GROUND-WATER REPORT 3

Geology and Ground-Water Resources of Eddy County, New Mexico

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UNITED STATES GEOLOGICAL SURVEY

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GEOLOGY AND GROUND-WATER RESOURCES OF EDDY COUNTY, NEW MEXICO

By G. E. HENDRICKSON AND R. S. JONES

Abstract

Eddy County is physiographically diverse. It includes the Guadalupe Mountains in the southwest, the foothills of the Sacramento Mountains in the northwest, two areas of alluvial terraces bordering the Pecos River on the west, the Mescalero pediment east of the Pecos, and a small area of the High Plains in the northeast corner of the county.

Ground water supplies all public and domestic requirements, most of the stock water, and much of the irrigation water in the county. Some ground water is used for potash refining. The greatest use of ground water is for irrigation. The uses for public supply, industrial supply, and stock and domestic supplies follow in that order.

Ground water occurs in limestone, sandstone, siltstone, and gypsum of Permian and Triassic age, and in sand, silt, gravel, and conglomerate of Tertiary and Quaternary age.

In the Guadalupe Mountains water occurs mostly in limestone, but also in sandstone and siltstone, of Permian age, and in sand and gravel of Quaternary age. Ground water is used for stock and domestic supply, and a little for garden and orchard irrigation. The chief ground-water problem in this area is to find water at moderate depth. The quality and quantity of water are generally satisfactory for all uses. Windmills pump water from depths as great as 900 feet, and dry holes have been drilled to depths of more than 1,000 feet. The most favorable locations for wells are in or near arroyos where recharge is concentrated and water may be perched at the base of the arroyo gravels.

In the Carlsbad area, ground water occurs in the Carlsbad limestone, in the gypsiferous Castile and Rustler formations, and in the alluvium. Ground water is used chiefly for public supply, irrigation, and potash refining. Ground water is available in sufficient quantities for all present uses and is generally of fairly good quality in the Carlsbad limestone, although impotable water is found locally. The water in the overlying Castile and Rustler formations and in the alluvium is impotable in most places. The quality of water pumped from the Carlsbad limestone by the Carlsbad city wells had a wide annual range, but the chloride content of the water pumped showed a general in-

crease from 1943 to 1950. If this increase continues the city of Carlsbad may be obliged to obtain its water from some other source. In the irrigation district south of Carlsbad, ground water is pumped from the alluvium primarily to supplement the surface supply of water for irrigation, except west of the main canal where some land having no surface-water rights is irrigated by ground water. Water levels in wells have declined several feet in places west of the main canal in recent years, but east of the canal water levels have declined little or not at all.

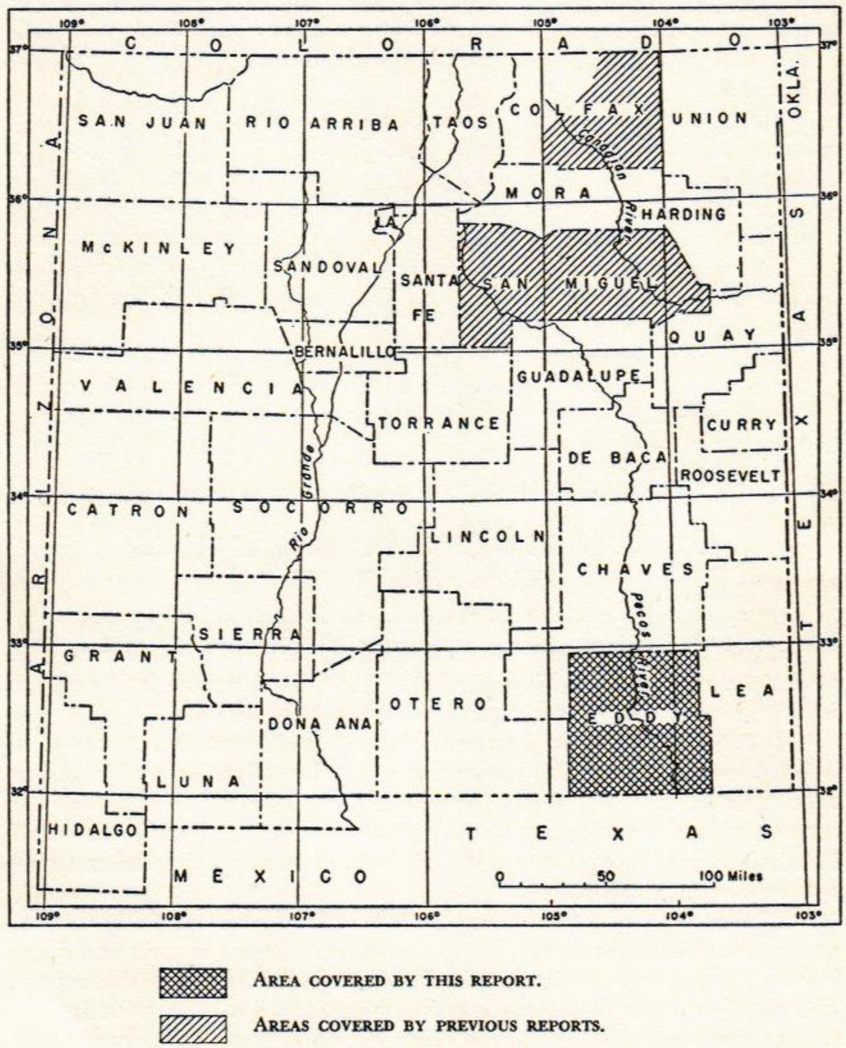
In the lower parts of the Roswell basin, the chief use of ground water is for irrigation. Water is obtained from shallow water-table wells in the alluvium, and from deep artesian wells in the San Andres formation and the lower part of the overlying Chalk Bluff formation. As all water rights are fully developed, the chief problem is to prevent wastage or overuse of water. Water levels in the artesian and especially in the water-table aquifers have, over a period of years, shown a marked decline. West of the irrigated area depths to water increase to more than 800 feet at the county line. The chief use of ground water west of the irrigated area is for stock and domestic supplies, and the problem is to find water at comparatively shallow depths.

In the area between the Guadalupe Mountains and the Pecos River and generally south of latitude 32°15', ground water is used chiefly for stock and domestic supplies. Water from Rattlesnake Springs is used for the public supply at the Carlsbad Caverns, and water from Blue and Geyser Springs is used for irrigation. Water is obtained from the alluvium, from the Castile formation, and possibly from the Rustler formation. Water from the alluvium near the mountains is generally of good quality, but farther east, as the water moves through gypsiferous rocks, the sulfate content increases and the water is locally unfit for domestic use. The depth to water in most wells is less than 100 feet, and the quantity of water available is generally sufficient for stock and domestic supplies.

East of the Pecos River ground water is used for stock and domestic supplies and for potash refining. Water is obtained from the limestone, gypsum, and red beds of the Chalk Bluff formation and the Rustler formation and from the sandstone of the Dockum group. The chief ground-water problem is to find water of good quality, as the quantity available is generally sufficient and depths to water are not great. Water of fair quality is obtained from wells in the Chalk Bluff formation, which extends northward from Lake Avalon to and beyond the county line in a belt 6 to 10 miles wide bordering the Pecos River on the east, and also from some wells in the Dockum group near the east boundary of the county. Water of poor quality is obtained from most of the wells in Clayton Basin and Nash Draw and just east of the Pecos River from Malaga Bend southward to and beyond the county line. In the small area of the High Plains in the northeast corner of the county a few stock wells provide water of good quality.

Introduction

LOCATION AND AREA



AREAS IN NEW MEXICO DISCUSSED IN GROUND-WATER REPORTS PUBLISHED BY THE NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES.

Fig. 1

HISTORY AND SCOPE OF THE PRESENT INVESTIGATION

This investigation was made by the United States Geological Survey in cooperation with the New Mexico Bureau of Mines and Mineral Resources, a division of New Mexico Institute of Mining and Technology, and the State Engineer of New Mexico. The areas discussed in this and previous reports completed under this program are shown in figure 1.

The geology and ground-water conditions in the Guadalupe Mountains were studied by R. S. Jones from June 1947 to June 1948, and a preliminary report of this area was prepared. From June 1948 to November 1949, G. E. Hendrickson completed the work in the Guadalupe Mountains and extended the study to include the entire county. The present report was written by G. E. Hendrickson and put in final form by E. H. Herrick and others of the Albuquerque office of the Ground Water Branch of the Survey.

During the investigation more than 400 wells were visited; depths to water were measured wherever possible; and water samples for chemical analyses were collected from representative wells and springs. Pumping tests were made of some of the wells to determine their discharge rates and specific capacities.

ACKNOWLEDGMENTS AND PREVIOUS INVESTIGATIONS

This investigation was made under the general supervision of A. N. Sayre, Chief of the Ground Water Branch, U. S. Geological Survey, and under the direct supervision of C. V. Theis, former District Geologist in charge of ground-water investigations in New Mexico.

J. P. Smith, geologist for the United States Potash Co., contributed helpful suggestions during the course of the investigation and gave further help in critically reviewing the report. The well drillers of the area furnished well logs and other ground-water information, and all farmers and stockmen contacted were helpful in supplying information concerning their wells.

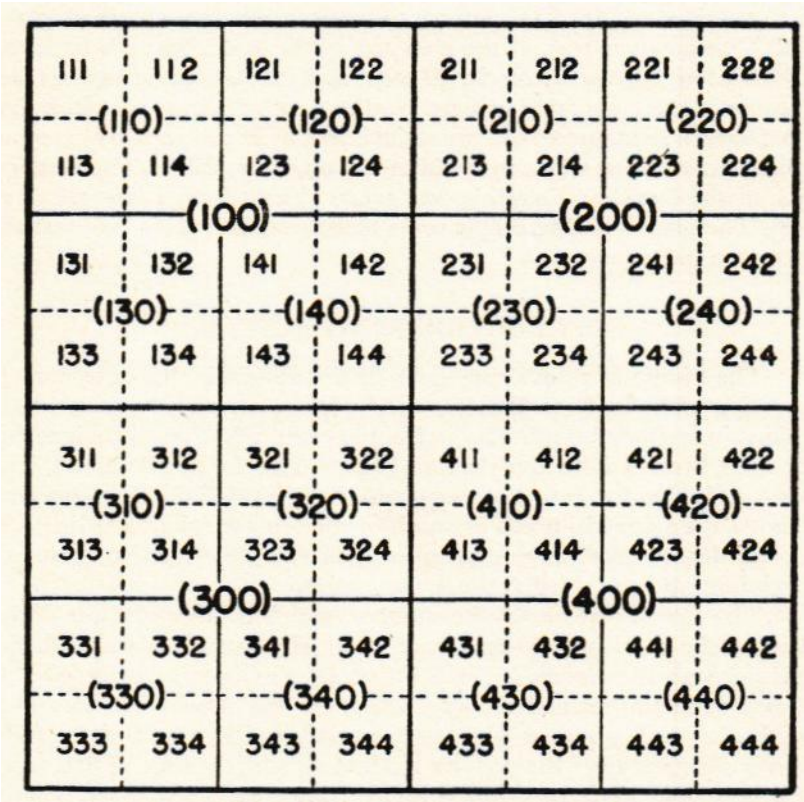
The geology and ground-water resources of parts of Eddy County are discussed in several earlier reports. A list of those reports and other references used appears in the list of references at the end of this report. Information from these previous investigations has been used in preparing this report, especially in determining changes in ground-water conditions from the time of the earlier studies to the present. The discussion of the ground-water conditions in the Roswell basin is taken almost entirely from earlier reports, although some additional information was obtained during the present investigation and from periodic water-level measurements made by personnel of the Albuquerque office of the Ground Water Branch. Well logs and other unpublished ground-water information collected by H. W. Robbins of the U. S. Bureau of Reclamation were used in preparing the discussion of the ground-water conditions in the vicinity of Carlsbad. Chemical analyses made by the Quality of Water Branch in previous years provided information on changes in quality of water from wells and springs in the area.

The geologic map of Eddy County accompanying this report was compiled from several sources. For the northwest part of the county the geologic map accompanying the report of Fiedler and Nye (1933, p1. 3) was used. For the south and southwest parts of the county the geologic map of New Mexico compiled by N. H. Darton (1928) was used, but was modified to conform to more recent data obtained in the field. The geologic map of the area east of the Pecos River is based on information from potash tests, oil tests, and data obtained in the field. Because of the large areas covered by the so-called Mescalero sands and the complex structure of this area, the boundaries are approximate and subject to revision when more information is available. The outcrop area of the Carlsbad limestone was taken chiefly from Lang (1937, p. 838). The names of all geologic units have been changed to conform to present terminology.

WELL-NUMBERING SYSTEM

The system of numbering wells in this report is that used for observation wells in New Mexico, and is based on the common subdivisions in sectioned land. The well number, in addition to designating the well, locates it to the nearest 10-acre tract in the land net. The number is divided into four segments by periods. The first segment denotes the township north or south of the New Mexico base line; the second denotes the range east or west of the New Mexico principal meridian; and the third denotes the section.

The fourth segment of the number, which consists of three digits, denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 16.23.15.323 in Eddy County is in the SW/NE/SW/ sec. 15, T. 16 S., R. 23 E. If a well cannot be located within a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately within a 40-acre tract, zeroes are used for both the second and third digits. If the well cannot be located more closely than the section, the fourth segment of the well number generally is omitted. However, this practice has not been followed in the table of wells accompanying this report. In the table the number of a well that cannot be located more accurately than the section will have three zeroes in the fourth segment. When it becomes possible to locate more accurately a well in whose number zeroes have been used, the proper digit or digits are substituted for the zeroes. Letters a, b, c, ... are added to the last segment to designate the second, third, fourth and succeeding wells listed in the same 10-acre tract. The following diagram shows the method of numbering the tracts within a section:



Geography

TOPOGRAPHY AND DRAINAGE

The main topographic features of Eddy County are shown, with the geology, on plate 1. The greater part of Eddy County is drained by the Pecos River and its tributaries. In the northeast corner of the county an area of about 5 square miles on the High Plains is drained to the east, away from the Pecos, and in the southwest corner of the county an area of about 12 square miles is drained northwestward into Big Dog Canyon and thence into Crow Flat, the northern part of Salt Basin in Texas, a long closed depression which extends southeasterly. The only perennial tributaries to the Pecos River are Cottonwood Creek, Black River, and the Delaware River. All other streams tributary to the Pecos carry water to the river only during periods of heavy rains. East of the Pecos, drainage is chiefly to enclosed basins, and the Pecos has no important tributaries from the east.

