7\frac{1}{2}$ minute or 15 minute-Quadrangles and the status of current topographic mapping projects in New Mexico are shown on figure 3.

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Figure 3.--Status of topographic mapping in New Mexico.

Geology

Rocks present in the Lower Colorado River basin range from Precambrian to Quaternary in age and include intrusive and volcanic igneous rocks, marine sediments, and continental deposits. Ore deposits occur at many places. The structure is complicated by the juxtaposition of the elevated lands of the Colorado Plateaus province and the complexly faulted lands of the Basin and Range province. Characteristics of both provinces are found interrelated along their common margins.

The various rock formations with their local structural modifications have widely different water-bearing characteristics. These characteristics, which have a great influence on the ecology of the basin, are summarized in table 1 along with the general physical characteristics and distribution of the rocks.

Sedimentary rocks

Stream-valley alluvium and bolson fill in the Gila, San Francisco, and Little Colorado River drainage basins, and in the San Simon Valley, consists of generally poorly sorted clay, silt, sand, and gravel, derived locally. A blue clay bed up to 400 feet thick is reported to underlie relatively well-sorted stream gravel in San Simon Valley (Schwennesen, 1917, p. 8-9).

The bolson fill in many places is moderately consolidated and locally well cemented. It is known to fill the San Simon Valley in New Mexico to a depth of at least 1,200 feet. The stream-valley deposits for the most part are not cemented; they are poorly sorted in the head-water areas, better sorted at lower elevations.

Marine and continental sediments consist mainly of limestones, dolomites, marine shales and sandstones, coal beds, "red-beds," local deposits of evaporites, and conglomerates. The limestones and dolomites are mostly dense, and the sandstones massive. The shales commonly contain much sandy material, disseminated gypsum, and locally beds of good-grade coal. The shale and coal beds underlie much of the drainage basin of the Little Colorado River but are not known further south.

The marine sediments, particularly the limestones and dolomites, locally are host rocks for ore mineralization in some of the mining districts of the basin. Alteration and mineral deposition most commonly occurs where the carbonate rock has been intruded by igneous rocks.

Igneous and metamorphic rocks

Igneous rocks of varied composition are found throughout the basin, but are concentrated in the high country of the San Francisco and Gila River drainage area in Catron and Grant Counties. There, the basalts, andesites, rhyolites, and associated rock varieties of volcanic origin make up a section estimated to be over 8,000 feet thick (Ferguson, 1927, p. 6). These rocks comprise the Datil Formation. Basalt flows of Quaternary age locally overlie bolson fill and rocks of Cretaceous age in western Valencia County, and east of Rodeo in Hidalgo County.

Granite and other deep-seated igneous and metamorphic rocks of precambrian age comprise the main mass of the Burro Mountains and underlie sedimentary rocks in the Little Burro Mountains, Silver City Range, and Zuni Mountains. Smaller intrusive masses have invaded both sedimentary and older igneous rocks locally. Such intrusions are found in the Peloncillo, Burro, Little Burro, Summit, and Mogollon Mountains where they commonly are associated with ore deposits.

Minerals

Mineral deposits of economic value have been found at many places in the basin, but occur mainly in the mountainous areas of the southern part. Most of the deposits have been known for many years and were described or mentioned by Lindgren (1910).

Lead, zinc, copper, and silver ores have been mined in the Peloncillo Mountains (Gillerman, 1958, p. 93). Ores of gold, tungsten, and fluorite have also been produced there, but in lesser amounts. Most of these ore deposits are in limestone, adjacent to dikes and sills of igneous rocks. Few of the mines in the Peloncillo Mountains have been active since about 1920.

An appreciable amount of gold and silver was produced in the late 1800's from a number of mines in the Steeple Rock district in the Summit Mountains, and in 1954 a small operation was being carried on in one of the old workings.

Ore deposits in the Burro Mountains and adjacent Little Burro Mountains have been worked for many years. Indians are reported to have mined turquoise in the Burro Mountains before the Spanish came, and the deposits were later mined extensively by Americans. Copper deposits in the vicinity of Tyrone (Paige, 1922) were located as early as 1871. The Phelps Dodge Corporation consolidated mining properties in the district about 1913 and for a few years during World War I, and immediately after, produced an appreciable amount of copper. Little activity other than exploratory drilling and maintenance has been carried on since about 1920.

The Black Hawk and White Signal districts in the Burro Mountains produced silver and gold in the period 1880 to 1900. The two districts in the early 1950's were the scene of additional exploratory drilling after radioactive minerals were found in some of the old mine workings (Lovering, 1956).

Fluorspar was mined extensively in the Burro Mountains (Gillerman, 1951) during World War II and for a time thereafter, but activity ceased about 1955. Some fluorspar has been mined also in the Zuni Mountains--there, as in the Burro Mountains, the deposits occur in the Precambrian granites. Manganese ore was mined and shipped from the Little Burro Mountains during the same period.

One of the better known, though now totally inactive mining districts is that of Mogollon (or Cooney) in southwestern Catron County (Ferguson, 1927). The district was discovered about 1875 and produced gold, silver, copper, and lead, with a total value of about $20,000,000 up to 1925. Mining on a large scale ceased in the early thirties but continued sporadically until the advent of World War II, when virtually all activity ceased. According to Ferguson (1927, p. 96-98) the possibilities for finding new ore bodies in the district are reasonably good; no exploratory work is known to have been done since publication of Ferguson's report.

No metal mining activity is known in the extensive area lying between the Mogollon district and the Zuni Plateau - Zuni Mountain area some 100 to 125 miles to the north. Salt has been mined for centuries from the shores and surface of salt lakes in the northwest corner of Catron County (Northrop, 1959, p. 275) and many deposits of coal have been located in beds of Cretaceous age in the area between Salt Lake and the Chuska Mountains. A few small coal mines are operated for local use in the Carrizo Creek-Zuni Plateau area. Coal has been mined in the past in large quantities near Gallup and some of the larger mines are still operating, though at reduced capacity.

Uranium ores are being mined from relatively small deposits at the northwest end of the Zuni Mountains, near Gallup.

Geologic mapping

The geology of the basin is shown on U.S. Geological Survey Miscellaneous Geologic Investigations Maps I-224 and I-344; at a scale of six miles to the inch (1:380,160) (Dane and Bachman, 1957 and 1961). These maps were compiled mostly from larger scale reconnaissance and detailed maps published at scales ranging from 1:125,000 to 1:48,000. Index maps and accompanying bibliographies shows the source of data used in the compilations. A few small areas, mostly underlain by bolson fill, never have been shown on large scale published maps.

Soils and vegetation

Soils

The general character of the soils of the basin are shown on figure 4. The soils of the bolsons commonly are low in humus, rich

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in soluble minerals, and tend to be alkaline. Locally they are sandy. Soil cover on the mountain slopes, above the bolson fill, usually is no more than a few inches thick where woodland cover is lacking. The soil cover is thick and contains large amounts of humus in the forrested areas of the Summit, Burro, Mogollon, Mangas, and Zuni Mountains.

The soils in the broader valleys along the lower reaches of the Gila and San Francisco Rivers are mostly sandy to silty and are suitable for agriculture. They usually are well drained and less alkaline than the bolson soils. Soils in the drainages north of the Gila-San Francisco basins tend to be somewhat more clayey as a result of being derived mainly from rock formations containing high percentages of shale and other fine-grained sediments.

Figure 4.--Soils resource map of New Mexico.

Vegetation

The general distribution of vegetative types in the basin is shown on figure 5. The valley floor and adjacent slopes are primarily

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areas of grassland and low brush. In the Burro, Summit, and Mogollon Mountains, the intermediate slopes commonly are dotted with pinyon, oak, and both high and low brush. Oak is less common and juniper more prevalent with progression to more northerly latitudes. Ponderosa pine and associated forest growth occurs generally between altitudes of 6,000 to 8,000 feet in the Summit, Burro, Mogollon, Zuni, and Chuska Mountains, and in the lesser mountain ranges of the middle and northern part of the basin. Spruce, fir, and aspen are found in dense stands at altitudes over 8,000 feet in the Mogollon and Chuska Mountains.

Figure 5.--Vegetative-type map of New Mexico.

Hydrology

The factors that control the hydrology of the basin are keyed to the climatology of the region. The source of all water in the basin is the precipitation that falls within the basin. All streams flowing out of the basin originate within the basin, and no ground water is known definitely to enter from areas outside; some underflow may move from the San Augustin Basin to the San Francisco River.

Climatology

The climate of the basin is mostly dry, the essential feature being that evaporation exceeds precipitation (Trewartha, 1937, p. 225). Only the higher altitudes in the Mogollon, Tularosa, Blue and San Francisco Mountains have a humid climate where perennial streams can originate.

The two commonly recognized (Trewartha, 1937, p. 226) subdivisions of arid climates -- desert and steppe -- are both present in the basin. The valley floors and lowlands are deserts, the transitional belts between the lowlands and the humid mountain areas are steppes.

The locations of weather stations and the climatological divisions in the basin are shown on figure 6. Figure 7 shows the average

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January and July temperatures and average dates of first and last killing frosts. Figure 8 shows the mean monthly temperatures at

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selected stations. Mean temperatures and average monthly precipitation rates for selected stations are shown in table 2. More detailed information on weather and climate is given in the monthly reports of the U.S. Weather Bureau.

Figure 6.--Weather stations and climatologic divisions in New Mexico.

Figure 7.--Graphs showing average January and July temperatures and average dates of last killing frost in spring and first killing frost in fall.

Figure 8.--Mean monthly temperatures at selected stations.

Table 2.--Mean temperature and precipitation at places in the Lower Colorado River basin, New Mexico 106

~~(U.S. Weather Bureau, 1959)~~

(From: Unpublished records of the U.S. Weather Bureau for the period of record through 1960) 93

Station	January		February		March		April		May		June		July		August		September		October		November		December		Annual	
	Temp. (°F)	Prec. (inches)	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.
Gallup	29.0	0.64	32.4	0.55	38.8	0.59	46.9	0.64	55.4	0.53	64.4	0.51	69.6	2.12	68.2	1.64	63.2	0.71	50.2	0.99	36.7	0.63	29.6	0.60	48.8	10.15
Zuni	29.8	.87	34.2	.77	40.0	.85	47.5	.66	56.0	.50	65.6	.44	70.8	2.10	69.0	1.72	62.9	1.17	52.0	.96	39.5	.59	31.3	.79	49.8	11.42
Quemado	29.4	.66	33.1	.57	38.1	.70	44.6	.57	53.4	.52	62.7	.61	67.2	2.10	65.4	2.10	60.1	1.20	50.0	.62	37.2	.42	31.2	.60	47.8	10.60
Glenwood	40.2	1.24	43.8	.85	48.8	1.02	56.6	.64	62.8	.37	71.8	.71	76.2	2.47	74.4	2.33	69.2	1.64	59.2	1.26	47.6	.69	41.8	1.25	57.7	14.47
Beaverhead	30.0	.88	33.2	.68	38.6	.68	45.0	.58	52.8	.39	62.0	.59	60.6	2.36	63.5	2.76	57.4	1.45	48.1	1.37	37.2	.36	31.9	.58	47.2	12.68
Cliff (near) 10 mi. SE	38.5	.93	41.4	.70	46.5	.86	55.0	.33	62.4	.16	72.6	.50	76.7	2.51	74.6	2.84	69.0	1.04	58.4	1.24	45.3	.41	39.2	.64	56.6	12.16
Rodeo	42.8	.72	46.6	.60	52.6	.59	59.0	.24	67.4	.21	77.4	.39	80.8	2.34	79.9	2.21	73.2	1.38	63.0	.84	50.6	.59	45.0	.85	61.6	10.96

Surface water

Streamflow measuring net

Streamflow records (table 3) for the Little Colorado River in New Mexico are available for Largo Creek near Mangas, Zuni River at Black Rock, and the Puerco River near Gallup. Records are available for the Gila River near Gila, Red Rock, Virden, and at the New Mexico-Arizona State line. Streamflow in the San Francisco River drainage basin is measured near Reserve, near Glenwood, and on Whitewater Creek near Glenwood. The discharge of San Simon Creek is measured near Rodeo, at the New Mexico-Arizona State line.

Runoff and virgin flow

The average annual runoff in acre-feet per year through 1963 also is given in table 3 for the major streams in the basin, and the average monthly runoff for the period 1913-51 is given in table 4 for selected stations. The periods of record are not the same for all stations and are not all continuous at the same station. The discharge records as shown in table 4 may be in conflict with discharge records found elsewhere. For example, runoff records of the San Francisco River have been used in previous reports to estimate the average annual runoff of the Zuni River for the period 1928-51; the estimated figure is 14,750 acre-feet whereas the period of record, 1910-30, shows an average annual runoff of 19,220 acre-feet.

Estimates of virgin streamflow (table 5) have been made by adding man-caused upstream depletions to the recorded or estimated streamflows. Much of the area of the Little Colorado River basin is ungaged and so virgin flow in that drainage is largely estimated. A relationship between runoff and drainage has been used to estimate streamflows diminished by upstream depletion. Upstream depletions were estimated for the Gila and San Francisco drainages from records of the Bureau of Census, U.S. Forest Service, and Bureau of Land Management. Estimates of upstream depletions for the Little Colorado drainage are based on data from previous studies.

Table 4.--Average monthly discharges and percentage distribution of monthly flows at selected stations, on the Gila and San Francisco Rivers, Lower Colorado River basin, New Mexico, 1913-1951.

Month	Gila River near Gila* drainage area = 1,870 sq mi		Gila River below Blue Cr. near Virden* drainage area = 3,220 sq mi		San Francisco River near Glenwood* drainage area = 1,660 sq mi	
Jan.	10,010 ac-ft	9.1%	19,150 ac-ft	13.2%	5,190 ac-ft	9.1%
Feb.	11,880	10.8	16,690	11.5	5,930	10.4
Mar.	19,800	18.0	24,810	17.1	9,980	17.5
Apr.	13,750	12.5	15,520	10.7	7,400	13.0
May	9,020	8.2	9,580	6.6	4,560	8.0
June	3,850	3.5	3,050	2.1	1,710	3.0
July	6,160	5.6	4,500	3.1	3,080	5.4
Aug.	9,350	8.5	9,870	6.8	5,930	10.4
Sept.	8,470	7.7	13,500	9.3	3,820	6.7
Oct.	6,820	6.2	9,720	6.7	2,740	4.8
Nov.	4,950	4.5	6,670	4.6	2,560	4.5
Dec.	5,940	5.4	12,040	8.3	4,100	7.2
Annual	110,000	100.0	145,100	100.0	57,000	100.0

* Records extended to full period.

Table 5.--Estimates of virgin streamflows in the

Lower Colorado River basin, New Mexico.

Gaging station	Estimated virgin flow	Remarks
Carrizo Wash at State line	5,110	Outflow point (essentially a closed basin)
Tributaries of Carrizo Wash at State line	210	Outflow point
Atarque (tributary of Zuni River) at State line	9,470	Outflow point
Zuni River at Black Rock Dam	19,480	
Zuni River at State line	28,960	Outflow point
Whitewater Draw at State line	1,990	Outflow point
Puerco River near Gallup	6,040	
Puerco River at State line	11,860	Outflow point
Black Creek at State line	2,890	Outflow point (includes 760 ac-FT. of inflow from Arizona)

The estimated virgin streamflow at the New Mexico-Arizona State line averages 60,490 acre-feet annually.

Gila River:		
Near Gila	91,540	No uses above station near Gila
Near Red Rock	129,000	
Below Blue Creek near Virden	129,260	
New Mexico-Arizona State line	131,340	Outflow point
Tributaries	980	Outflow point of ungaged tributaries
San Francisco River:		
New Mexico-Arizona State line	3,050	Inflow from Arizona
Near Reserve	15,910	Includes 3,050 inflow from Arizona
Near Glenwood	50,260	Includes 3,970 ac-FT of inflow from Arizona
New Mexico-Arizona State line	54,190	Outflow point. Includes 3,920 ac-FT of inflow from Arizona
Blue River:		
At New Mexico-Arizona State line	750	Outflow point
San Simon Creek	5,360	Outflow point. Includes 130 ac-FT of inflow from Mexico
Black Draw	340	Outflow point

Regulation

No large retention or regulatory dams have been constructed on the main stem of any of the principal streams in the basin. Two small retention dams, one at Wall Lake on the headwaters of the East Fork of the Gila and one at Lake Roberts on Sapillo Creek, a tributary to the Gila, were constructed to form lakes for recreational purposes. According to Forest Service records (oral communication), Wall Lake has a capacity of 126 acre-feet, and Lake Roberts a design capacity of 1,008 acre-feet.

The Indian Service reports (oral communication) that in the Little Colorado River drainage, the four Nutria Lakes have capacities of 10 acre-feet, 2,560 acre-feet, 700 acre-feet, and 800 acre-feet, respectively, McGaffey Lake, 110 acre-feet, Black Rock, 2,600 acre-feet, Bolton Lake, 500 acre-feet, Ojo Caliente, 325 acre-feet, Eustace, 300 acre-feet, Tekapo, 200 acre-feet, Rama, 1,500 acre-feet, Atarque, 1,000 acre-feet, and Pescado, 710 acre-feet; these are all man-made lakes created for recreation, irrigation, and limited flood control use.

Floods

All the principal streams and their tributaries in the basin are subject to flood runoff but no wide-spread damaging floods have been recorded. High water, verging on near-flood to flood stage, may occur on the main stems in the early spring if the snow pack in the high mountains has been heavy and weather conditions cause rapid melt. Most floods are of the local or flash type and occur during the summer rainy season from early July through September. The flash floods generally are confined to tributaries and are dissipated in the main stems.