MOUNTAINS

The Guadalupe Mountains trend northwest for a distance of about 60 miles from the New Mexico-Texas line at the southwest corner of the county and are continuous with the Sacramento Mountains to the north and the Delaware Mountains to the south. The highest and most rugged part of the mountains has the form of a southward-pointing "V." The northwest limb is the Guadalupe Mountains proper, and the northeast limb is the "Barrera del Guadalupe." The apex of the "V" is Guadalupe Peak, which is about 7 miles south of the New Mexico State line. The altitude at Guadalupe Peak is 8,751 feet, and it becomes progressively lower away from the peak along both the northwest and northeast limbs of the "V." Between the limbs of the "V" is a lower land of moderate relief called the Seven Rivers embayment.

The northwest limb of the mountains, or Guadalupe Mountains proper, is bounded on the southwest by a fault scarp 1,200 to 1,500 feet high and on the northeast by an escarpment on the Huapache monocline about 500 feet high. The upland surface of this part of the mountains has a moderate relief and a general slope to the north and northeast. The upland surface is cut by steep-walled canyons as much as 500 feet deep.

The northeast limb of the mountains widens to the north as the altitude becomes less, and it disappears as a topographic feature a short distance north of Carlsbad. The part of the northeast limb south of

Dark Canyon is called Guadalupe Ridge; the part between Dark Canyon and Rocky Arroyo is called Azotea Mesa; and the part north of Rocky Arroyo is called the Seven Rivers Hills. The east boundary of the northeast limb of the mountains is the escarpment of an old reef, which declines from a height of about 1,700 feet at the south State line to about 500 feet near Carlsbad. South of Carlsbad this escarpment is concave to the east, forming the Cueva reentrant. East of and paralleling the escarpment in this reentrant are the Frontier Hills.

The Seven Rivers embayment, between the two limbs of the mountains, widens to the north from its apex near Sitting Bull Falls. The embayment, an area of moderate relief, has comparatively shallow arroyos and some small undrained depressions.

The chief drainage channels from the Guadalupe Mountains to the Pecos River are the North and South Seven Rivers, Rocky Arroyo, and Dark Canyon. North and South Seven Rivers drain the Seven Rivers embayment to the northeast; Rocky Arroyo drains the central part of the embayment and crosses the northeast limb of the mountains just south of the Seven Rivers Hills. Dark Canyon originates near the south boundary of the county in the high part of the mountains, flows northward across the south tip of the Seven Rivers embayment, and turns eastward to cross the northeast limb of the mountains and the Frontier Hills about 10 miles south of Carlsbad.

MESCALERO PEDIMENT

The Mescalero pediment slopes westward from the High Plains escarpment in the northeast corner of the county almost to the Pecos River, and it covers most of Eddy County east of the Pecos. The general slope of the pediment is about 30 feet to the mile, but it is broken by numerous depressions ranging in size from less than 1 square mile to more than 100 square miles. The two largest depressions, which are nearly continuous, are Clayton Basin on the north and Nash Draw on the south. These two depressions have a combined area of more than 100 square miles and extend from a point about 30 miles east of Artesia southward to Salt Lake, about 5 miles east of Loving. The larger depressions, bordered by steep escarpments, contain numerous smaller shallow depressions. In addition to the enclosed depressions, the topography of the pediment has been modified by a mantle of dune sand. Over most of the area the dunes are held in place by mesquite and other vegetation, but locally they are still moving and causing damage by covering fences, roads, and buildings. The west part of the pediment is dissected by short arroyos draining to the Pecos River Valley. This dissected belt is narrow, and none of the arroyos on the east bank of the Pecos River drains more than a few square miles.

RIVER TERRACES

The two areas of river terraces in Eddy County border the Pecos River on the west. One area extends from north of the north county line south to North Seven Rivers, and the other extends from Carlsbad south to the Black River. The lowest terrace, which is confined to a small area immediately adjacent to the river, in both the north and the south areas, is called the Lakewood terrace. This terrace is about 20 to 30 feet above the level of the Pecos River and about 10 to 25 feet above the tributary streams. About 5 to 10 feet above the Lakewood terrace is the Orchard Park terrace, which slopes very gently toward the Pecos River. This terrace is very little dissected, and it is the site of more than 90 percent of the irrigated farms in the county. The Blackdom terrace is about 30 to 60 feet above the Orchard Park terrace. In the northern part of the county it extends in a nearly continuous belt from the Orchard Park terrace westward to the limestone uplands, although it is cut by several east-flowing stream channels. South of Carlsbad the Blackdom terrace is more highly dissected and is present only as small disconnected remnants.

DIAMOND "A" PLAIN

North of the Seven Rivers Hills is an area of moderate relief which slopes eastward from beyond the west county line to the river terraces. The upland surfaces in this area, between the drainage lines, form a comparatively regular eastward-sloping plain which is called the Diamond "A" Plain.

GYPSUM HILLS

South of Black River and west of the Pecos is an area of conical hills and rolling uplands which is called the Gypsum Hills area in this report. The east part of this area is an extension of the Rustler Hills of Texas. The general slope of the area is northeast and east to the Pecos River.

HIGH PLAINS

Except in the northeast corner of the county the escarpment marking the west boundary of the High Plains is east of the county line. The area of the High Plains in Eddy County is about 5 square miles. The escarpment on the west of the plains is about 200 feet high, and the slope of the plains to the east is about 10 feet to the mile.

CLIMATE

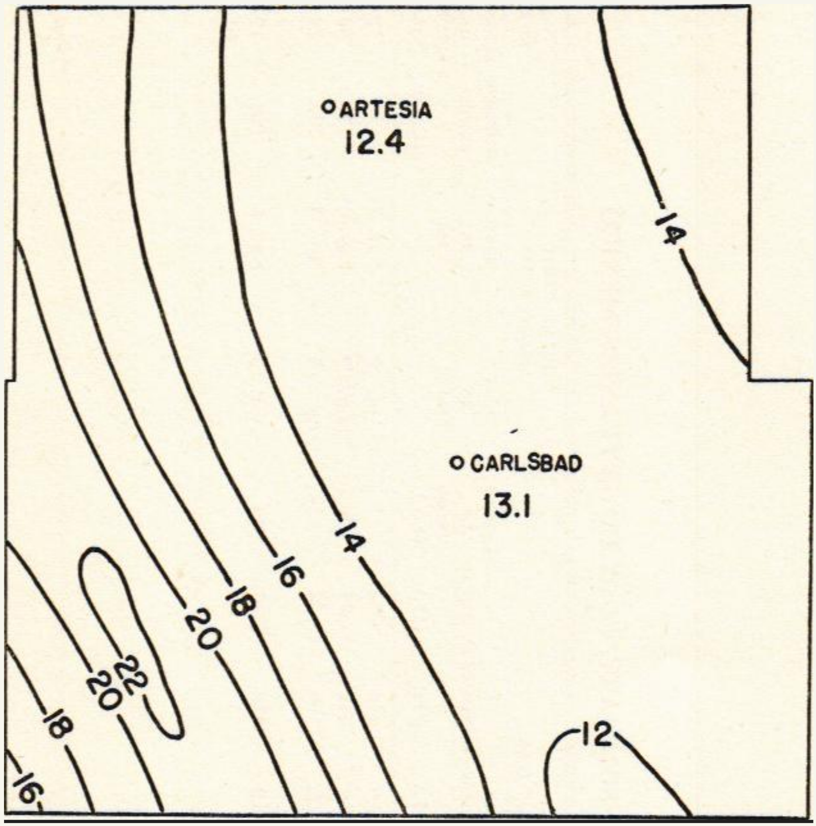
The following climatological information, including tables and map, was obtained mainly from the United States Weather Bureau (1941).

The climate of Eddy County is semiarid. The average annual precipitation ranges from 12 inches in the southeast part of the county to 22 inches in the higher parts of the Guadalupe Mountains in the southwest part of the county. (See fig. 2.) Carlsbad has an average annual precipitation of 13.13 inches, of which more than two-thirds occurs from June to October, inclusive, mainly in the form of thundershowers. The precipitation varies considerably from year to year, and occasional droughts cause much damage to the forage crops and reduce the supply of water available for irrigation. Conversely, unusually heavy rains have caused floods which have damaged parts of the city of Carlsbad.

Winters in Eddy County are generally mild. The average January temperature is 40° F. at the northeast corner of the county and 46° F. at the southwest corner. The average July temperature is slightly greater than 80° F. in the central lowlands and about 76° F. in the northwest corner of the county. Although the low relative humidity minimizes the discomfort caused by the summer heat, most homes in Carlsbad are equipped with evaporative air coolers to relieve the daytime heat. Even in summer the nights are comparatively cool. The length of the growing season ranges from 220 days at Carlsbad to 202 days near Lakewood, close to the north boundary of the county. The climatic conditions in the county are summarized in the following table.

CLIMATIC SUMMARY, EDDY COUNTY, NEW MEXICO

STATION	TEMPERATURE					KILLING FROST AVERAGE DATES				ANNUAL AVERAGE PRECIPITATION	
	LENGTH OF RECORD (Yrs.)	JANUARY AVERAGE (°F.)	JULY AVERAGE (°F.)	MAXIMUM (°F.)	MINIMUM (°F.)	LENGTH OF RECORD (Yrs.)	LAST IN SPRING	FIRST IN FALL	GROWING SEASON (Days)	LENGTH OF RECORD (Yrs.)	ANNUAL (In.)
Artesia	31	41.5	79.6	116	—35	31	Apr. 6	Nov. 2	210	32	12.38
Carlsbad	36	44.3	80.5	112	—17	40	Mar. 29	Nov. 4	220	40	13.13
Hope	18	42.2	77.2	106	—22	24	Apr. 5	Nov. 4	213	20	13.83
Lake Avalon										25	11.79
Lakewood (near)	15	42.2	80.2	110	—11	16	Apr. 15	Nov. 3	202	17	10.95
Loving										21	11.17



APPROXIMATE LINES OF EQUAL AVERAGE ANNUAL PRECIPITATION IN INCHES, IN EDDY COUNTY, N. MEX.

Fig. 2

POPULATION

The population of Eddy County in 1950 was 40,421. The following table from the County Agricultural Agent's report (Rierson, p. 4) and a preliminary report of the U. S. Census Bureau show the increase in rural and urban populations from 1920 to 1950.

POPULATION GROUP	1920	1930	1940	1950 *
Rural	9,116	12,134	13,124	14,391
Urban	—	3,708	11,187	26,030
Total	9,116	15,842	24,311	40,421

* 1950 figures from preliminary release of U. S. Census Bureau. Urban population for 1950 includes only Carlsbad and Artesia.

More than 90 percent of the increase in population from 1930 to 1950 was in the urban population. This resulted primarily from increased employment in the potash mines near Carlsbad, but the growth of the tourist and oil industries was partly responsible.

INDUSTRY

Potash mining and refining is the chief industry of Eddy County, providing employment for about 3,000 persons in 1949. That year the annual payroll of the potash companies exceeded $12,000,000. The oil industry in northeast Eddy County employed about 1,000 persons that year.

Ranching and farming, formerly the only sources of income for residents of Eddy County, in 1949 provided employment for less than half the working population. Employment in ranching and farming is not expected to increase, as nearly all grazing land and irrigation water rights are now fully developed.

Of the 2,664,320 acres in Eddy County, 1,410,097 acres is in the public domain, 190,080 acres in National Forest, and 49,280 acres in the Carlsbad Caverns National Park. Land use according to the 1945 census of agriculture is as follows:

Irrigated land	72,000 acres
Dry-farming land	None
Fruit orchards	250 acres
Grazing land	2,057,423 acres

Although irrigated land is less than 4 percent of all agricultural land, it provides more than 75 percent of the agricultural income of the county. This is shown in the following table which gives the agricultural income for the county for 1947, according to the County Agricultural Agent's report:

PRODUCT	INCOME, 1947
Cotton	$ 6,000,000
Legumes	1,377,838
Grain sorghums	371,616
Small grains	124,282
Miscellaneous	113,059
Dairying	350,192
Beef	1,600,000
Sheep and wool	831,000
Total	$10,768,887

Geology

STRATIGRAPHY

The following discussion of the geology of Eddy County is based on the reports listed in the list of references and on information obtained in the field during the present investigation. The areas of outcrop of the different geologic units are shown on plate 1.

The rocks exposed in Eddy County are all of sedimentary origin, with the exception of a small igneous dike about 10 miles south of the Carlsbad Caverns, and are of Permian, Triassic, Tertiary, and Quaternary age. The correlation chart, figure 3, from King (1948, p. 101), shows the general relationship of the formations in the county.