The peak discharge of record for the period 1929-63 on the Gila River near Gila, and downstream at the station near Redrock occurred September 29, 1941, and was computed at 25,400 cfs (cubic feet per second) and 40,000 cfs, respectively (U.S. Geol. Survey, 1963, p. 198). The peak discharge of record for the period 1927-63 on the San Francisco River, near Glenwood, occurred January 13, 1949, and was computed at 7,800 cfs. A discharge of 25,000 cfs occurred at Alma (upstream from Glenwood) on November 26, 1905 (U.S. Geol. Survey, 1954, p. 605). Damage in New Mexico resulting from these floods is believed to have been restricted to loss of some crops, and silting and washing out of roads and irrigation facilities.

Sedimentation

Sediment-load sampling stations are located on the San Francisco River at the gaging station near Glenwood, and on the Gila River at the gaging station near Gila. Samples at the station near Gila are collected daily, and are collected monthly or semi-monthly at the station near Glenwood. The sediment load varies greatly at both stations but generally is low except during periods of flood. The concentration in Gila water commonly ranges from 5 to 200 ppm (parts per million) and 1 to 50 tons per day. It has dropped as low as 1 ppm and less than ½ ton per day. The maximum of record was 26,000 ppm and 130,000 tons per day. Peak sediment loads generally occur in August and September ~~(U.S. 1964)~~. The water in the San Francisco River shows similar characteristics. The concentration commonly is below 100 ppm and 10 tons per day, but has dropped as low as 10 ppm and 0.28 tons per day, and ranged as high as 2,470 ppm, and 190 tons per day.

Chemical quality

Periodic sampling of waters from the San Francisco and Gila Rivers for chemical analysis was started at two points in 1963; the sampling points are at the gaging stations near Glenwood and near Gila. Analyses made to September 1964 indicate that the waters from the rivers are of similar chemical character. Both are low in total dissolved solids. The Gila water has a specific conductance generally in the range of 275 to 351 micromhos at 25°C, averages about 300 ppm of dissolved solids, or 1/3 ton per acre-foot of water. The water is a calcium bicarbonate water which has a pH commonly about 6.9. The fluoride concentration averages about 1.5 ppm. The chloride content is low. The San Francisco water has a specific conductance ranging from about 290 to 365 micromhos and a pH averaging about 7.5. The chloride content is very low and the fluoride concentration is about 0.5 ppm (unpublished records of the U.S. Geological Survey).

Ground water

Economic development in the basin has not created a widespread demand for large quantities of ground water at any given place. The most important need for ground water has been for domestic and stock use. Almost all the rock formations will yield locally, if not generally, enough water for domestic and stock needs. Although all the rock formations contain some water, only a few can be considered good aquifers. (See table 1.) Known and probable aquifers are designated by asterisks in the stratigraphic-unit column.

Known and probable reservoirs

The alluvium of the stream valleys, and the bolson fill constitute the most important and the only known extensive ground water reservoirs. These reservoirs have been tapped in the Gila River Valley, locally in the San Francisco Valley, and in San Simon Valley. The alluvial reservoirs in the Gila and San Francisco Valleys are stream-connected, and recharge occurs simultaneously with ground-water withdrawal. The principal aquifer in San Simon Valley is the deeper bolson fill, and there ground-water withdrawals are mainly from storage. The alluvial aquifers in the channels and valleys of the Little Colorado River drainage system also are stream-connected. They are in general thin, and have not been developed for other than domestic and stock use. Because most of the streams in the drainage are intermittent, recharge occurs only during the infrequent periods of flow.

The bedrock underlying the bolson fill is largely unexplored so far as ground water is concerned. The rocks for the most part are the same as those found in the mountains flanking the valleys, and are presumed to have similar water-bearing characteristics, therefore, in general, to be poor aquifers, and to constitute reservoirs of limited capacity.

The bedrock of the mountainous areas of the southern part of the basin are composed mostly of intrusive rocks, and volcanic rocks of the Datil Formation. These rocks also are generally poor aquifers and constitute reservoirs of limited capacity. Granitoid rocks almost never yield more than a few gallons of water per minute to wells; the andesites and rhyolite rocks are nearly as poor.

The basalt flows of Recent age that lie in stream valleys may yield large quantities of water locally, and may serve as reservoirs of limited extent.

Limestone and sandstone rocks of Cambrian to Cretaceous age underlie, at varying depths, most of the drainage of the Little Colorado River. These rocks have not been adequately tested for ground water. It is possible, even probably, that the San Andres Limestone and the Glorieta Sandstone of Permian age, together, constitute a ground-water reservoir of great areal extent and tremendous capacity. The water in this reservoir has been tapped at several widely scattered points and locally has been found to be of poor quality. The distribution of water of good quality can be determined surely only by test drilling. It is possible also that large quantities of water occur in the limestone of Mississippian and Pennsylvanian age under the bolson fill, and under the volcanic rocks of the Datil Formation. These potential bedrock aquifers for the most part are not stream-connected and water developed would come primarily from storage. It is likely that artesian water would be found locally in these rocks in the Little Colorado River drainage area.

Supply

The volume of ground water available for development is great but so distributed as to make recovery in large quantities economically impractical at most places. Data are lacking for quantitative determinations of the overall supply in the basin. It may be said only that locally large supplies are available but must be sought out and tested for both extent and quality.

Chemical quality

Miscellaneous chemical analyses only are available for aquifers in the basin. In general ground water from stream-valley alluvium and from bolson deposits is of good quality, suitable for domestic, stock, irrigation, and most industrial uses. Total dissolved solids average about 250 ppm (parts per million) but range as high as 1,000 ppm. Generally water in the bolson fill has somewhat more dissolved solids than does water in the stream-valley alluvium.

Water in the intrusive and volcanic rocks also is of generally good quality although it tends to be somewhat more highly mineralized than water in the alluvium and bolson fill. Water in the volcanic rocks in the mining districts may be highly mineralized locally and unsuitable for domestic use. Fluoride in concentrations up to 12 ppm occurs in thermal spring waters originating in volcanic rocks at several places in the Gila drainage.

Ground water in the sedimentary rocks of Cambrian to Cretaceous age in the drainage of the Little Colorado River commonly is highly mineralized, except in the immediate vicinity of outcrops where recharge tends to freshen the water. The water as it moves away from the area of recharge rapidly picks up mineral matter from the thick sequence of carboniferous shales, limestones, and locally interbedded evaporites. Many wells in the vicinity of Gallup have total dissolved solids of more than 1,000 ppm.

Ground-water studies

Areas in which ground water investigations have been made in New Mexico are shown on figure 9, and areas in which water-level

Figure 9 (caption on next page) belongs near here.

measurements are made periodically are shown on figure 10. By far the

Figure 10 (caption on next page) belongs near here.

greater part of the Lower Colorado River basin in New Mexico has not been examined hydrologically. Virtually nothing is known of the occurrence and regimen of ground water in the vast area of the Mogollon Mountains and the plateau country of the Little Colorado River drainage, and only broad reconnaissance or local studies have been made in most of the adjacent areas. Extrapolation of data from these adjacent areas to the areas of no study requires that any conclusions drawn be considered with caution. No area should be rejected for development on the basis of these conclusions, and without first-hand investigation of hydrologic conditions.

Figure 9.--Areas in New Mexico in which ground-water studies have been made.

Figure 10.--Areas of observation of water-level fluctuation in New Mexico.

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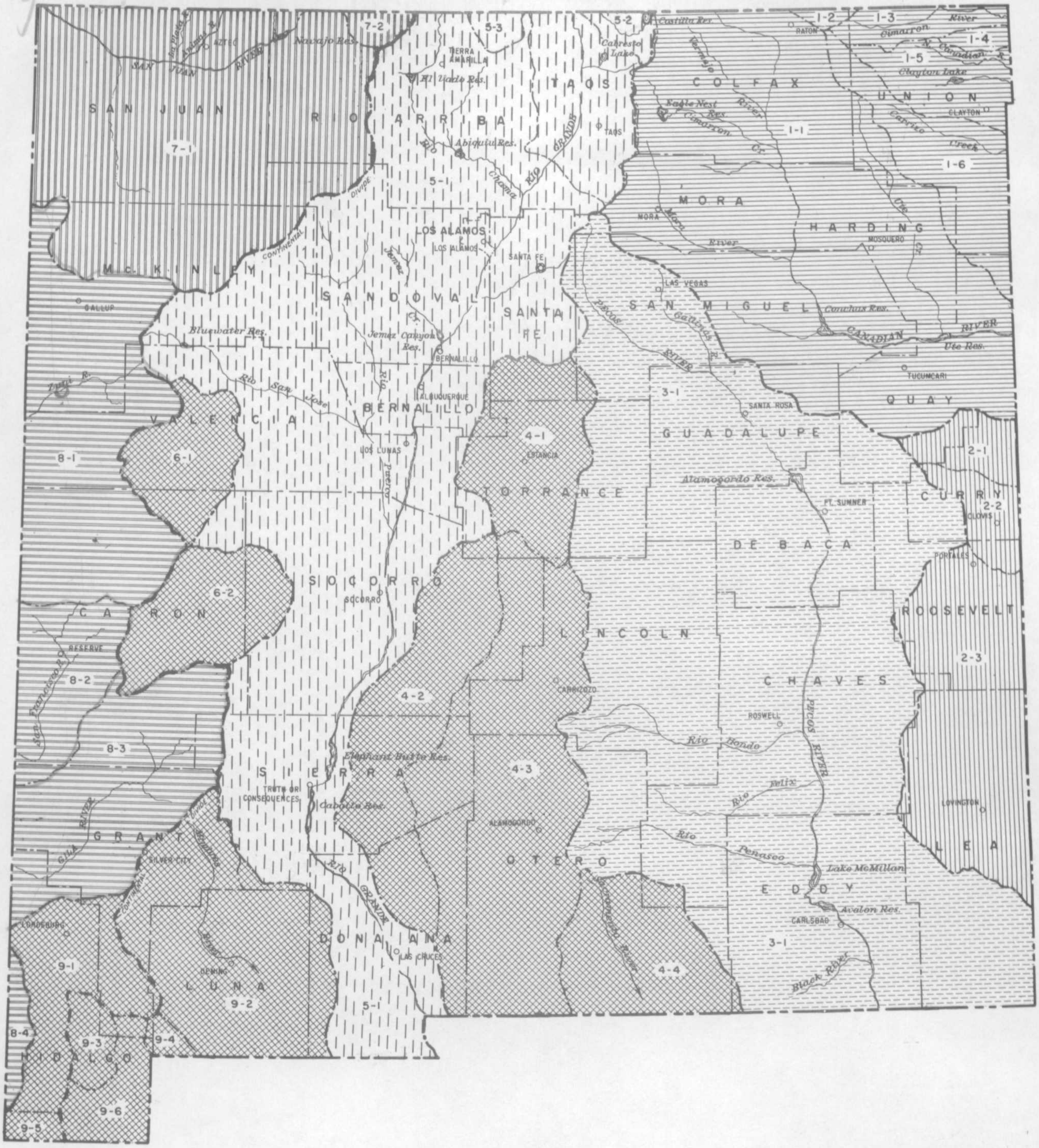
Table 2.--Mean temperature and precipitation at places in the Lower Colorado River basin, New Mexico

(From: Unpublished records of the U.S. Weather Bureau for the period of record through 1960)

Station	January		February		March		April		May		June		July		August		September		October		November		December		Annual	
	Temp. (°F)	Prec. (inches)	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.	Temp.	Prec.
Gallup	29.0	0.64	32.4	0.55	38.8	0.59	46.9	0.64	55.4	0.53	64.4	0.51	69.6	2.12	68.2	1.64	63.2	0.71	50.2	0.99	36.7	0.63	29.6	0.60	48.8	10.15
Zuni	29.8	.87	34.2	.77	40.0	.85	47.5	.66	56.0	.50	65.6	.44	70.8	2.10	69.0	1.72	62.9	1.17	52.0	.96	39.5	.59	31.3	.79	49.8	11.42
Quemado	29.4	.66	33.1	.57	38.1	.70	44.6	.57	53.4	.52	62.7	.61	67.2	2.10	65.4	2.10	60.1	1.20	50.0	.62	37.2	.42	31.2	.60	47.8	10.60
Glenwood	40.2	1.24	43.8	.85	48.8	1.02	56.6	.64	62.8	.37	71.8	.71	76.2	2.47	74.4	2.33	69.2	1.64	59.2	1.26	47.6	.69	41.8	1.25	57.7	14.47
Beaverhead	30.0	.88	33.2	.68	38.6	.68	45.0	.58	52.8	.39	62.0	.59	60.6	2.36	63.5	2.76	57.4	1.45	48.1	1.37	37.2	.36	31.9	.58	47.2	12.68
Cliff (near) 10 mi. SE	38.5	.93	41.4	.70	46.5	.86	55.0	.33	62.4	.16	72.6	.50	76.7	2.51	74.6	2.84	69.0	1.04	58.4	1.24	45.3	.41	39.2	.64	56.6	12.16
Rodeo	42.8	.72	46.6	.60	52.6	.59	59.0	.24	67.4	.21	77.4	.39	80.8	2.34	79.9	2.21	73.2	1.38	63.0	.84	50.6	.59	45.0	.85	61.6	10.96

Traugott — Lower Colorado



BASIN INDEX

ARKANSAS RIVER BASIN
1-1, CANADIAN RIVER
1-2, PURGATOIRE RIVER
1-3, CIMARRON RIVER
1-4, CARRIZOZO CREEK
1-5, NORTH CANADIAN RIVER
1-6, CARRIZO CREEK

SOUTHERN HIGH PLAINS
2-1, RED RIVER
2-2, BRAZOS RIVER
2-3, LEA PLATEAU

PECOS RIVER BASIN
3-1, PECOS RIVER

CENTRAL CLOSED BASINS
4-1, ESTANCIA BASIN
4-2, JORNADA DEL MUERTO BASIN
4-3, TULAROSA BASIN
4-4, SALT BASIN

RIO GRANDE BASIN
5-1, RIO GRANDE
5-2, COSTILLA CREEK
5-3, RIO SAN ANTONIO

WESTERN CLOSED BASINS
6-1, NORTH PLAINS
6-2, SAN AUGUSTIN PLAINS

SAN JUAN RIVER BASIN
7-1, SAN JUAN RIVER
7-2, NAVAJO RIVER

LOWER COLORADO RIVER BASIN
8-1, LITTLE COLORADO RIVER
8-2, SAN FRANCISCO RIVER
8-3, GILA RIVER
8-4, SAN SIMON CREEK

SOUTHWESTERN CLOSED BASINS
9-1, ANIMAS BASIN
9-2, MIMBRES BASIN
9-3, PLAYAS BASIN
9-4, WAMEL BASIN
9-5, SAN LUIS BASIN
9-6, HACHITA BASIN