PERMIAN SYSTEM

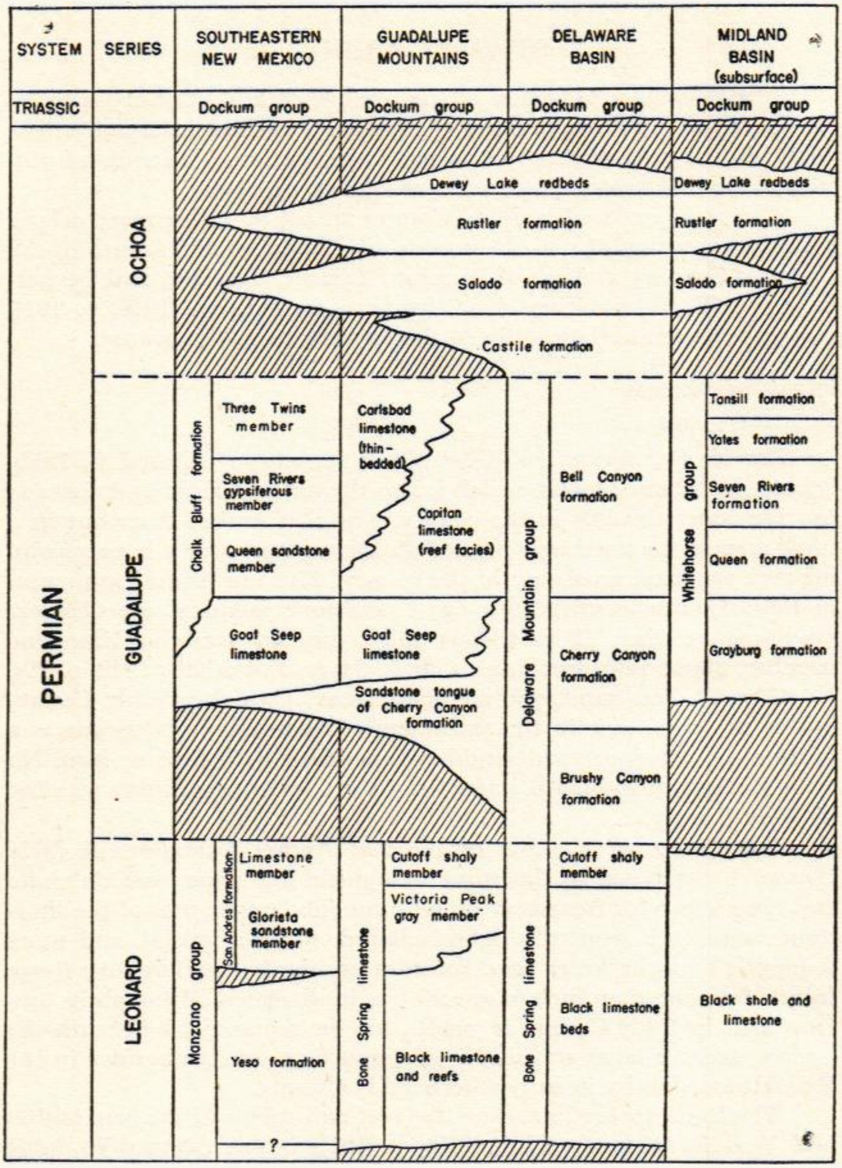
Leonard series

San Andres formation.—The oldest formation exposed in Eddy County is the San Andres, which is also the oldest formation known to provide water to wells in the county. The San Andres crops out in a small area in the northwest part of the county and over a large adjoining area west and northwest of the county. The San Andres formation in Eddy County consists of a basal sandstone member, the Glorieta sandstone member, 12 to 90 feet thick, and an overlying limestone member, about 1,000 feet thick (Theis, Sayre, and others, 1942, p. 29).

The Glorieta sandstone member is not exposed in Eddy County but to the northwest in the Sacramento Mountains it crops out as a medium- to coarse-grained sandstone cemented with lime or iron. No wells are known to obtain water from the Glorieta sandstone member in Eddy County.

The limestone member of the San Andres formation in Eddy County is composed of limestone, dolomitic limestone, and dolomite and ranges in color from gray to light tan. The upper part of the limestone member is generally lighter-colored, thinner-bedded, and more dolomitic than the lower part. Solution cavities in the limestone range from a fraction of an inch to several feet in diameter. Although its outcrop area in Eddy County is small, this limestone exists beneath the surface under a large area and is an important artesian aquifer in the Roswell artesian basin in northern Eddy County.

The Bone Spring limestone, the reef equivalent of the San Andres and Yeso formations (King, 1948, p. 101), is not exposed in Eddy County. Well drillers have reported a black shaly limestone in some of the deep wells in the Guadalupe Mountains in southern Eddy County which may be the Cutoff shaly member at the top of the Bone Spring limestone. In each case water was reported just above the black shaly limestone.



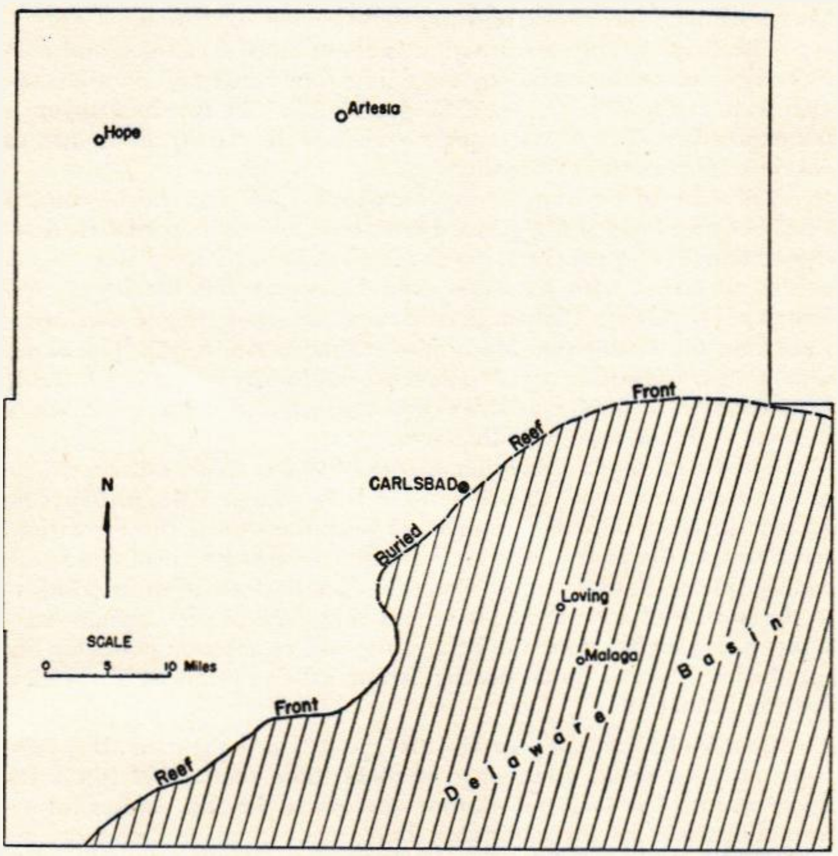
CORRELATION OF GEOLOGIC FORMATIONS OF THE PERMIAN AND TRIASSIC SYSTEMS IN AND NEAR EDDY COUNTY, N. MEX. *(Modified from chart by P. B. King, U. S. Geol. Survey Prof. Paper 215, fig. 12.)*

Fig. 3

Guadalupe series

The Guadalupe series, which overlies the San Andres formation and its equivalent, the Bone Spring limestone, is a thick series of sedimentary rocks that has a wide lateral range in composition. The lateral changes in character of these rocks in the Guadalupe Mountains area, noted by Girty (1909, p. 138) and Richardson (1910, pp. 325-337), were first interpreted by Lloyd (1929, pp. 645-648) as being due to reef deposition.

In Eddy County the reef follows approximately the southeast escarpment of the Guadalupe Mountains from the south county line to the vicinity of Carlsbad. (See fig. 4). Northeast of Carlsbad the reef is overlain by younger sedimentary rocks. The buried reef trends north-



REEF FRONT AND EXTENT OF DELAWARE BASIN IN EDDY COUNTY, N. **MEX.** *(After Walter B. Long, Am. Assoc. Petroleum Geologists* **Bull.,** *vol. 21, no. 7, 1937.)*

Fig. 4

east and intersects the east county line at about T. 20 S. The area southeast of the reef is called the Delaware Basin and the area northwest of the reef is called the back-reef or shelf area. The sedimentary rocks of Guadalupe age are thus divided into three facies: (1) a basinal facies of sandstone and some thin-bedded limestone interfingering to the northwest with the limestone of the reef zone; (2) a reef facies of massive to medium-bedded limestone grading to the northwest into medium- to thin-bedded limestone and dolomite; (3) a shelf or back-reef facies of medium- to thin-bedded dolomite and limestone grading to the northwest into red beds and gypsum.

Delaware Mountain group.—The basinal sedimentary rocks of the Guadalupe series are called the Delaware Mountain group, which includes, from oldest to youngest, the Brushy Canyon formation, the Cherry Canyon formation, and the Bell Canyon formation.

The Brushy Canyon formation is about 1,000 feet thick and consists chiefly of sandstone having some limestone lenses and, locally, conglomerate at the base (King, 1948, pp. 28, 29). The Brushy Canyon is not exposed in Eddy County, and no wells in the county are known to obtain water from this formation.

The Cherry Canyon formation, about 1,000 feet thick, consists chiefly of thin-bedded fine-grained sandstone and some persistent limestone beds. The upper three-fourths of the Cherry Canyon interfingers to the northwest with the Goat Seep limestone, but the lower one-fourth of the Cherry Canyon persists as a sandstone tongue northwestward into the Guadalupe Mountains. (King, 1948, p. 32). This sandstone tongue of the Cherry Canyon crops out locally in canyons in Eddy County south of the Seven Rivers embayment, and it may yield water to some wells and springs in that area.

The Bell Canyon formation, 670 to 1,040 feet thick, consists chiefly of sandstone and some thin limestone beds (King, 1948, p. 53). The Lamar limestone member, which lies near the top of the formation, crops out at the base of the reef escarpment just north of the south county line of Eddy County. The Bell Canyon formation interfingers to the northwest with the massive reef limestone of the Capitan limestone. Large springs near the base of the reef escarpment probably are supplied by ground water moving through the upper beds of the Bell Canyon formation.

Goat Seep limestone.—Lang (1937, p. 858) gave the name *Dog Canyon limestone* to an assemblage of rocks more than 1,000 feet thick lying beneath the Queen sandstone and above the San Andres formation. The rocks are predominantly buff to gray massive limestone. Because of possible confusion of the name *Dog Canyon* with the term *Dog Creek shale,* used in Oklahoma for beds of about the same age, King (1948, pp. 38, 39) proposed that the name *Goat Seep limestone* be substituted for the name *Dog Canyon limestone.* The Goat Seep is the approximate equivalent of the Grayburg formation of the Whitehorse group and interfingers to the southeast with the Cherry Canyon formation.

The Goat Seep limestone crops out in Eddy County along the west escarpment of the Guadalupe Mountains and in canyons in the Guadalupe Mountains from Last Chance Canyon southward to and beyond the county line. It may crop out also in places in the Seven Rivers embayment. It furnishes water to stock and domestic wells in and near its outcrop area in the mountains and probably furnishes water to most of the deeper wells in the Seven Rivers embayment. In the southern part of the Roswell artesian basin in northern Eddy County the lower part of the Chalk Bluff formation, which is the equivalent of the Goat Seep limestone and the Grayburg formation of the Whitehorse group (see fig. 3), is an important source of ground water for irrigation.

Capitan limestone.—The Capitan limestone crops out along the front of the reef escarpment and in the canyon walls in Guadalupe Ridge in the southern part of the county. It interfingers to the southeast with the Bell Canyon formation and to the northwest with the Carlsbad limestone. The Capitan is a massive gray to buff limestone 1,000 to 2,000 feet thick containing solution cavities ranging in size from slight enlargements of joints and bedding planes to the huge caverns of the Carlsbad Caverns National Park.

The Capitan limestone yields water to several deep wells at White City and probably yields water to a few stock wells near the reef escarpment northeast of White City. Several small springs issue from the Capitan in canyons in Guadalupe Ridge, and it is probable that water discharging from several large springs southeast of the reef front comes indirectly from the Capitan limestone.

Carlsbad limestone.—The Carlsbad limestone interfingers with and in part overlaps the Capitan limestone. It crops out over a large area high in the Guadalupe Mountains in the southwest part of the county as the cap rock overlying the Capitan limestone and over most of the area between the Seven Rivers embayment and the reef escarpment. (See pl. 1.) The Carlsbad limestone lies progressively lower to the northeast and plunges beneath the surface a short distance north of Carlsbad. The Azotea tongue of the Carlsbad limestone, named by Lang (1937, p. 868), extends northwest into the back-reef area and forms the cap rock on Azotea Mesa and the Seven Rivers Hills.

The Carlsbad limestone is a medium- to thin-bedded gray to buff limestone and dolomite but has some interbedded buff to pink siltstone. Its maximum thickness is about 1,000 feet. The formation thins to the northwest as it grades into redbeds and evaporates of the Chalk Bluff formation. It also thins to the southeast as it interfingers with and overlaps the Capitan limestone.

In the southern part of the mountains the Carlsbad limestone lies well above the water table, but to the northeast, as it descends in altitude, it becomes an important source of water, supplying some of the

Carlsbad municipal wells, irrigation wells in La Huerta, and many stock and domestic wells in the Carlsbad area.

Chalk Bluff formation.—In the northern Guadalupe Mountains and northwest of Carlsbad the Carlsbad limestone grades into and interfingers with back-reef sedimentary rocks, which include evaporates, dolomites, redbeds, and sandstones. These back-reef equivalents of the Carlsbad limestone, together with the underlying clastic equivalents of the Goat Seep limestone, compose the Chalk Bluff formation. The subsurface equivalent of the Chalk Bluff formation is called the Whitehorse group. That part of the Chalk Bluff formation above the equivalent of the Goat Seep limestone has been divided into three members: the Queen sandstone member at the base, the Seven Rivers gypsiferous member, and the Three Twins member. The Whitehorse group is divided into five formations: the Grayburg formation at the base, the Queen formation, the Seven Rivers formation, the Yates formation, and the Tansill formation. The Grayburg formation is the approximate equivalent of the Goat Seep limestone; the Queen formation is the equivalent of the Queen sandstone member of the Chalk Bluff formation; the Seven Rivers formation is the equivalent of the Seven Rivers gypsiferous member of the Chalk Bluff formation; and the Yates and Tansill formations are the equivalents of the Three Twins member of the Chalk Bluff. (See fig. 3.)

The Queen sandstone member of the Chalk Bluff formation, first described by Crandall (1929), is exposed on the tableland in the vicinity of the old Queen Post Office, on the northwest slope of the Hess Hills, and over a large area in the Seven Rivers embayment. The sandstone member ranges from 60 to 100 feet in thickness and consists of white, buff to brown, and red fine-grained sandstone and some interbedded limestone (Lang, 1937, p. 859). Peterson and Skinner (1947, pp. 23-27) consider the Queen sandstone member a sandstone fades interfingering laterally with the dolomites of the Grayburg formation.

On the tableland in the vicinity of the old Queen Post Office, the Queen sandstone member is above the water level in all wells investigated, but northeast of the Huapache monodine, in the Seven Rivers embayment, it probably furnishes water to most of the shallower stock and domestic wells.

The Seven *Rivers* gypsiferous member of the Chalk Bluff formation consists chiefly of anhydrite, gypsum, redbeds, and some interbedded limestone and dolomite. It is exposed along the east boundary of the Seven Rivers embayment in the western escarpments of the Hess Hills, Azotea Mesa, and the Seven Rivers Hills. It also crops out in the McMillan escarpment southeast of Lake McMillan. In the Seven Rivers Hills the Seven Rivers gypsiferous member has a maximum thickness of about 200 feet. It thins to the southeast as it is replaced by the Carlsbad limestone. In the Seven Rivers Hills and in Azotea Mesa, the Seven Rivers gypsiferous member is capped by the Azotea tongue of the Carlsbad limestone. It thins to the southeast as the limestone becomes thicker (Lang, 1937, p. 860). The Seven Rivers embayment was formed primarily by erosion of the weakly resistant Seven Rivers gypsiferous member.

The Seven Rivers gypsiferous member is not an important source of ground water in the Guadalupe Mountains. Over most of its extent in the mountains it probably lies above the water table and thus does not yield water to wells. Water leaks from Lake McMillan into the Seven Rivers gypsiferous member, and the water is discharged to the Pecos River at Major Johnson Springs. The Seven Rivers member of the Chalk Bluff formation and its subsurface equivalent, the Seven Rivers formation of the Whitehorse group, may yield water to some wells in the vicinity of Major Johnson Springs and along a narrow belt just east of the Pecos River from Lake McMillan north to and beyond the county line.

The top member of the Chalk Bluff formation, the Three Twins member, overlies the Azotea tongue of the Carlsbad limestone and the Seven Rivers gypsiferous member. The Three Twins member consists of evaporites, redbeds, and dolomitic limestone, and it grades southeastward into the Carlsbad limestone (Lang, 1937, p. 860). It is exposed over a small area in the northern part of Azotea Mesa and over a large area east of Lake McMillan.

The Three Twins member probably yields perched ground water to some of the wells and springs in its outcrop area northwest of Carlsbad. East of the Pecos River the Three Twins member and its subsurface equivalents, the Yates and Tansill formations of the Whitehorse group, probably yield water to most of the wells in a belt 5 to 10 miles wide from Lake Avalon north to and beyond the county line.

Ochoa series

Castile formation.—Overlying the sedimentary rocks of the Delaware Mountain group in the Delaware Basin is the Castile formation, consisting of 1,300 to 2,000 feet of anhydrite, gypsum, and small amounts of halite, dolomite, and sandstone. As originally deposited, most of the gypsum probably was anhydrite, but it has since been altered by ground water. The Castile formation thins northwest to a feather edge along the base of the reef escarpment and thickens to the southeast toward the lower part of the basin. It crops out in a broad belt south and southeast of Black River and is buried elsewhere in the Delaware Basin, but it does not extend northwest of the buried limestone reef of the Capitan. The extent of the Delaware Basin in Eddy County is shown in figure 4.

In the outcrop area the Castile formation yields water to many stock and domestic wells. The water from many of these wells is high in sulfate and is undesirable for human consumption. Several springs near the base of the reef escarpment issue from the Castile formation through the alluvium. The larger springs yield water of fair to good quality.

Salado formation.—The Salado formation, consisting of halite and small amounts of anhydrite, polyhalite and other potassium salts, and red sandy shale, overlies the Castile formation in the area east of the Pecos River. West of the river most of it has been removed by solution. The Salado formation does not crop out in Eddy County, but it occurs at depth in most of the county east of the Pecos. Potash ore is mined in this formation.

No wells in the county take water from this formation. In the potash mines area the Salado contains no pore spaces capable of transmitting any great quantity of water. No water enters the potash mines from this formation, although the overlying Rustler formation contains water. The brine contaminating the Pecos River water at Malaga Bend is derived from solution at the top of the Salado formation (Robinson and Lang, 1938, pp. 77-100).

Rustler formation.—The Rustler formation unconformably overlies the Salado formation in most of the area east of the Pecos River, and the Castile formation and the Whitehorse group or its equivalents west of the Pecos. In the potash-mines area the bedding of the Rustler is generally parallel to the truncated upper surface of the Salado formation. The Rustler formation ranges in thickness from about 200 feet in northern Eddy County to about 500 feet southeast of Carlsbad. It consists of anhydrite, gypsum, interbedded red and green sandy clay, and some beds of dolomite.

The Rustler in the area of the potash mines can be divided into two units: a lower clastic unit 165 to 235 feet thick and an upper anhydrite unit about 225 feet thick (Theis, Sayre, and others, 1942, pp. 62, 63) . The clastic unit is mainly red and gray shale but includes some interbedded anhydrite. The upper anhydrite unit contains irregular beds of dolomite and has a 20- to 30-foot persistent basal dolomite.

The following generalized section of the Rustler formation in the potash-mines area has been given by Lang (Robinson and Lang, 1938, pp. 83, 84) . Lang divides this section into two parts: The upper part,

GENERALIZED SECTION OF THE RUSTLER FORMATION IN THE PECOS VALLEY, NEW MEXICO

MATERIAL	THICKNESS *Ft.*	DEPTH *Ft.*
Gypsum	30	30
Dolomitic gypsum	30	60
Gypsum	100	160
Redbeds	30	190
Gypsum	20	210
Dolomitic limestone	35	245
Redbeds	30	275
Gray sand		345
Redbeds	20	365
Gypsum		495
Redbeds	5	500

generally about 200 feet thick, includes all beds lying above the 35-foot dolomitic limestone unit, and the lower part, about 300 feet thick, includes the 35-foot dolomitic limestone unit and all beds below it down to the Salado formation.

In the northern part of the county the Rustler crops out east of the Pecos River in the eastern part of a belt of gypsum and redbeds. In this area the Rustler overlies the Chalk Bluff formation and is not easily distinguished from it. South of Carlsbad the west boundary of the main outcrop arc of the Rustler approximately follows the Pecos River, but it extends a few miles west of the river near the south county line. The east boundary of the outcrop area of the Rustler is largely concealed by the mantle of the so-called Mescalero sands which cover both the Rustler and the overlying Triassic redbeds. The Rustler also crops out west of the Pecos in the Frontier Hills.

In its outcrop areas the Rustler yields water to many stock wells and some domestic wells. It also furnishes some of the water used by the International Minerals and Chemical Co., and the Potash Co. of America for refining potash. In the Carlsbad area it yields some water for small-scale irrigation. The water from the Rustler generally is not desirable for domestic use because of its high chloride and sulfate content. In certain areas wells penetrating the lower part of the Rustler yield concentrated brine derived from the underlying Salado formation which cannot be used even for livestock. This brine aquifer at the base of the Rustler discharges salt water into the Pecos River in the vicinity of Malaga Bend (Robinson and Lang, 1938, pp. 77-100).

TRIASSIC SYSTEM

Dockum group

Overlying the Rustler formation in Eddy County are redbeds and sandstones of the Dockum group. The lower part of these beds has been considered Permian and correlated with the Dewey Lake redbeds by some geologists (DeFord, Willis, and Riggs, 1940). The total thickness of the Dockum group east of Artesia is about 1,000 feet. The formations of the Dockum group exposed in Eddy County are the Pierce Canyon redbeds, the Santa Rosa sandstone, and redbeds that possibly represent the Chinle formation.

The Pierce Canyon redbeds overlie the Rustler formation. They are about 350 feet thick and consist of red sandy shale and fine-grained sandstones marked with greenish-gray reduction spots. The formation thins to the north and is absent north of the latitude of Artesia. The Pierce Canyon redbeds crop out in the upper part of Nash Draw, in Clayton Basin, in some of the canyons on the east side of the Pecos River south of Malaga, and in other isolated areas east of the Pecos.

The Santa Rosa sandstone overlies the Pierce Canyon redbeds south of the latitude of Artesia and the Rustler formation north of Artesia. The Santa Rosa is 200 to 300 feet thick and consists of gray and red sandstone and lenses of red shale and conglomerate. The Santa Rosa either crops out or is overlain by a thin mantle of sand over a large area in eastern Eddy County.

Overlying the Santa Rosa sandstone in the southeast part of the county are redbeds, possibly the Chinle formation, consisting of a thick series of red shales and thin interbedded sandstones. In Eddy County the Chinle is covered, in large part at least, by a thin mantle of dune sand.

Stock wells in the east and southeast parts of Eddy County probably obtain water from the sandstones of the Dockum group. The water is generally of better quality than that in the underlying Rustler formation, although some wells in the Dockum group produce impotable water.

TERTIARY SYSTEM

Ogallala formation

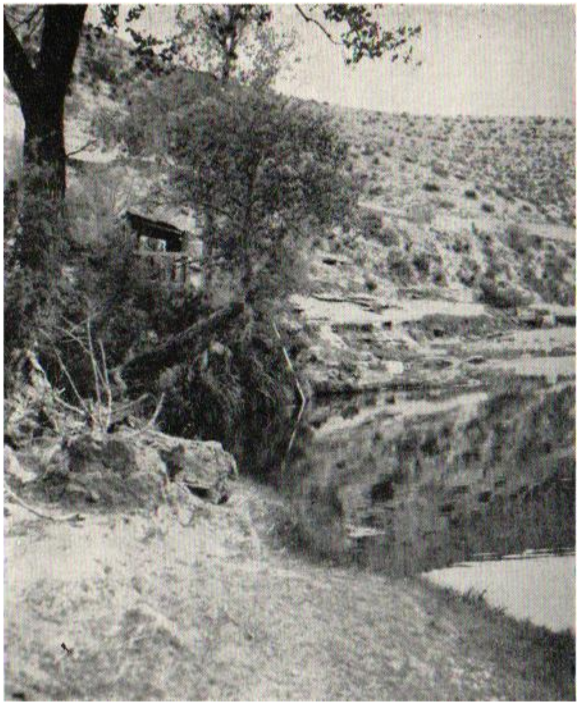
The Ogallala formation of late Tertiary age, caps the small area of the High Plains in the northeast corner of the county. The Ogallala is composed of clay, silt, sand, and gravel, locally cemented with calcium carbonate (caliche). The formation supplies water of good quality to a few stock wells in its outcrop area in the county. The Potash Co. of America gets a part of its water from the High Plains east of Eddy County, and this general area has been considered as a possible source of water for the city of Carlsbad.

QUATERNARY SYSTEM

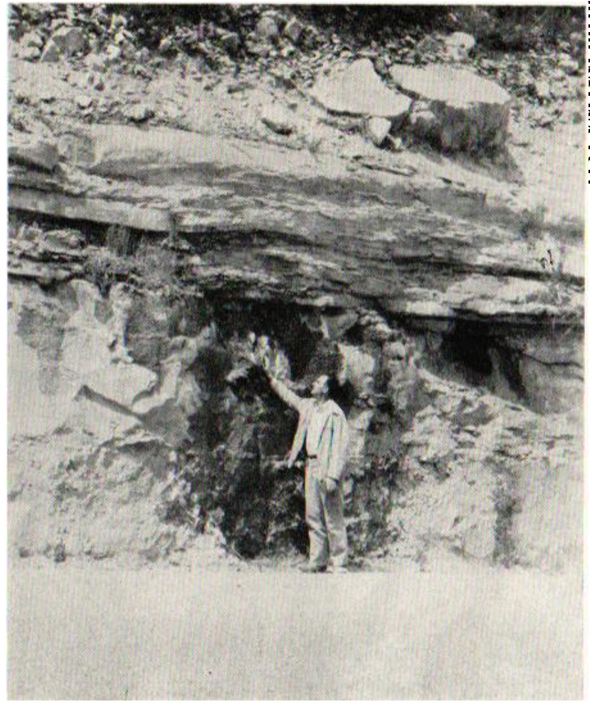
The Quaternary deposits in Eddy County include large areas of alluvium and dune sand and some small isolated areas of lake and spring deposits. The alluvium can be divided into older and younger alluvium which is separated in most places by an angular unconformity.

Older alluvium

Quartzose conglomerate.—The quartzose conglomerate may be basal Ogallala as suggested by Bretz and Horberg (1949), rather than an early Pleistocene deposit as has been commonly believed. It is present in two large areas in Eddy County. In the Roswell basin it extends in a belt 10 to 20 miles wide, mostly west of the Pecos, from Seven Rivers north to and beyond the county line. The other area is also mainly west of the Pecos and extends south from Carlsbad to the Black River. The quartzose conglomerate ranges in thickness from a feather edge to more than 300 feet and consists of clay, silt, sand, gravel, and conglomerate. In both areas the conglomerate appears to be thickest a few miles west of the Pecos and to thin abruptly to the east and more gradually to the west. It is nearly everywhere slumped

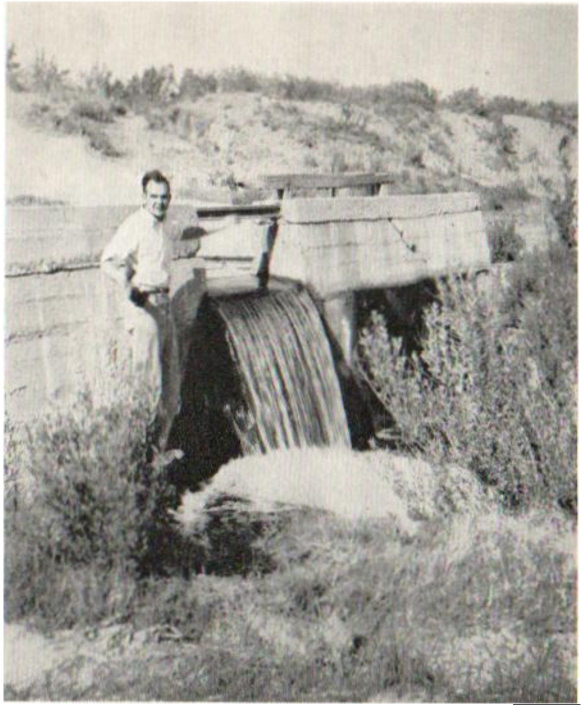


/I. ONE OF Fin: DEEP POOL SPRINGS, INDIAN
BIG SPRINGS, ROCKY ARROYO, **T. 21 S., R. 24 E.**

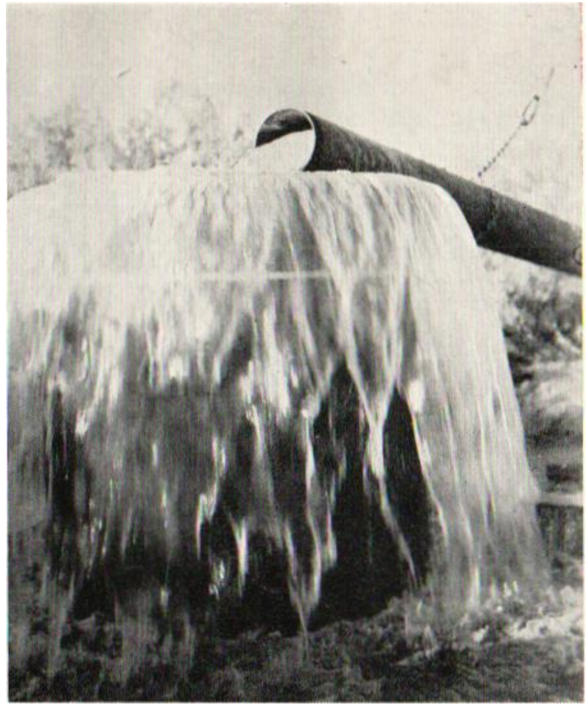


B. SEEP AT CONTACT (IF LIMESTONE OVER SILT-
STONE IN CAPITAN LIMESTONE ALONG WALNUT
CANYON, CARLSBAD CAVERNS ROAD.

Plate 5



CARLSBAD SPRING DISCHARGING INTO THE PECOS RIVER NEAR CARLSBAD. (SEE TABLE 2.)