Fig 1

FIGURE 1

DRAINAGE BASINS
OF
NEW MEXICO

Trauger — Lower Colorado

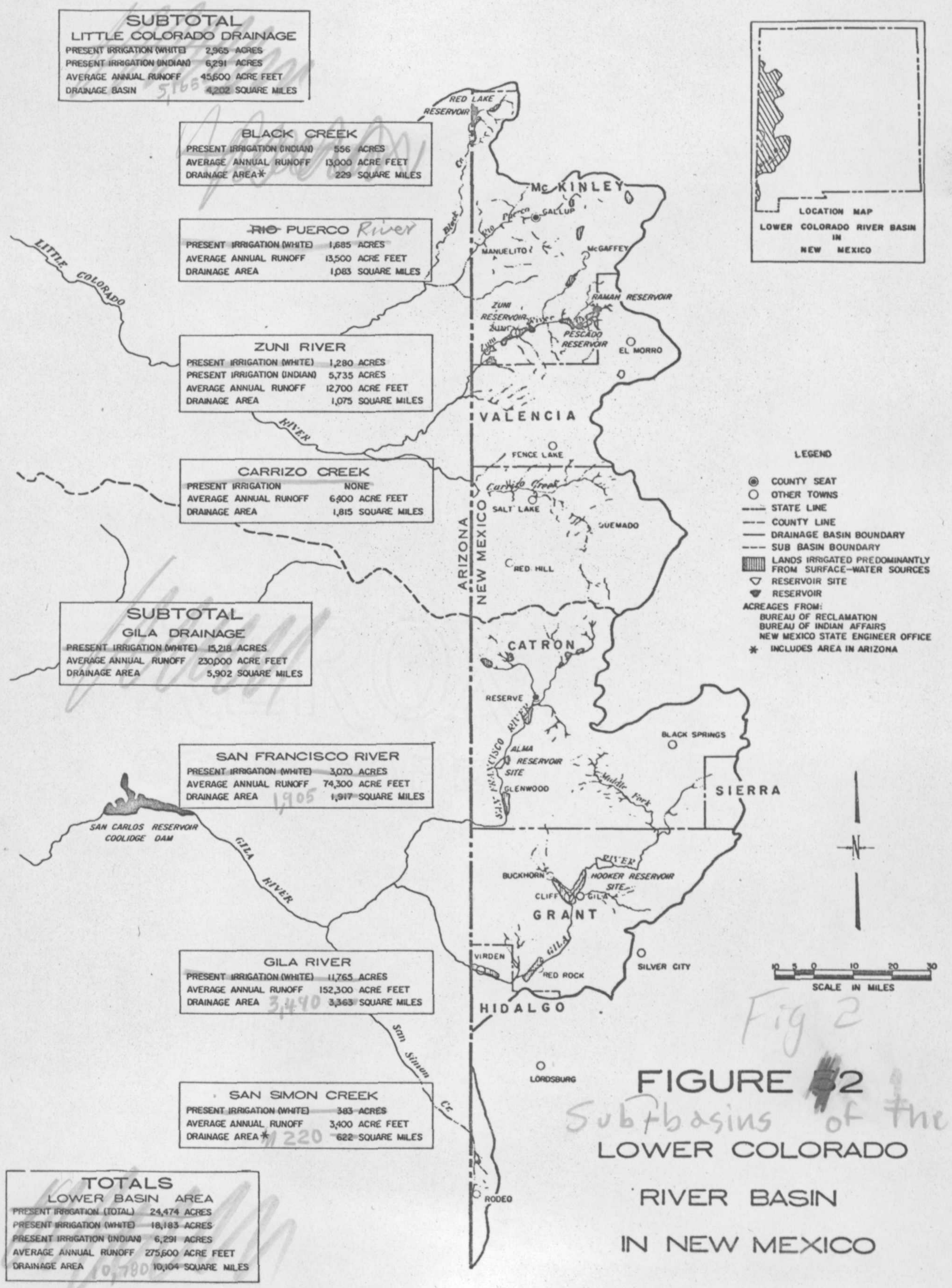


Fig 2

FIGURE 2

Subbasins of the

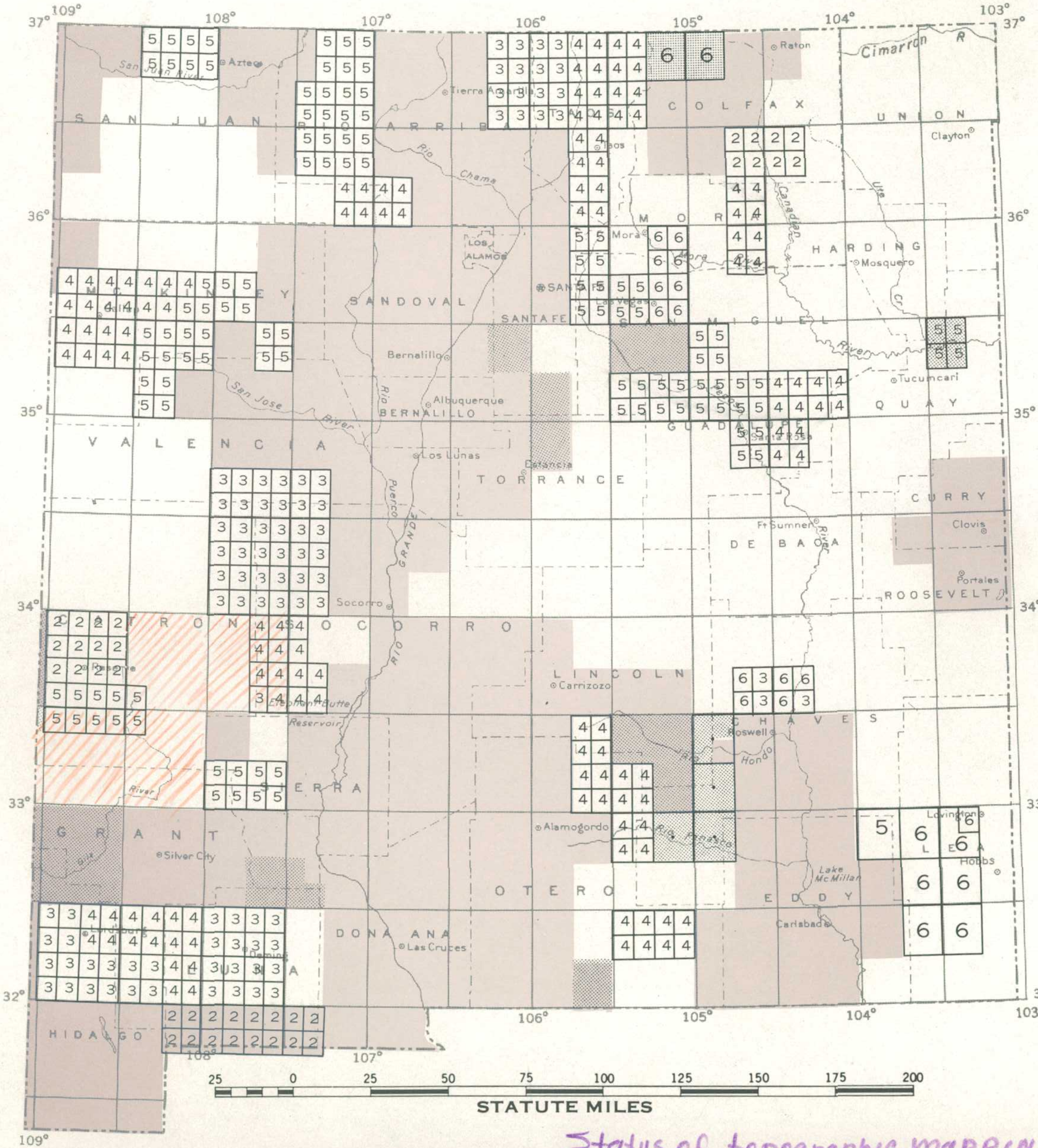
LOWER COLORADO RIVER BASIN IN NEW MEXICO

Traugr - Lower Colorado

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

NEW MEXICO

TOPOGRAPHIC DIVISON
ROCKY MOUNTAIN AREA
DENVER, COLORADO
OCTOBER 1, 1964



ADVANCE MATERIAL AVAILABLE FROM CURRENT TOPOGRAPHIC MAPPING QUARTERLY EDITION

2 — Aerial photography completed. Information available from U.S. Geological Survey, Topographic Division, Federal Center, Bldg. 25, Denver, Colorado, 80225, or Map Information Office, U.S. Geological Survey, Washington, D.C., 20242.

3 — Basic horizontal and vertical control surveys completed. Descriptions and unadjusted coordinates and/or elevations are available. Price 50 cents for each 15-minute quadrangle horizontal or vertical control list. See notes.

P 4 — Prints of manuscripts compiled from aerial photographs are available at 50 cents each. Contours are shown in areas suitable for stereocontouring. Letter "P" indicates quadrangles on which contouring is not complete and which will require fieldwork to complete the contouring. (If shaded, see explanation below.)

5 — Field mapping and checking completed. One-color advance prints (without names) available for 50 cents each. (If shaded, see explanation below.)

6 — Final drafting completed. Partially-edited one-color advance prints (with names) available for 50 cents each. (If shaded, see explanation below.)

· — Maps published since latest edition of Index to Topographic Mapping— May, 1964. See statement below regarding published maps. (If shaded, see explanation below.)

EXPLANATION OF SHADING

Maps of areas shaded will be (or have been) published at 1:62,500 scale only. However, 1:24,000-scale advance prints in 7½-minute units (without names) are and will remain available, with accuracy and contour interval appropriate for that scale. Each 7½-minute print is 50 cents, or $2 for prints covering a complete 15-minute quadrangle.

NOTES

1. Send requests for control lists and advance prints to U.S. Geological Survey, Topographic Division, Federal Center, Bldg. 25, Denver, Colorado, 80225. Check, money order or draft in correct amount made payable to U.S. Geological Survey should accompany order. Please do not send stamps. No discount allowed.

2. In ordering materials or requesting information, mark the area of interest on this index and forward it with your order. A new copy of the index will be returned to you for future use.