B. TEST WELL OF THE U. S. POTASH CO., 23.28.13.131, EAST OF THE PECOS RIVER NEAR LOVING, DISCHARGING ABOUT 1,200 GALLONS PER MINUTE FROM ALLUVIUM.

Plate 6

and deformed. It is the chief source of shallow water in the Roswell basin (Morgan, 1938, p. 170) and in the irrigated area in the vicinity of Carlsbad.

Gatuna formation.—The Gatuna formation, of Pleistocene age, consists of reddish-brown silt, sand, and clay. The Gatuna is exposed in the margins of the large sink depressions on the east side of the Pecos River. The remnants of the formation are discontinuous and were probably deposited in local depressions. Several potash test holes have penetrated as much as 200 feet of clay and sand of this formation. The Gatuna appears to be only slightly permeable where exposed at the surface, but it may yield small quantities of water adequate for stock.

Younger alluvium

Terrace and channel deposits.—The younger alluvium deposited by the Pecos River and its tributaries is a veneer from 5 to 20 feet thick on the Blackdom and Orchard Park terraces; it underlies the Lakewood terrace and stream channels, and, with these latter deposits, has a maximum thickness of at least 40 feet. The deposits associated with the Blackdom and Orchard Park terraces are of Pleistocene age, whereas those of the Lakewood terrace were deposited in Recent time. The younger alluvium consists of undisturbed silt, sand, gravel, and cobbles. The deposits associated with the Orchard Park and Lakewood terraces are generally finer-grained than those associated with the Blackdom terrace. The channel deposits consist of silt, sand, gravel, cobbles, and boulders. Those in the Guadalupe Mountains are chiefly limestone cobbles and boulders.

The younger alluvium is above the water table over most of the Orchard Park and Blackdom terraces. It yields some water to wells on the Lakewood terrace, but the strongest wells on this terrace probably penetrate the underlying quartzose conglomerate. The channel deposits in the Guadalupe Mountains yield water to some stock and domestic wells.

Travertine deposits

Large masses of travertine occur along Cottonwood Creek, Rocky Arroyo, and Rio Penasco (Fiedler and Nye, 1933, p. 30). Smaller deposits occur at Blue Spring and along the Black River and other drainage channels. In Rocky Arroyo and in Sitting Bull and Last Chance Canyons are travertine deposits as much as about 30 feet thick. The travertine is very porous and is buff to brown in color. It is similar in age to the younger alluvium. All deposits noted were above the water table, and the travertine probably does not yield water to wells in Eddy County.

Lake and playa deposits

The many small closed shallow depressions east of the Pecos contain silt and clay washed in from the surrounding areas. Some of the depressions contain shallow lakes, such as Salt Lake (Laguna Grande de la Sal) , which have deposited and are depositing gypsite and some halite. The lake and playa deposits are similar in age to the younger alluvium. Water wells in and near these depressions generally yield highly mineralized water which can be used, if at all, only for stock.

Dune sands

The dune sands that mantle most of the area east of the Pecos in Eddy County are generally called the Mescalero sands. The sands range in thickness from the vanishing point to about 60 feet and are probably above the water table. The dune sands take up water readily so that little runs off in this area. Some of the precipitation that falls on these permeable sands probably moves downward to the base of the sands, and some is evaporated or transpired near the surface. As mesquite roots may extend to great depths, a large part of the water that moves below the zone of surface evaporation may be transpired by the mesquite that commonly grows on the sands. The remainder of the water probably recharges underlying formations, especially the permeable Rustler formation. A thin zone of saturation may exist at the base of the thicker and more extensive areas of the Mescalero sands, where they overlie less permeable Triassic rocks. However, even these less permeable rocks probably are recharged to some extent by seepage from the Mescalero sands.

STRUCTURE

WESTERN HIGHLANDS

The Guadalupe Mountains are fault-block mountains lying within the Sacramento section of the Basin and Range province (Fenneman, 1931, pp. 394, 395). In cross section the mountains have a cuesta-like or asymmetric profile with a fault scarp forming the short, steep western slope and a gently eastward dipping back-slope. The regional dip of the rocks generally is less than 3 degrees to the east and southeast. However, the beds dip more steeply than the land surface, and progressively younger rocks are exposed to the east and southeast. The Huapache monocline and the reef escarpment are areas of locally steeper dip. The dip of the beds is about 10 degrees east in the Huapache monocline and about 20 degrees southeast in the reef escarpment. Numerous minor flexures in the mountains cause dips in various directions. Locally the rocks dip toward the arroyos, indicating structural control for some of the drainage ways. One such example is just west of Carlsbad where the hills and valleys are, respectively, structural highs and lows. North of the Guadalupe Mountains the rocks dip eastward from the Sacramento Mountains toward the Pecos River, and the dip of the beds is slightly steeper than the slope of the land surface.

PECOS RIVER VALLEY

The dip of the beds under the Pecos Valley is generally east and southeast, although locally the beds are much disrupted by slumping. Morgan (1938, pp. 165, 166) showed that the widened and deepened parts of the Pecos Valley were developed largely by solution of the gypsum, anhydrite, and salt of the underlying Permian Chalk Bluff formation and subsequent collapse of the overlying rocks. According to Morgan the maximum effects of solution and subsidence and normal stream erosion were localized along the same belts, for solution by upward-percolating water would be most rapid where the material was thinnest—that is, below the valleys of the streams. These depressions were filled with alluvium carried by the streams as they formed and were gradually integrated into a more or less continuous north south-trending trough. The river apparently slipped down dip and eastward as the area subsided. The combination of sinking and erosion by the river of its eastern bands removed traces of pediment and terrace surfaces corresponding to those west of the river (Morgan, 1938, pp. 165, 166).

AREA EAST OF THE PECOS RIVER

The regional dip of the sedimentary rocks east of the Pecos River in Eddy County is east and southeast, but many irregularities of structure have been produced by solution of salt and gypsum beds and the resultant collapse of the overlying rocks. Plate 2 is a contour map showing the top of the salt of the Salado formation. As all ground water of economic importance occurs in beds above the salt, and as the dip of the overlying beds conforms in general to the top of the salt, this map shows the structure effective in controlling the availability of ground water in the area.

Ground Water

GENERAL PRINCIPLES OF OCCURRENCE

Ground water in Eddy County is obtained from openings in consolidated rocks of Permian and Triassic age and in relatively unconsolidated sediments of Tertiary and Quaternary age. Any formation or other rock unit that yields water to wells is called an aquifer. The openings in an aquifer may be in the form of solution cavities, joints, and bedding planes, or in the form of pore spaces between grains of silt, sand, or gravel. Openings in limestone, dolomite, and gypsum are chiefly solution cavities—mostly enlarged joints and openings along bedding planes. Openings in alluvium are generally the pore spaces between particles of sand and gravel, but locally the alluvium is cemented with lime and may contain fractures and solution cavities. Sandstone and siltstone may contain openings of other kinds, but the ones chiefly affecting the movement of ground water are the intergranular openings.

The proportion of the volume of the pore spaces to the volume of the rock is called the porosity of the material. In order to transmit water to a well the pore spaces must be connected. In general, the larger the connected pore spaces or openings the greater the amount of water that can be transmitted to a well. The capacity of the material to transmit water is called the permeability of the material. The coefficient of permeability of a material is defined as the number of gallons of water that can pass in 1 day through a square-foot cross-sectional area of the material at right angles to the direction of flow under a unit hydraulic gradient. The number of gallons of water that will pass in 1 day through a vertical strip of the aquifer 1 foot wide under a unit hydraulic gradient is called the coefficient of transmissibility of the aquifer.

Recharge to the ground water in Eddy County comes from precipitation directly by infiltration from the land surface or indirectly by surface water leaking from streams, ponds, reservoirs, or ditches, or infiltrating from irrigated land. In areas underlain by sandstone, siltstone, or unconsolidated alluvium, water soaking into the ground generally moves downward until it reaches a horizon below which all openings in the material are filled with water. The surface of this zone is called the water table. In areas underlain by soluble rocks, such as limestone, dolomite, and gypsum, the recharging water moves downward through a complex system of fractures and solution cavities which are more or less interconnected, and the upper limit of the zone of saturation may be so irregular as to make the concept of a water table valueless (Theis, 1936, pp. 38-40).

In some places a relatively small body of ground water may be held above the principal ground-water body by a comparatively impermeable layer or stratum. This is called perched ground water. Several of the wells shown on figure 7 yield water from perched groundwater bodies.

MOVEMENT

The water table is not flat but slopes from an area of recharge where the water enters the aquifer to an area of discharge where the water leaves the aquifer. The slope of the water table is the result of ground water moving from the areas of recharge to the areas of discharge. This movement of ground water is controlled to a major extent by the structure and composition of the water-bearing and associated rocks. Where an aquifer overlain by a relatively impermeable unit dips away from an area of recharge, ground water may be confined under pressure in the down-dip part of the aquifer. The hydrostatic head, called artesian head, of the confined water is caused by the height of the water up dip in the aquifer. When a well penetrates a confined aquifer, the water will rise in a tightly cased hole to an altitude determined by the artesian pressure at that place. The imaginary surface connecting these altitudes is called the piezometric surface. The piezometric surface, like the water table, slopes generally from an area of recharge to an area of discharge. Where the piezometric surface is above the land surface wells will flow. Many of the wells in the Roswell basin originally flowed and a few still flow.

Ground water may pass through several different aquifers, in its movement from areas of recharge to areas of discharge. West of the Pecos River ground water moves generally eastward to discharge into the river. East of the Pecos ground water moves southward and southwestward into the river, but the rate of movement and the amount of water discharged into the Pecos from the east are comparatively small. The amount of water moving eastward beneath the High Plains from Eddy County probably is small.

When a well discharges, a cone of depression is formed in the water table or piezometric surface. This cone of depression deepens and widens at a rate decreasing with time. The ultimate limits of the cone of depression are the physical boundaries of the aquifer or areas of rejected recharge, or discharge (Theis, 1938, pp. 889-902). When the discharge of the well is shut off the water rises again in the well at a rate decreasing with time, and the cone of depression becomes shallower until it nearly vanishes, although if a large amount of water is taken out of the aquifer a measurable persistent lowering of water level may result.

The drawdown or amount of lowering of water level in a discharging well is approximately proportional to the rate of pumping for equal periods of pumping. The amount of water that can be obtained from a well, expressed in gallons per minute per foot of drawdown, is called the specific capacity of the well and is dependent upon the structure of the well, the hydrologic properties of the aquifer, and the length of time the well has discharged. As the drawdown nearly always increases the longer a well is pumped, this is not an exact quantity, but the term specific capacity is useful to show the comparative yields of wells. In many limestone aquifers, however, the yield of a well frequently is not directly proportional to the drawdown, owing to turbulent flow in conduits in the limestone in the immediate vicinity of the well. The yield may be proportional to some fractional power of the drawdown. Assuming a conduit type of flow common to limestone aquifers, when the drawdown reaches the level below the lowest conduit supplying water to the well further drawdown will not increase the yield of the well.

USE OF GROUND WATER IN EDDY COUNTY

The use of ground water in Eddy County is dependent on the quantity of water available, the depth from which it must be pumped, the chemical quality of the water, and its geographic location in relation to the area of use.

Ground water for irrigation must be available in or very near the irrigated area, in large quantities without too great a pumping lift. Pumping from depths greater than roughly 250 feet is not generally considered profitable in Eddy County, and wells producing less than 500 gallons per minute rarely are used for commercial irrigation in Eddy County. Water from most irrigation wells in the Roswell basin in northern Eddy County contains less than 2,000 parts per million of dissolved solids, but in the area south of Carlsbad ground water containing as much as 5,000 parts per million of dissolved solids is used.

Ground water for domestic use must be of good quality, but wells yielding only a few gallons per minute are adequate. United States Public Health Service standards which are commonly used in evaluating the quality of domestic water supplies state that water preferably should contain no more than 500 parts per million of dissolved solids, though 1,000 parts is permitted where better water is not available. However, water having more than 1,000 parts is commonly used in parts of Eddy County, especially south of the Black River and east of the Pecos. The depth to water is not as important for domestic supplies as for irrigation, because much smaller quantities are pumped. Water for domestic use is pumped from depths of several hundred feet in the Guadalupe Mountains and in the western part of the Roswell basin area in northwestern Eddy County.

To be satisfactory for domestic use, a water should contain no more than 1.5 parts per million of fluoride. When water containing larger amounts of fluoride is used by young children for drinking, the enamel of their permanent teeth may become mottled. A few of the waters samples in the county do contain more than 1.5 parts per million of fluoride, but most of these waters contain so much other dissolved matter that they cannot be used for drinking. Recent studies indicate that waters of high nitrate content may contribute to cyanosis (blue babies) in infants. The National Research Council, through its Committee on Sanitary Engineering and Environment, Abel Wolman, Chairman, recommends that water containing more than 44 parts per million of nitrate be regarded as unsafe for infant feeding (Nat. Research Council, 1950, p. 271).

Ground water for public supply must be of good quality and available in sufficient quantity to meet the needs of the community. The city of Carlsbad uses about 200 gallons per person per day during the summer months and less than 100 gallons per person per day during the winter months.

Water that is unfit for humans may be used for livestock in cases of need, but ordinarily livestock do better when their water is of good quality. Many of the stock wells in the south and east parts of the county produce water containing more than 5,000 parts per million of dissolved solids. The quantity of water required for livestock is small—about 10 gallons per day per head of beef and 10 to 20 gallons per day per head of dairy cattle. Most stock wells in Eddy County are pumped by windmills and produce from 1 to 10 gallons per minute. Water for livestock can be pumped profitably from depths of many hundreds of feet if other factors are favorable. Locally, in western Eddy County, the depth to water in stock wells exceeds 800 feet.