PUBLISHED MAPS

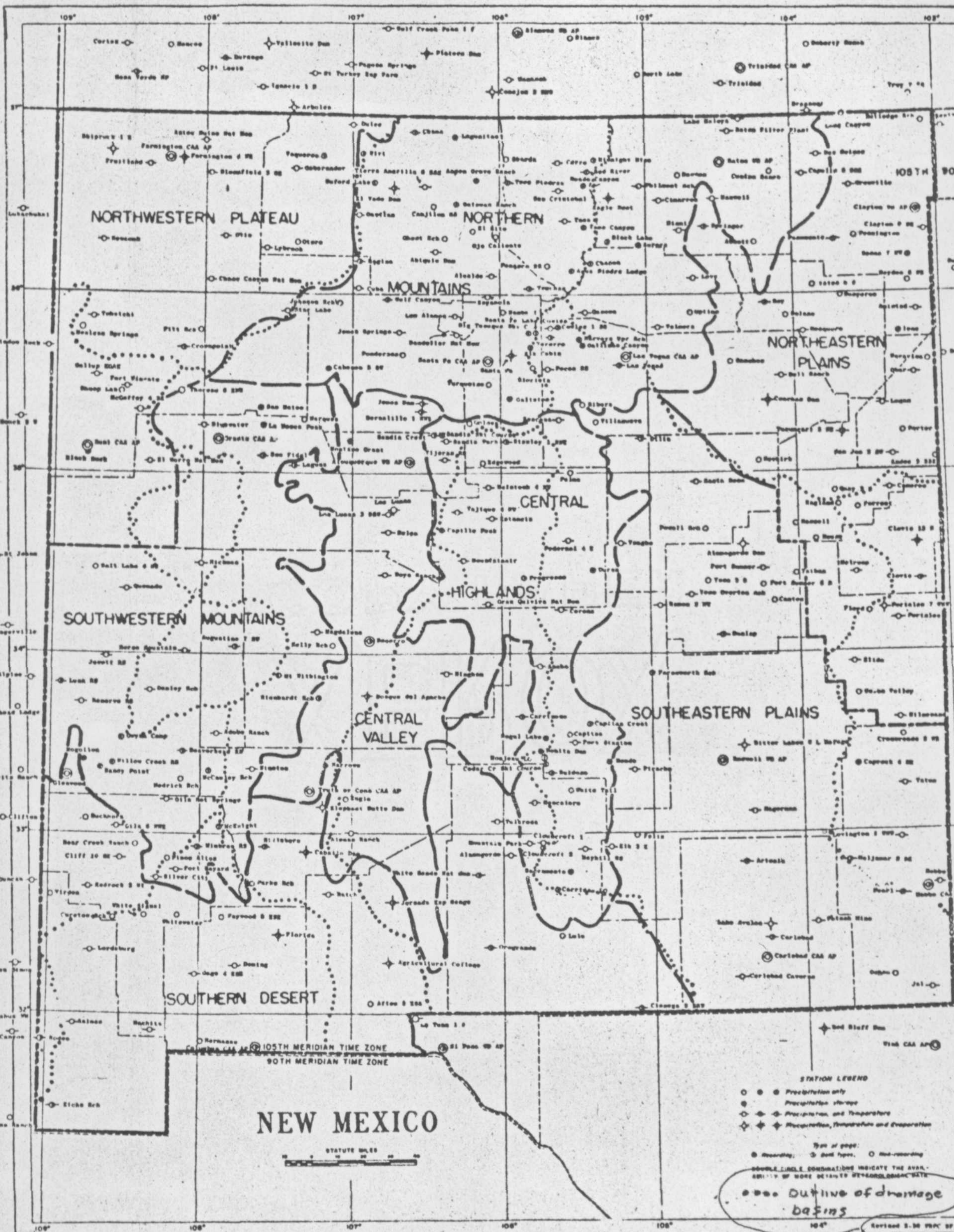
Published 7½' or 15' Quadrangles

Published 30' quadrangles

State Index giving more detail available free. Published maps available at 30 cents each from U.S. Geological Survey, Denver Distribution Section, Federal Center, Bldg. 25, Denver, Colorado, 80225, or U.S. Geological Survey, Washington, D.C., 20242. On orders amounting to $10 or more a 20 percent discount is allowed; on orders amounting to $60 or more a 40 percent discount is allowed. Remittance may be made by check, money order or cash. Checks or money orders should be made payable to the U.S. Geological Survey.

Status of topographic mapping in New Mexico

Figure 3.-[~~Published 7½', 15' and 30' quadrangles and status of current topographic~~ mapping



U.S. GOVERNMENT PRINTING OFFICE: 1959 O - 533379

Figure 6.--Weather stations ~~locations~~ and climatologic divisions in New Mexico

Note

Will be revised and checked by J. Kovzler.

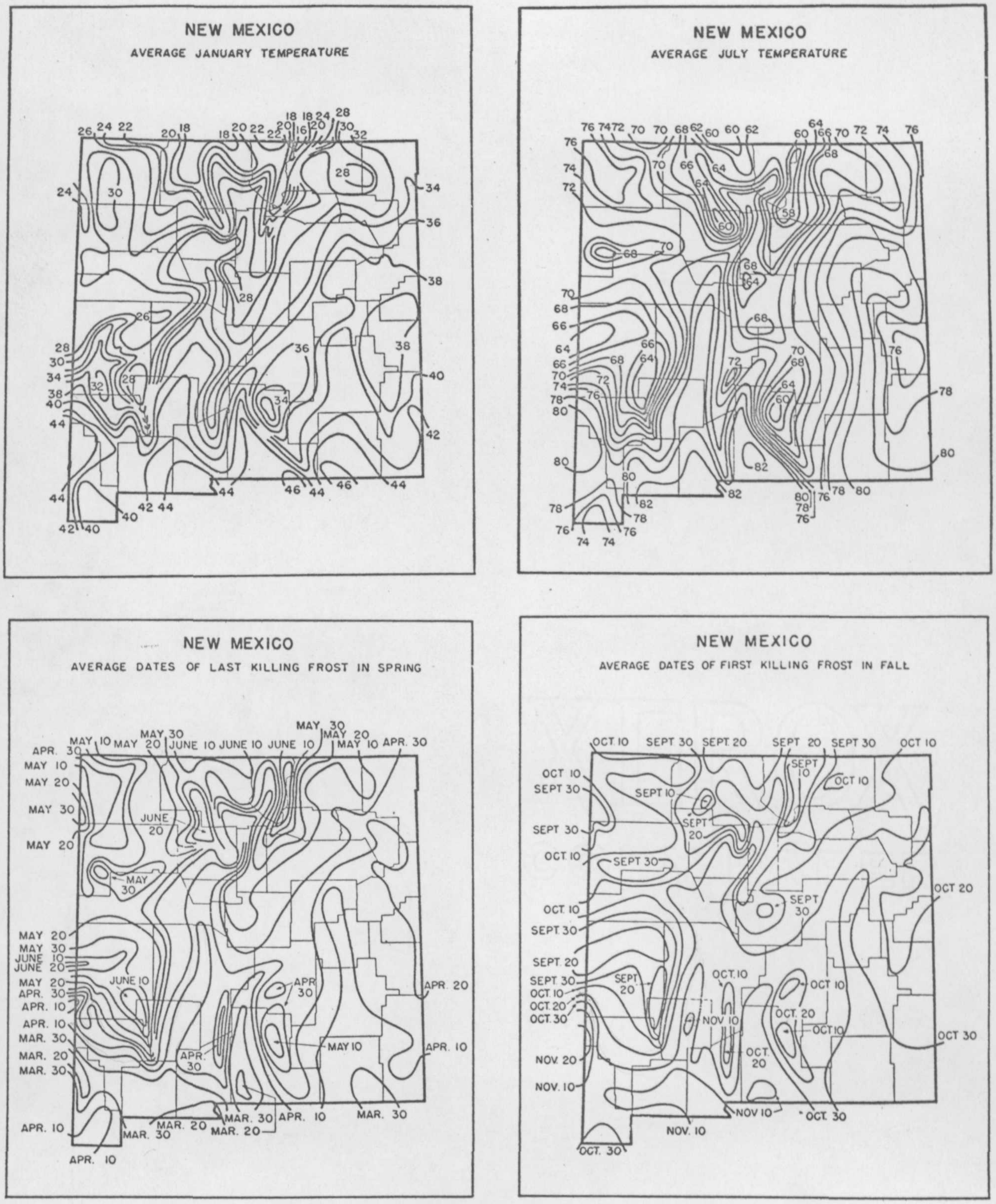


FIGURE 12 7

GRAPHS SHOWING AVERAGE JANUARY AND JULY TEMPERATURES AND AVERAGE DATES OF LAST KILLING FROST IN SPRING AND FIRST KILLING FROST IN FALL

(From *Climate and Man-Yearbook of Agriculture*, 1941)