The quantity and quality of water required for industrial use are determined by the type of industry. The potash refineries are the only industries using large quantities of ground water in Eddy County. One of the potash refineries uses water of rather poor quality, containing about 3,500 parts per million solids, from the Pecos River; one uses water suitable for domestic uses from wells on the High Plains in Lea County together with rather highly mineralized water from wells penetrating the limestone of the Rustler formation at the plant site; and the third uses water similar to Carlsbad city water from wells in the Carlsbad limestone in La Huerta and highly mineralized water from wells in the limestone of the Rustler formation at the plant site.

The approximate quantities of ground water used in Eddy County for various purposes in 1949 are given in the following table:

USE	ACRE FEET	
Irrigation:		
Artesian wells—Roswell basin	70,000	Estimated from acreage irrigated.
Shallow wells—Roswell basin	40,000	
Carlsbad irrigation district	20,000	
Total irrigation	130,000	
Public supply:		
Carlsbad	3,500	Reported
Artesia	1,500	Reported
Industry:		
Potash companies	* 4,000	Reported
Stock and domestic	2,000	Estimated from rural population and approximate livestock population.
Total	141,000	

* Includes only ground water produced in Eddy County. An additional 85o acre-feet per year of ground water is brought in for potash refining from the High Plains area in Lea County.

GUADALUPE MOUNTAINS

The Guadalupe Mountains area in this discussion is in the southwestern part of the county and includes: the northeast limb of the mountains, called the Guadalupe Ridge and Azotea Mesa, which extends a short distance north of the latitude of Carlsbad; the northwest limb which is continuous with the Sacramento Mountains west and northwest of the county; and the area between the two limbs, called the Seven Rivers embayment. The Guadalupe Mountains area is shown on plate 3 as areas la, 1b, and 1c.

PRINCIPAL AQUIFERS

Ground water obtained from wells in the Guadalupe Mountains is chiefly from the Goat Seep limestone, Capitan limestone, Carlsbad limestone, and alluvium in the arroyos. Some ground water is obtained also from the sandstone and siltstone and probably from gypsiferous beds of the Queen Sandstone member and Seven Rivers gypsiferous member of the Chalk Bluff formation. Well drillers have reported a black shale and shaly limestone in some of the deeper wells in the upper reaches of Dark Canyon and Last Chance Canyon. This may be the Cutoff shaly member of the Bone Spring limestone, equivalent of the San Andres formation. In each case where the black shale was penetrated in drilling, water was reported above the shale. This black shaly limestone is not reported northeast of the Huapache monocline, where it is probably below ordinary drilling depths.

RECHARGE

Recharge to the ground water in the Guadalupe Mountains area is for the most part from flood flows in the arroyos. Most of the arroyos in the mountains are partly filled with coarse gravel, cobbles, and boulders. Storm waters gather in these arroyos, and, as the bottom material is extremely permeable, much of the water goes underground. Usually one or two storms a year provide enough surface runoff to reach the Pecos River for short periods of time. All the runoff of lesser storms recharges the ground water or is lost by evaporation or transpiration. Much of the rainfall in the areas between arroyos runs off to the arroyos or is evaporated or transpired. However, considerable recharge may occur in the inter-arroyo areas from slowly melting snow.

MOVEMENT

Water that enters the gravel and boulders in the arroyo bottoms moves downward to the underlying bedrock. Locally, where the bedrock is less permeable than the arroyo gravel, part of the water is deflected and follows the course of the arroyo as underflow in the arroyo gravel. Some of the underflow may reappear as springs farther down the arroyo or it may all percolate down into the underlying rocks. In the upper reaches of Dark Canyon (T. 24 S., Rs. 22 and 23 E.) the underflow comes to the surface as springs which flow at the surface for a few hundred yards and again disappear into the gravels. In Rocky Arroyo the underflow comes to the surface at Indian Big Springs in sec. 27, T. 21. S., R. 24 E., (see pl. 5, *A),* approximately at the contact between the Chalk Bluff formation and the Carlsbad limestone, and flows northeast for a distance of about 7 miles before it disappears into the gravels of the arroyo. Downstream from Indian Big Springs the surface flow and underflow are perched, at least in places, as the water level in well 21.25.9.342, about half a mile from Rocky Arroyo, is about 100 feet lower than water in the arroyo.

The amount of underflow that percolates downward from arroyo gravels to the underlying rocks depends on the permeability of those rocks. Where the gravels are underlain by cavernous limestones all the water probably enters the limestone. Movement of ground water after it reaches the bedrock is controlled chiefly by fractures and bedding planes, more or less enlarged by solution in limestone and dolomite, and by the grain size and degree of cementation of the siltstone and sandstone beds.

Solution cavities in the limestone and dolomite range from very slight enlargement of fractures and openings along bedding planes to the huge openings of the Carlsbad Caverns. Drillers report that the limestone and dolomite contain caverns over a large area in the mountains, and that these caverns extend to great depths. A cavern 2 feet deep was penetrated in well 22.22.32.344 at a depth of 898 feet. Further evidence of caverns is the "sucking and blowing" of many wells with changes in barometric pressure. When barometric pressure is increasing, the outside air is under greater pressure than the air in the caverns, and air is forced into the caverns through the well opening. When barometric pressure is decreasing, as before a storm, the air in the caverns is under greater pressure than the outside air, and air is forced out of the caverns through the well opening.

In the Guadalupe Mountains cavernous limestone and dolomite allow more rapid movement of ground water than the fine-grained sandstone and siltstone. The less permeable sandstone and siltstone thus serve to deflect the downward-percolating ground water in the direction of the dip of the beds. Many small springs and seeps occur in the canyon walls in limestone just above sandstone and siltstone beds. (See pl. 5, *B).* The springs and seeps are more numerous on the up-dip sides of the canyons. Inasmuch as the sandstone and siltstone beds grade laterally into and interfinger with limestone beds, the deflected water may find access to lower horizons somewhere down the dip. The black shaly beds penetrated in some of the deeper wells in the mountains may serve as an impermeable barrier restricting the downward circulation of the water.

Water was found at several different horizons in some of the wells in the Guadalupe Mountains area. This may not be perched water in the usual sense of the term. The water may be supplied by conduits and not related to water levels at any other place. Most of the groundwater flow here is in channels or conduits, and it is possible that no definite zone of saturation or water table exists, or the zone of saturation, if present, may be so low that only the deepest wells penetrate it. If only the deepest water levels are considered, a suggestion of conformity indicates the slope of the water table or piezometric surface.

The probable directions of movement of ground water in the Guadalupe Mountains area are shown on the map, plate 3. In the Seven Rivers embayment the ground water moves generally to the northeast. South of Dark Canyon ground water moves to the east and southeast. In Azotea Mesa between Dark Canyon and the latitude of Carlsbad the ground water moves generally to the east. In Azotea Mesa north of the latitude of Carlsbad and in the Seven Rivers Hills the ground water moves to the east and southeast. At the west escarpment of the mountains a small amount of ground water may move westward out of the county into Dog Canyon.

DISCHARGE

The areas of discharge of ground water from the rocks of the Guadalupe Mountains probably are limited to a narrow belt east of the mountains. East and southeast of the discharge areas the rocks exposed in the mountains are deeply buried by overlying sedimentary rocks.

The areas of greatest discharge from the mountains are, from north to south:

1. Seven Rivers drainage area:
   Some of the ground water moving northeastward from the Seven Rivers embayment probably enters the Pecos River along the Seven Rivers drainage north of the Seven Rivers Hills. Some of this water may enter the river at Major Johnson Springs below Lake McMillan, although most of the flow of the springs represents leakage from Lake McMillan.
2. Carlsbad area:
   Ground water that moves in an eastward direction in the Carlsbad limestone toward Carlsbad is discharged naturally in the Carlsbad Springs area on the Pecos near Carlsbad. (See fig. 8.) Of the water that entered the Pecos River in the Carlsbad Springs area in 1940 it is estimated that about 13 cubic feet per second, or about 22 percent of the total flow of the springs, came from the Carlsbad limestone to the west (Theis, Sayre, and others, 1942, p. 61). In addition to the 43,400 acre-feet discharged by the springs, about 6,700 acre-feet of water was pumped from wells in the Carlsbad limestone in the Carlsbad area.
3. Alluvium south of Carlsbad:
   Along the southeast flank of the mountains south of Carlsbad ground water discharges from the Carlsbad and Capitan limestones into the alluvium and thence to the Pecos River. Part of the water may pass through gypsum and limestone of the Castile and Rustler formations before reaching the alluvium.
4. Springs along the reef escarpment in southern Eddy County:
   The flow of the Black River is sustained chiefly by several springs near the base of the reef escarpment from the south county line northward to the latitude of the Carlsbad Caverns. The largest spring is Blue Spring, sec. 33, T. 24 S., R. 26 E., which is estimated to flow 10 to 15 cubic feet per second. The principal source of these springs is almost certainly discharge from the Guadalupe Mountains area, as the recharge in the area between the reef escarpment and springs is not enough to provide their flow. In addition to the water discharged by the springs, ground water probably moves from the Capitan limestone and the Lamar limestone member of the Bell Canyon limestone into the alluvium and the underlying Castile formation and thence to the Pecos River.

In each of the above areas the dip of the beds is steeper than the slope of the water table or piezometric surface of the discharging ground water. Accordingly, discharging ground water must move across the bedding planes.

CARLSBAD CAVERNS AREA

Although the Carlsbad Caverns were formed by the work of circulating ground water, the explored part of the caverns at the present time is remarkably dry. No springs or streams flow in the explored part of the caverns. The relatively small quantity of ground water that enters the caverns as seeps along the cavern walls in the explored part of the caverns is discharged by evaporation for, although the relative humidity in the caverns is high, the evaporation surface is large and air circulation results from changes in barometric pressure. That evaporation is active in the caverns is evident by the fact that the temperature in places where circulation of air is greatest is lower than in places where the air is nearly stagnant. Formation of dripstone is another proof of evaporation.

A small pool of water stands at an altitude of about 3,300 feet in the caverns. This may be simply a collecting pool for the slowly draining moisture on the rock walls, or it may be related to a water table. The water level in one of the deep wells at White City is reported to be at an altitude of about 3,100 feet, which may represent the true water table or piezometric surface in the caverns area.

Southeast of the reef escarpment a number of springs each discharge as much as several cubic feet of water per second. The largest of these, Rattlesnake Springs, is at an altitude of 3,634 feet, about 300 feet higher than the lowest explored levels of the caverns. Obviously the lower explored levels of the caverns and the conduits supplying water to Rattlesnake Springs are not connected, for if they were the lower levels of the caverns would be flooded. Ground water apparently moves eastward from the mountains in conduits below the explored caverns and discharges into the alluvium and to springs fronting the reef escarpment.

CHEMICAL QUALITY

The chemical quality of ground water in the Guadalupe Mountains generally is good, although the water is moderately hard. (See analysis for well 25.21.10.223 in table 3.) Nearly all the analyses of water from wells and springs in the mountains show potable water low in chloride and in dissolved solids. Water in gypsiferous rocks may be expected to be high in calcium and sulfate. Wells 22.23.26.413 and 22.23.26.431 obtain water from the Seven Rivers gypsiferous member or from the alluvium derived from this member. Water from both these wells has an unpleasant taste, and an analysis of water from well

22.23.26.413 showed 2,100 parts per million of sulfate. "Sulfur water" has been reported at depths of 800 feet or more in some of the oil tests in the mountains.

USE

The chief use of ground water in the Guadalupe Mountains is for stock and domestic supply. Part of the flow of springs in Dark Canyon and Rocky Arroyo is used for irrigation; gardens, lawns, and orchards at ranch headquarters are irrigated from wells and springs.

AVAILABILITY TO WELLS

Ground water in the Guadalupe Mountains area occurs in a complex system of conduits and perched bodies, which makes prospecting for ground water difficult. A water-bearing conduit may be at a comparatively shallow depth in one well, and in a nearby well at a considerably greater depth, or no water at all may be within reasonable drilling depths. It is reported that in an area of a few square miles in T. 23 S., near the boundary of Rs. 25 and 26 E., 32 dry holes ranging in depth from 220 to 690 feet were drilled. Near Picket Hill, in sec. 5, T. 25 S., R. 21 E., a dry hole 1,000 feet deep was reported. Two dry holes, one 826 feet deep and one 1,400 feet deep, reportedly were drilled in Dog Canyon, just west of Eddy County.

Southwest of the Huapache monocline, between Dark Canyon and Last Chance Canyon, water levels in wells and springs appear to be fairly conformable, and the depth to water may be predicted with some degree of accuracy. The slope of the piezometric surface is northeastward from an elevation of about 6,000 feet near the west escarpment of the mountains to about 5,000 feet near the Huapache monocline, as shown by plate 3. In some recently drilled wells water reportedly was found just above a black shaly limestone which may be the Cutoff shaly member of the Bone Spring limestone, an equivalent of the upper part of the San Andres formation. This black shaly limestone may be useful to mark the minimum depth at which a well would have to be abandoned as a "dry hole" in this area. The shaly limestone was penetrated at a depth of about 614 feet in well 24.22.30.130, near the old Queen Post Office, and at a depth of about 410 feet at the Thayer Headquarters well, 24.21.23.320.

Northeast of the Huapache monocline the altitude of water levels in wells declines abruptly. This could be due partly to the downwarping of the black shaly limestone which may perch the water southwest of the monocline. Water levels in the Seven Rivers embayment, between the Huapache monocline and the northeast prong of the mountains, range in altitude from 3,600 feet to about 4,300 feet, and the relation between water levels at different locations was not determined. An accurate prediction of the altitude at which water will be encountered or to which it will rise in wells at any given place is impossible. Water at the lower altitudes may be moving in the San Andres formation northeast into the Roswell basin. Some of the water at higher levels may be perched on siltstone beds, but not enough information is available to correlate perched bodies.

East of the Seven Rivers embayment, in the Azotea Mesa, perched water also occurs, but water levels decline fairly uniformly to the east. Predictions of altitudes at which water will be encountered can be made with some degree of accuracy here. However, the predictions will not approach the degree of accuracy possible in areas where water is in comparatively homogeneous materials. Dry holes as much as 690 feet deep have been reported adjacent to the reef escarpment in T. 23 S., near the boundary of Rs. 25 and 26 E. Southwest of Carlsbad Caverns the only places where the level of ground water is shown is at springs which are indicated on topographic maps of the U. S. Geological Survey. Little is known about these springs, but from their position it is probable that most, if not all, of them are fed by perched ground-water bodies.