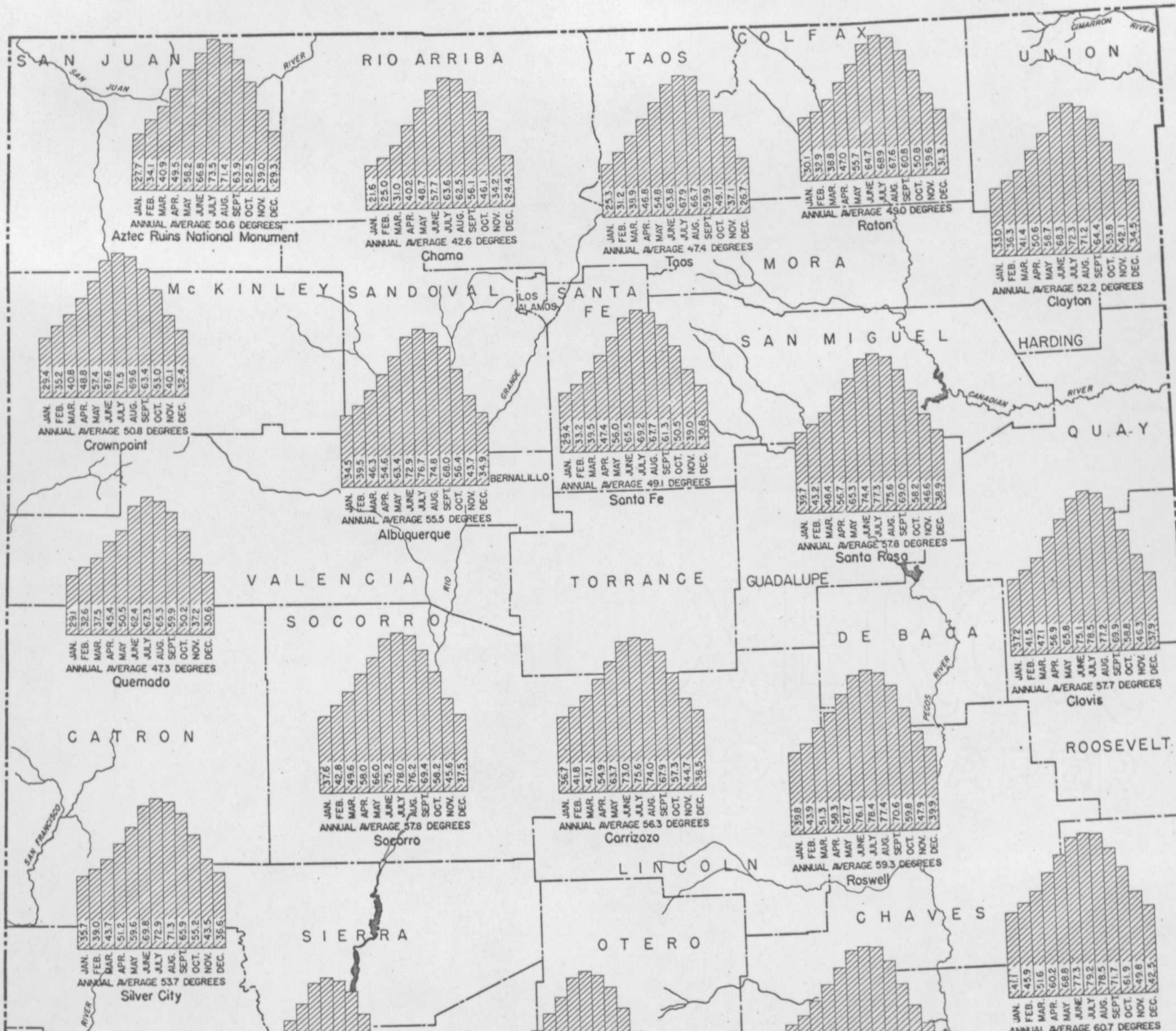


FIGURE 11 8

MEAN MONTHLY TEMPERATURES AT SELECTED STATIONS

UNITS = DEGREES FAHRENHEIT

COMPILED BY L.B. SEWARD
DRAWN BY E.H. HARRIS
MAY 1955

10 0 10 20 40 60
SCALE IN MILES

NOTE:
DATA OBTAINED FROM U.S. WEATHER BUREAU RECORDS.

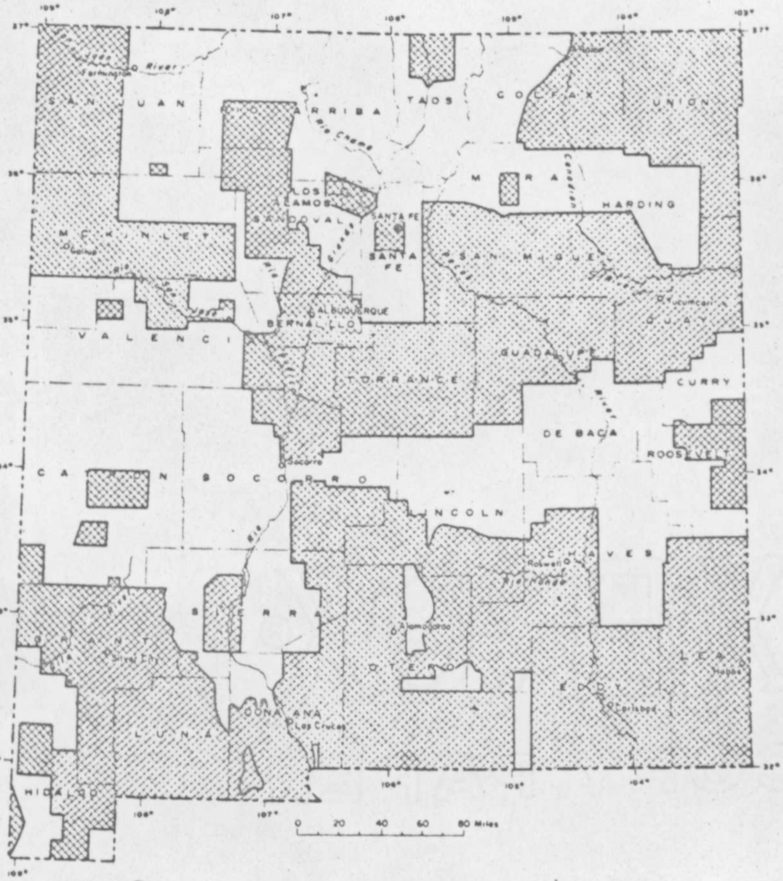


Figure ~~11~~ 9.--Areas in New Mexico in which ground-water studies have been made.

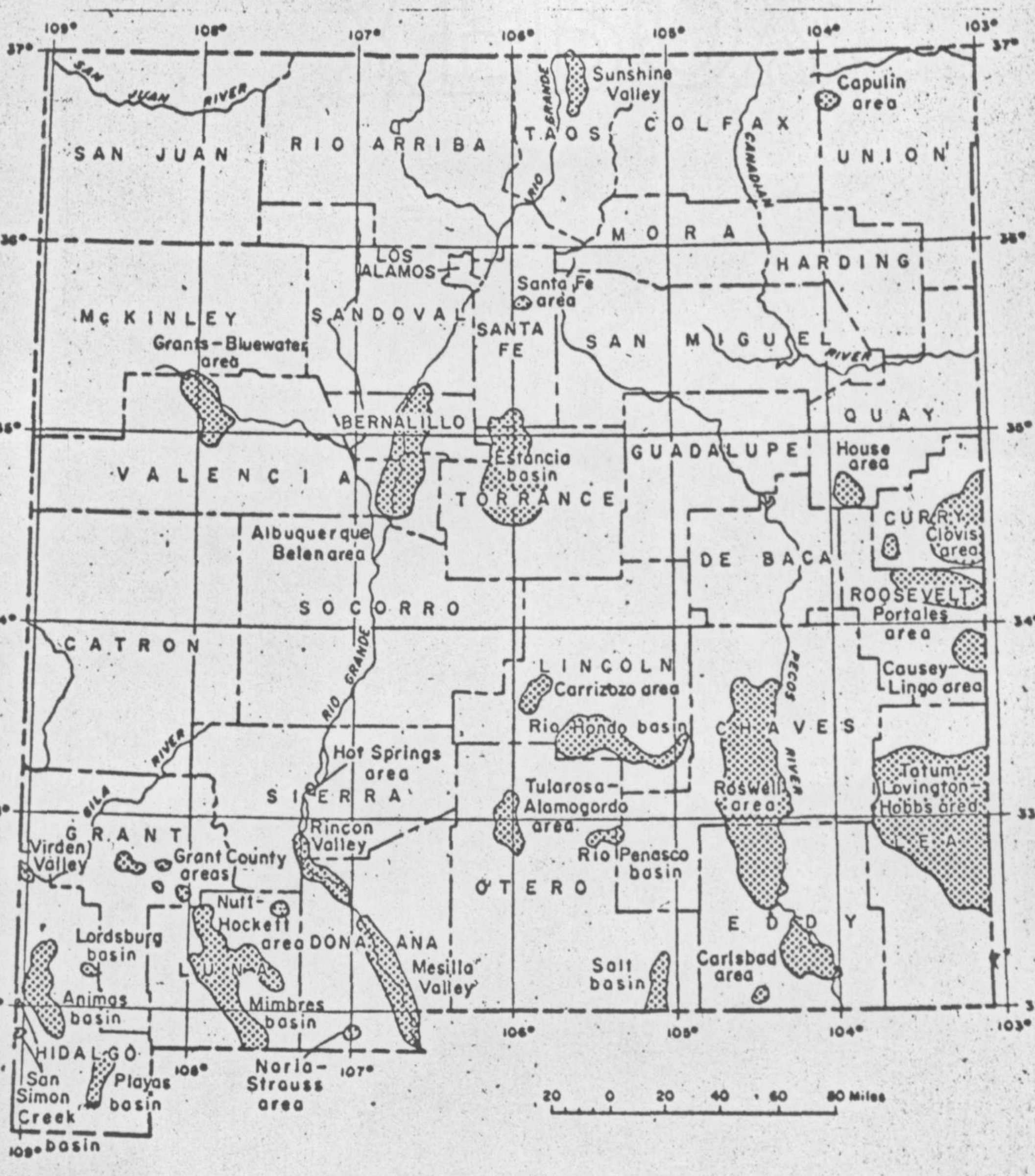
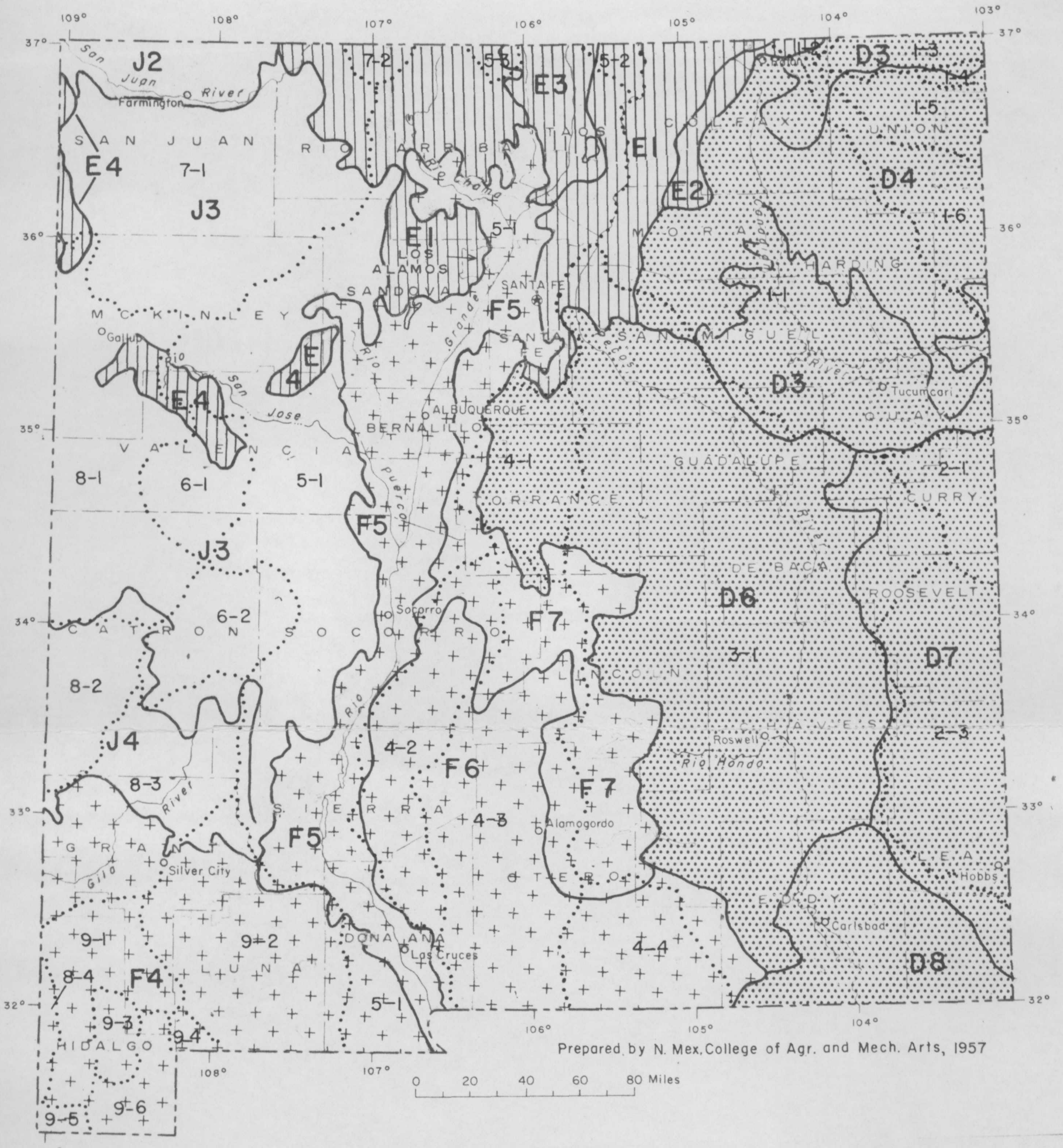