Probably the most favorable sites for wells in the mountains are in or near arroyos. Recharge of ground water is mainly in these arroyos, and the water may be perched in the arroyo gravels at shallow depth, especially where the gravels are underlain by siltstone. Where the dip of the bedrock is toward the arroyos, as west of Carlsbad, ground water is diverted toward the arroyos, especially where permeable limestone and siltstone of low permeability are interbedded. Also, wells in the arroyos have the obvious advantage of starting at lower elevations, and, other things being equal, will penetrate water at shallower depths than wells on adjacent highlands.

Some wells must be drilled on the upland areas to utilize the range fully for grazing. Water has been obtained from deep wells in some areas that were considered hopeless until recent years. Water probably can be obtained in almost all areas in the mountains at some depth, but the practical limits of depth of drilling and pumping may exclude some areas from development. One such area may be on the uplands of Guadalupe Ridge southwest of the Carlsbad Caverns, although the numerous small springs there suggest that small quantities of perched water may be available. The best sites of perched water will be found in synclines or structural troughs, in which the water will accumulate above impermeable beds.

Favorable sites for wells are areas up slope from springs and seeps. Where springs and seeps emerge in canyon walls above a siltstone bed, a favorable well site may be found by following the siltstone bed to a point where it plunges beneath the canyon floor. Siltstone beds can be distinguished easily in some areas by bands of vegetation that are concentrated on the outcrop areas of the siltstone.

CARLSBAD AREA

The Carlsbad area discussed here includes principally the city of Carlsbad, La Huerta across the river from Carlsbad, Happy Valley northwest of Carlsbad, the irrigated area west of the river south of Carlsbad, and the area between the irrigated area and the Guadalupe Mountains. The Carlsbad area approximates areas 2a and 2b on plate 3 and la in the vicinity of Happy Valley and La Huerta.

Studies of the ground water in the vicinity of Carlsbad were made by Theis, Hale, and others in the period 1939 to 1945 (Theis, Sayre, and others, 1942; Theis and Hale, 1942; Hale, 1945). Much of the following discussion of the Carlsbad area is covered in more detail by Hale (1945). Since the time of these earlier studies ground water for irrigation in the area has been developed on a considerable scale. Many new wells have been drilled, and additional ground-water information, including well logs, depths to water, and quality of water, has become available. Many of the well logs that were used in the following discussion and in preparing the cross sections in figure 6 were collected by H. W. Robbins of the United States Bureau of Reclamation, and some were obtained by the authors from local well drillers.

USE

Ground water in the Carlsbad area is used for public supply, irrigation, potash refining, and stock and domestic supplies. The approximate quantities used for the various purposes are indicated in the following table:

USE OF WATER	QUANTITY USED: ACRE FEET PER YEAR	QUANTITY USED: MILLION GALLONS PER YEAR	CHIEF SOURCE OF WATER
Carlsbad city'	8,500	1,141	Carlsbad limestone and alluvium (?)
Air base (Thayer) 1	200	65	Alluvium
Irrigation 2	19,000	6,194	Alluvium
2	1,000	826	Carlsbad limestone
Potash refining	1,500	489	do.
Stock and domestic 2	200	65	Carlsbad limestone, Rustler and Castile formations, and alluvium

1Quantities reported.
2Quantities estimated.

Prior to 1945 probably not more than 25 wells were used for irrigation in the Carlsbad area. After World War II many new wells were drilled for irrigation because steel casing and pumping equipment became available, prices of farm produce were rising, and surface water for the Carlsbad project was insufficient. Wells were drilled east of the Southern canal by individual farmers to supplement the inadequate supply of water from the Pecos River for the Carlsbad Project; wells west of the canal furnish all the water used for irrigation in that area. Most of the new wells were drilled in 1947. In October 1947 the area was declared by the New Mexico State Engineer as an underground water basin, and permits were required for all new wells to be drilled in the declared area. Drilling of new irrigation wells west of the Southern canal is not allowed except as replacements for or to supplement wells that deteriorate.

The number of irrigation wells is not known accurately but is estimated to be about 200. The acreage irrigated from the wells east of the Southern Canal is indeterminate, as the distribution system of the district is used to convey water from wells to lands not having wells. By this method a large part of the irrigated land in the district is furnished ground water. The land irrigated west of the canal is estimated to be approximately 2,000 acres. The pumping of ground water for irrigation of land east of the canal varies from year to year, depending upon the amount of Pecos River water available. The total water permitted, including both surface and ground water, is 3 acre-feet per acre. Records are not kept of the amount of water pumped to supplement the river water, but farmers estimate that it is 1 to 2 acre-feet per acre of land irrigated. Pumping for irrigation west of the Southern Canal also varies somewhat from year to year, depending upon the type of crops grown and the precipitation. However, it is believed that the pumpage west of the canal is less than the allowable 3 acre-feet per acre.

PRINCIPAL AQUIFERS

The ground water used in the Carlsbad area is from three sources: the alluvium, the gypsiferous Rustler and Castile formations, and the Carlsbad limestone. The approximate areas of outcrop of these formations are shown on plate 1, and the subsurface relations are shown in figure 5.

Alluvium

Character, extent, and thickness.—The alluvium consists of clay, silt, sand, gravel, caliche, and conglomerate, and the component materials are irregularly distributed both horizontally and vertically. Locally the conglomerate is so well cemented that it is reported as limestone by well drillers. Elsewhere the conglomerate locally contains fractures and solution cavities which yield most of the ground water, and is similar in hydrologic properties to limestone, as at the air-base wells southwest of Carlsbad. In the absence of cuttings it frequently is impossible to tell from drillers' logs whether the "limestone" found in a well is conglomerate or limestone (Hale, 1945, p. 15). Following is a log of the air-base well 3 which indicates the character of the alluvium (Hale, 1945, p. 18).

LOG OF WELL 2226.35.222, FORMER CARLSBAD AIR FORCE BASE WELL 3 (DRILLER'S LOG TO 166 FEET; LOGGED BY J. P. SMITH, GEOLOGIST, U. S. POTASH CO., FROM CUTTINGS 166 TO 256 FEET)

	THICKNESS *(feet)*	DEPTH *(feet)*
Soil	12	12
Gravel	68	80
Pink sandy clay	82	162
Conglomerate (seep of water)	2	164
Pink sandy shale	10	174
Hard indurated buff limy sand and fine gravel conglomerate	3	177
Conglomerate; matrix yellow limestone, medium coarse dolomitic and siliceous pebbles (water at 180 feet)	16	193
Hard buff fine gravel and sand conglomerate	7	200
Hard indurated buff limy sand	10	210
Medium-coarse limestone conglomerate	5	215
Buff, greenish, and pink calcareous shale with a few pebbles and a few sandy laminae	10	225
Very hard indurated limy sand	10	235
Medium-coarse gray and buff conglomerate (increase of water?)	10	245
Hard fine-textured buff conglomerate	11	256

The principal areas of alluvium within the Carlsbad area are the city of Carlsbad, La Huerta, most of the irrigated area in Happy Valley, and a large area south of Carlsbad between the Guadalupe Mountains and the Pecos River. The thickness of the alluvium varies greatly in short distances, owing to pronounced irregularities in the surface on which it was deposited. These irregularities were caused by solution and collapse of the underlying rocks. The thickest part of the alluvium is under the present drainage system (Hale, 1945, p. 14). South of Carlsbad the thickness of the alluvium, on the basis of drillers' logs, ranges from a feather edge near the mountains on the west to more than 200 feet near the Pecos River. In La Huerta the maximum recorded thickness of alluvium is 127 feet. Well 3 at the Carlsbad Air Base near Dark Canyon penetrated valley fill to a depth of 256 feet without encountering bedrock (Hale, 1945, p. 15).

Recharge, movement, and discharge.—*Recharge* to the alluvium is from several sources. Water from the Carlsbad limestone moves into the alluvium in the Carlsbad area. Underflow from Dark Canyon and other arroyos probably *adds* a considerable quantity of water to the alluvium, and during heavy storms part of the surface runoff carried by the arroyos is absorbed by the alluvium. In La Huerta confined water from the Carlsbad limestone may leak upward into the alluvium in poorly cased wells. During the irrigation season part of the Pecos River water applied to the irrigated lands recharges the alluvium. Water is also lost to the alluvium from leaky irrigation canals and ditches, and this process probably contributes the greatest amount of recharge in the area east of the main irrigation canal, the Southern Canal.

The altitudes of water levels in wells are shown on figure 6. Not all water levels shown on the map by means of figures are directly related. Some water bodies are as much as 50 feet above the "main" water table. The upper water generally is in comparatively more compacted material and some wells can be emptied with a bailer. Locally, where the upper water is not cased off, it can be heard cascading into the well. One such area is near the main (Southern) canal northwest of Loving where the water in the upper zone comes at least in part from leakage from the canal.

Contours on the main or deeper water table are shown in figure 6. As the general movement of the ground water is perpendicular to the contours on the water table, the map shows that south of Carlsbad ground water in the alluvium moves generally eastward toward the Pecos River. Leakage from the Southern canal locally has forced the flow of ground water to the south or southwest, with the result that a trough in the water table exists west of the canal, as pointed out by Hale (1945, p. 24) and as shown by the contours on figure 6 in sec. 9, T. 23 S., R. 27 E. This condition is probably most pronounced during the irrigation season.

The slope of the water table in the southern part of the area south of Carlsbad is generally eastward 15 to 25 feet to the mile. In the area immediately south of Carlsbad and west of Otis, the water table is nearly flat, probably in part as the result of lowering of water levels by heavy pumping in the western part of the area. Hale's report (1945, p. 22) shows an eastward gradient of 10 feet to the mile at a time before large-scale pumping began.

Little information is available concerning the slope of the water table and direction of movement of ground water in the alluvium in La Huerta, inasmuch as most wells there are drilled through the alluvium and into the Carlsbad limestone. The water probably moves south and southeast to the Pecos River.

The depth to water in wells in the alluvium (fig. 7) ranges from about 10 feet in places along the Pecos River to more than 150 feet a few miles west of the Southern Canal. The depth to water in most of the irrigated area is 10 to 70 feet.

Fluctuations of water levels.—Measurements of water levels have been made at intervals of about 2 months since 1942 in the three wells at the air base and, since 1944, in two nearby wells. Beginning in 1948, measurements of water levels were begun in about 60 wells in the irrigated area. Records of water levels, with discussions of the changes year by year, have been published by the U. S. Geological Survey in annual reports (Water levels and artesian pressure in observation wells in the United States, 1947, 1948, and 1949).

The report for 1949 states that the bimonthly measurements of water levels show that when surface water is available the water table in the area east of the Southern Canal is generally lowest in the spring prior to irrigation and rises throughout the summer to the high level for the year in about September. The effect of seepage to the groundwater body from applied irrigation water and from canals is quite evident. When there is excessive pumping of ground water, and surface water is inadequate, the pattern of seasonal fluctuations changes in accordance with the change in conditions and ground-water levels are low in the summer. In the area west of the Southern Canal, where irrigation is exclusively by ground water, the low levels during the year are in August or September, near the end of the pumping season.

The annual water-level reports show that the net change in water levels from one winter to the next depends primarily upon the amount of pumping, which in turn depends in part upon the amount of precipitation and, in the irrigated area cast of the Southern Canal, upon the amount of surface water available for irrigation. Maps of yearly changes in water level are given in the annual reports.

In 1947 precipitation during the growing season was only about 26 percent of normal and surface water was inadequate. Because of this, much ground water was pumped, with the result that water levels declined from January 1947 to January 1948 as much as 14 feet just west of the Southern Canal near Otis and as much as 10 feet east of the canal. In 1948 precipitation was greater than in 1947 but not distributed favorably for the growing of crops. Surface water was available for the full growing season in 1948. As a result the water levels in the period from January 1948 to January 1949 rose in the area east of the Southern Canal, though not as much as the decline of the previous year, and declined about 8 feet in the area west of the Southern Canal. In 1949, as the precipitation was above normal, pumping of ground water west of the canal was considerably less than in 1948 and surface water was adequate for lands east of the canal. As a result water levels rose under the entire area east of the canal and under most of the area west of the canal. However, as the rises did not equal previous declines, water levels in January 1950 were about 2 feet lower in the area east of the canal than when records began in January 1947, and as much as 20 feet lower in part of the area west of the canal.

Chemical quality.—In La Huerta, water in the alluvium generally is of much poorer quality than that in the underlying Carlsbad limestone. This is probably due largely to seepage of water from the irrigated lands and from the Eastern Canal which borders La Huerta on the north; also, there probably is movement of ground water from Lake Avalon to the alluvium in this area. An analysis made in 1950 of water from well 21.27.9.330 (see table 3), which supplies stock water from the alluvium, showed 1,090 parts per million of dissolved solids and 608 parts per million of sulfate but only 5 parts per million of chloride. Water samples taken by Hale (1945, p. 6) in 1938 from wells drilled in the alluvium in secs. 19, 29, and 30, T. 21 S., R. 27 E., ranged from 1,870 to 2,340 parts per million in sulfate and from 755 to 1,100 parts per million in chloride. Three of these wells supplied water for domestic use.

South of Carlsbad, the alluvium near Dark Canyon contains the best water in the vicinity of Carlsbad. This water, as represented by the air-base wells, contains about 340 parts per million of bicarbonate but only 15 parts per million of chloride. Eastward from Dark Canyon the water becomes more highly mineralized as it mixes with water returned from irrigation and leaking from the Southern Canal. Near the canal it generally contains more than 1,000 parts per million of sulfate and from 400 to 900 parts per million of chloride (Hale, 1945, p. 24). This water generally is nearly impotable, although it is of necessity used for domestic purposes as well as for irrigation. East of the Southern Canal the water generally contains more than 1,000 parts per million of chloride and 2,000 parts per million of sulfate.

The east boundary of water in the alluvium containing less than 200 parts per million of chloride extends southeastward from Carlsbad to Black River just west of the Southern Canal. According to Hale (1945, p. 26), during periods of relatively heavy rainfall the highly mineralized water probably moves eastward as it is displaced by better water added by floods in Dark Canyon. In times of drought the highly mineralized water probably moves westward and displaces the better water near the western edge of the alluvium. A narrow transitional zone in which the character of the water changes rapidly probably exists a short distance west of the Southern Canal. Hale (1945, p. 26) concluded that large developments of the good-quality water near Dark Canyon might cause the more highly mineralized water to be drawn from the east into that area.