Figure 10.--Areas of observation of water-level fluctuation in New Mexico



D_3 Generally shallow soils in steeply rolling and rough broken areas. Moderately deep and deep soils in valley bottoms and alluvial fans.

D_4 Largely moderately deep to deep, medium to heavy-textured soils interspersed with some areas of shallow soils; generally gently rolling topography.

D_6 Dominantly moderately deep to deep, medium-textured soils with rolling topography, interspersed with areas of shallow soils and deep sandy soils with dune-like topography.

D_7 Generally loose sandy soils with dune-like topography east of Pecos river, interspersed with areas of shallow to moderately deep, medium to heavy-textured soils west of Pecos river.

D_8 Similar to D-7, east of Pecos river, interspersed with areas of shallow to moderately deep, medium-textured soils west of Pecos river.

E_1, E_2, E_3, E_4 Largely shallow to moderately deep, light to medium-textured soils with rolling to mountainous topography. Generally shallow soils on escarpments and mountainous areas.

2-1

Outline of river basins

F_4 Generally light to medium-textured, deep and shallow soils with rolling topography, interspersed with low mountains. Dominantly shallow soils and rock outcrops in mountainous areas.

F_5 Large areas of light to medium-textured, shallow to moderately deep soils with gentle to moderate slopes.

F_6 Mesas, benchlands, and mountain slopes. Largely light to medium-textured, shallow to moderately deep soils on mesas and benchlands, and gravelly shallow soils on mountain slopes and foothills.

F_7 Largely mountain ranges and foothill slopes. Dominantly medium-textured soils on mountain slopes, and moderately deep to deep soils on foothill slopes.

J_2 Dominantly medium-textured, shallow soils on steep slopes. Medium-textured moderately deep soils on sloping plains, and dissected mesas; and medium to heavy-textured deep soils in valleys.

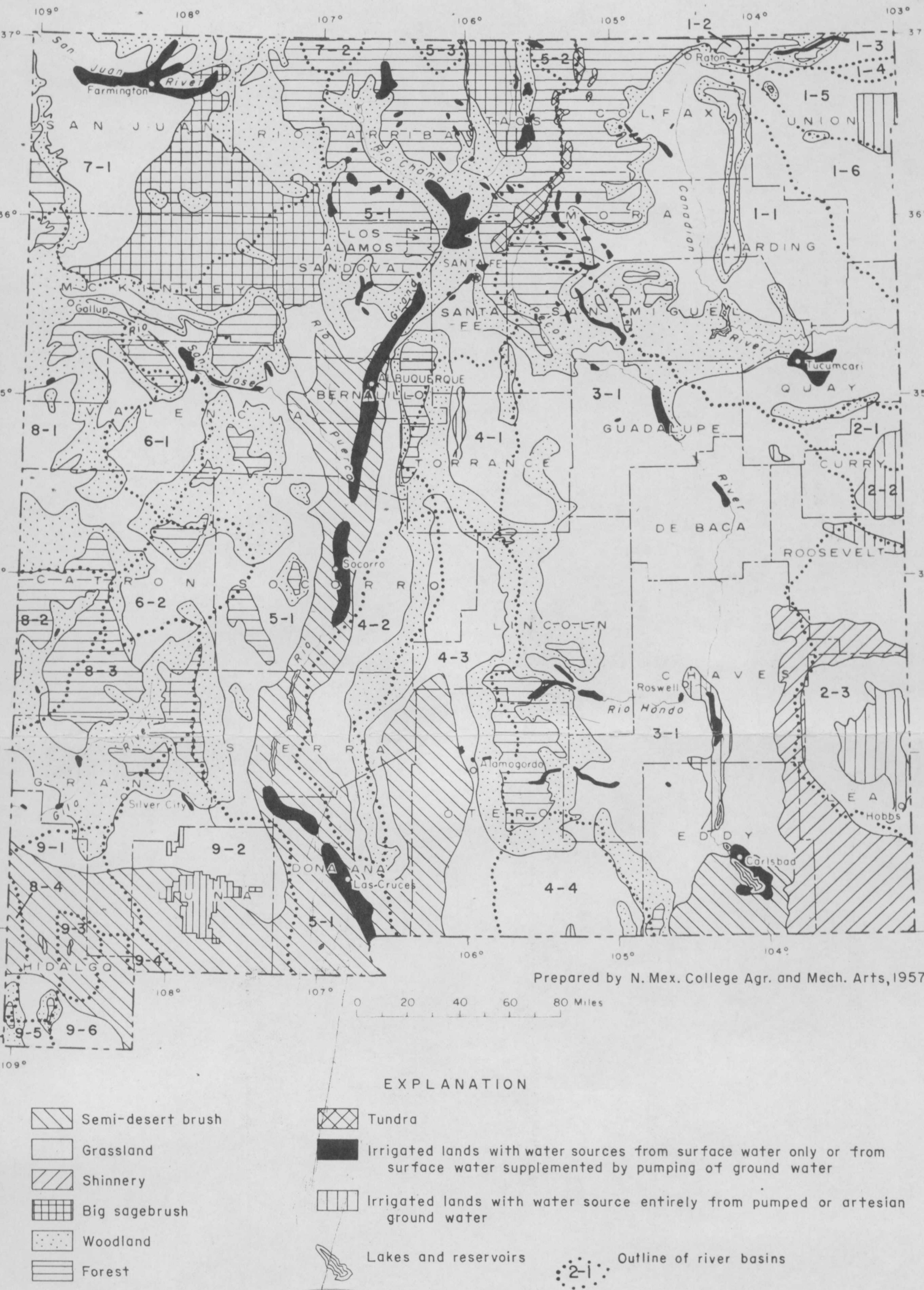
J_3 Largely medium-textured, moderately deep to shallow soils interspersed with areas of light-textured soils. Generally rolling topography with steep slopes in mountainous areas.

J_4 Generally mountainous shallow soils interspersed with rock outcrops and small areas of moderately deep soils. Generally mountainous topography.

Soils resource map of New Mexico

Figure 4. - -

Trauger - Lower Colorado



Vegetative-type map of New Mexico

Figure 5. --