Specific capacities of wells.—Measured specific capacities of irrigation wells in the alluvium south of Carlsbad range from about 12 to 200 gallons per minute per foot of drawdown. Specific capacities of some of the wells are given in the table below. Inasmuch as the time interval *between* measurements of static levels and pumping levels ranged from several hours to several weeks, the figures given are neither exact nor directly comparable but are useful to indicate the order of magnitude.

Specific capacities in excess of about 100 are high and indicate a very permeable aquifer. Specific capacities may be lower than 12 locally, as some wells drilled for irrigation have been abandoned as "dry holes." Well drillers report that some of the most productive irrigation wells obtain water from crevices and solution cavities in conglomerate.

WELL NUMBER	MEASURED RATE OF PUMPING (*g.p.m.*)	DRAWDOWN (*feet*)	SPECIFIC CAPACITY (*g.p.m./ft.*)
22.27.15.113	1,900	12	162
22.27.15.233	3,000	20	150
22.27.26.331	2,600	50	52
22.27.35.233	1,200	30	40
23.27.2.122	500	40	12
23.28.7.113	3,750	90	42
23.28.15.411	800	18	44

Use.—The alluvium furnishes water for the public supply at the Thayer Apartments at the former air base southwest of Carlsbad, for many stock and domestic wells, for some of the irrigation wells in La Huerta, and for nearly all the irrigation wells south of Carlsbad. Rustler and Castile formations.

Character, extent, and thickness.—Because the Salado formation, which lies between the Rustler and Castile formations in most of the area east of the Pecos, is absent in most places west of the river, this discussion relates to the Rustler and Castile formations in the Carlsbad area.

In the Frontier Hills the Rustler is about 150 feet thick and consists of thin-bedded gray to buff dolomite underlain by redbeds and gypsum of the Castile formation. The dolomite capping the hills is about 80 to 100 feet thick. East of the Frontier Hills the dolomite grades into gypsum and anhydrite. The Castile formation consists of redbeds, gypsum, and anhydrite. Inasmuch as the two formations cannot always be distinguished in drillers' logs and in most places have the same hydrologic properties, they are considered as one aquifer called the Castile-Rustler aquifer in this discussion. The Rustler and Castile formations crop out in the Carlsbad area and also in small patches in Happy Valley and in Hagerman Heights. The combined thickness of the Rustler and Castile ranges from a feather edge along the reef escarpment to about 1,700 feet at the Pool-State oil-test drill hole in the SW1/4 sec. 16, T. 22 S., R. 27 E. (See fig. 5.)

Recharge, movement, and discharge.—In Happy Valley the underflow in the alluvium, moving southeastward from the Guadalupe Mountains, probably contributes most of the recharge to the Castile-Rustler aquifer. Irrigation water pumped from wells in the Carlsbad limestone may supply some additional recharge. In the upper part of Happy Valley, water in the Castile-Rustler aquifer is apparently perched above the piezometric surface of the water in the Carlsbad limestone. The water in the Castile-Rustler aquifer in Happy Valley moves eastward to discharge into the alluvium and thence into the Pecos River.

In La Huerta the Castile-Rustler aquifer is probably recharged in part by upward leakage from the Carlsbad limestone in poorly cased wells and where the confining beds in the lower part of the Castile formation are thin or broken. Irrigation water from Lake Avalon and from wells in the Carlsbad limestone may percolate downward through the alluvium to recharge the Castile-Rustler aquifer. Drillers' records indicate that the water levels in the Castile-Rustler aquifer in La Huerta probably are about the same as those in the overlying alluvium and lower than the piezometric surface in the underlying Carlsbad limestone. Discharge from the Castile-Rustler aquifer in La Huerta is south and southeast to the Pecos River.

In Hagerman Heights, as elsewhere in the outcrop area of the Castile and Rustler formations east of the Pecos, recharge to the aquifer is from local precipitation. In the Hagerman Heights area water in the Castile-Rustler aquifer moves southwestward to discharge into the Pecos.

South of Carlsbad the Castile-Rustler aquifer receives some recharge, especially at times when Dark Canyon is in flood in the Frontier Hills area, where the aquifer is at or near the surface. Farther east in the irrigated area some of the water leaking from canals and irrigation water applied to the land may percolate through the alluvium to recharge the Castile-Rustler aquifer. The water in the aquifer, as in the overlying alluvium, moves eastward to discharge into the Pecos River.

Chemical quality.—The water from the Castile-Rustler aquifer is generally high in sulfate and moderately high in chloride. Water from nearly all wells in this aquifer has an unpleasant taste and is generally considered unsuitable for drinking. The water from all wells probably is suitable for stock, although dairymen report greater milk production when the water of better quality from the Carlsbad limestone is used.

Specific capacities of wells.—No pumping tests were made of wells in the Castile-Rustler aquifer in the Carlsbad area. Most of the wells are reported to have small specific capacities in comparison to wells yielding water from either the overlying alluvium or the underlying Carlsbad limestone.

Use.—The Castile-Rustler aquifer furnishes some water to stock and domestic wells in the Frontier Hills area, in Happy Valley, and in Hagerman Heights. It also furnishes a comparatively small amount of water for irrigation in Happy Valley, in Hagerman Heights, and possibly in La Huerta and the irrigated area south of Carlsbad.

Carlsbad limestone

Character, extent, and depth.—In the outcrop area west of Carlsbad the Carlsbad limestone consists of medium- to thin-bedded gray to buff limestone and dolomite and some beds of buff sandstone and silt-stone. The subsurface character of the material is indicated in the drillers' logs of the Carlsbad city wells, pp. 60-61.

The Carlsbad limestone crops out in the Ocotillo Hills and the Hackberry Hills west of Carlsbad and in the Avalon Hills between Lake Avalon and La Huerta. It underlies the alluvium in the western part of Carlsbad and in the west and north parts of La Huerta, and it underlies the Castile-Rustler aquifer in the eastern part of Carlsbad and La Huerta, in Happy Valley, and, at great depth, in the irrigated area southeast of Carlsbad.

As indicated in the cross sections (fig. 5) the depth to the top of the Carlsbad limestone increases to the east and southeast. In La Huerta the depth to the limestone ranges from a few feet near the outcrop area in the northwestern part to about 350 feet in the south-eastern part. In Hagerman Heights the top of the limestone is more than 400 feet below the surface. In Happy Valley the depth to the top of the limestone increases toward the center of the valley and also southeastward along the axis of the valley. South of Carlsbad the Carlsbad limestone plunges steeply to the southeast, and the limestone is more than 1,000 feet below the surface in two oil-test drill holes near the Frontier Hills, less than 2 miles east of the reef escarpment. The limestone is probably beyond ordinary drilling depths in the entire irrigated area southeast of Carlsbad.

Occurrence, recharge, movement, and discharge.—Ground water occurs in the limestone in a complex system of conduits formed by solution along fractures and bedding planes. The conduits are irregularly distributed, and water may be encountered at different depths in adjoining wells. The Bobbit well in Happy Valley, 21.26.31.240, reportedly penetrated the limestone at a depth of 70 feet, but no significant amount of water was obtained until a cavern was penetrated at a depth of 611 feet. In another well in Happy Valley, 22.26.3.344, the water was obtained in the limestone at depths between 150 and 360 feet. One of the Bluebird Water Co. wells, 22.26.3.214, on the north side of Happy Valley, reportedly penetrated two water-bearing zones in the limestones, one at a depth of 146 feet and one at 288 feet. The Blake Spruill well in the western part of Carlsbad, 21.26.35.441, encountered water at 118 feet in the limestone. No additional water was found when the well was later deepened to 200 feet. Most of the Carlsbad city wells obtained water in the limestone at depths between 150 and 200 feet, but well 12 obtained no significant amount of water until a depth of 245 feet was reached. In La Huerta water has been obtained in wells in the limestone at various depths ranging from about 110 to 350 feet.

Ground water in the Carlsbad limestone in the vicinity of Carlsbad is generally confined. Although the depth to which it is necessary to drill to obtain sufficient water in the limestone generally cannot be predicted, the level to which the water will rise in the wells can be predicted with a considerable degree of accuracy. The altitude of the water surface in the Carlsbad limestone in nearly all wells near Carlsbad is between 3,105 and 3,110 feet above sea level. The only known exceptions are a few stock wells that are supplied by perched water in the limestone hills west of Carlsbad.

In its outcrop area west of Carlsbad, the Carlsbad limestone receives recharge directly from precipitation and from surface drainage. East of the outcrop area much of the recharge is leakage from Lake Avalon, from irrigation canals above Carlsbad, and from irrigation in La Huerta. Some recharge also seemingly is from leakage from the Pecos River in the stretch below Major Johnson Springs and above Lake Avalon.

The water in general moves from these areas of recharge to discharge into the Pecos River in the Carlsbad Springs area north of Carlsbad. As the movement of the water and the quantities involved are best determined on the basis of chemical quality, a more detailed discussion is included under chemical quality.

The piezometric surface in the Carlsbad limestone slopes very gently toward the Carlsbad Springs area in the Pecos River at Carlsbad. The ponding altitude back of the Tansil Dam in Carlsbad, about 3,095 feet above sea level, represents the lowest discharge altitude in the springs area. The water in one of the core tests for dam site 3, about 8 miles northwest of Carlsbad, stands at an altitude of 3,112 feet. This water is almost certainly discharging in the Carlsbad Springs area, indicating a maximum gradient of 17 feet in 8 miles, or about 2 feet per mile. Carlsbad Spring, 21.26.26.443 (see pl. 6, *A)* , one of the springs in the Carlsbad Springs area, on the south bank of the Pecos about 200 yards east of the Southern Canal flume is impounded by a concrete tank to overflow at an elevation of about 3,105 feet. Thus, it appears probable that the gradient of the piezometric surface is much less than 2 feet per mile to within a short distance of the discharge area, becoming rather steep near the springs.

Chemical quality.—The water in the Carlsbad limestone in the hills west of Carlsbad is generally of good quality, although hard. An analysis of water from McKittrick Springs, 22.25.12.120, showed only 33 parts per million of sulfate, 6 parts per million of chloride, and a hardness of 301 parts per million as calcium carbonate. As the water in the limestone moves eastward to the discharge area at Carlsbad Springs it becomes mixed with water of poorer quality which originates as: (1) leakage from Lake Avalon, (2) leakage from the Southern and East canals, and (3) return from irrigation in La Huerta (Theis, Sayre, and others, 1942, p. 60).

Estimates of the relative amounts of water entering the Pecos

River in the Carlsbad Springs area from these various sources, except for irrigation return from La Huerta which is small, and the average chloride content of the water from the different sources were given by Theis, Sayre, and others (1942, p. 62), as follows:

	AMOUNT *(cubic feet per second)*	CHLORIDE *(parts per million)*
River above Carlsbad Springs	1.8	940
From the Carlsbad limestone to the west	13	153
Leakage from Lake Avalon	26	658
Leakage from canals	20	671
River below Carlsbad Springs	61.8	579

The average chloride content of water in the Carlsbad limestone was determined by averaging the chloride content of water from wells chiefly in west Carlsbad and in Happy Valley. Recent additional analyses of water from wells in the Carlsbad limestone west of Carlsbad indicate that the average chloride content of the water moving toward the springs from the west is much less than 153 parts per million. Thus, it appears that the water in the wells in the immediate vicinity of Carlsbad is a mixture to some extent of water from the west with water leaking from Lake Avalon and from the canals between the lake and Carlsbad. It also appears that the amount of water discharging into the springs from the Carlsbad limestone to the west was somewhat less than the estimated 13 cubic feet per second, and that the amount of water leaking from Lake Avalon and the canals was somewhat greater than the estimated 46 cubic feet per second.

The chloride content of water from wells and springs in the Carlsbad limestone in the vicinity of Carlsbad is shown on the map, fig. 8. This map shows the effect of the poor-quality water moving southward from Lake Avalon. The water from the State Game Farm well, 21.26.25.142, contained 670 parts per million of chloride. The Rayroux well, 21.26.24.424a, and the Judson Boyd well, 21.26.23.133, both produce impotable water slightly lower in chloride than the State Game Farm well. Farther south in La Huerta, as the water from Lake Avalon becomes mixed with the water of better quality moving from the west, under the river, the chloride content of the water becomes less, and the water is of about the same quality as the water from the Carlsbad city wells.

The movement of the water of good quality from the west and the water of poor quality from the east is in a complex system of conduits, and the relation of the two is not fully shown by the present data. Part of the water of good quality moving from the west apparently circulates beyond the Carlsbad Springs discharge area, for no other source of the potable water obtained in wells in La Huerta is possible. Well drillers report that the water penetrated at shallow depth in the limestone in La Huerta generally is highly mineralized and must be cased off, but no analyses are available to substantiate these reports.

On the other hand, drillers' records indicate that water at depths greater than 300 feet in some wells has been so highly mineralized that it had to be plugged back. A small quantity of water of good quality was reportedly obtained in city well 10, 22.26.2.211, at a depth between 200 and 280 feet, and a larger quantity of highly mineralized water containing 845 parts per million of chloride was obtained at a depth between 350 and 400 feet. The well was sealed and abandoned: The water from a well in Happy Valley, 21.26.31.243, about 250 feet deep, contained 350 parts per million of sulfate and 16 parts per million of chloride. Another well about a quarter of a mile north, 21.26.31.241, obtained water from a depth of 611 feet and the water contained 1,268 parts per million of sulfate and 110 parts per million of chloride. Inasmuch as the water from the deeper well had much higher concentrations of sulfate and chloride than the water in the mountains to the west, it appears probable that some of the water leaking from Lake Avalon and possibly from the Pecos above Lake Avalon moves at considerable depths southwestward at least as far as this well. The probable directions of movement of the highly mineralized water leaking from the Pecos River, Lake Avalon, and canals and of the water of better quality moving in from the mountains to the west are indicated on figure 8.

Periodic analyses of water from wells and springs discharging from the Carlsbad limestone show a wide fluctuation in chloride content. Any prediction of the future supply of water of good quality in the Carlsbad area requires interpretation of these fluctuations. Figure 9 is a graph showing the following:

1. Chloride content of water from two of the springs in the Carlsbad Springs area.
2. Chloride content of water from Carlsbad city wells.
3. Amount of chloride leaking from Lake Avalon, in tons per month, computed as the product of leakage from the lake and the chloride content of the lake water.
4. Pumpage of the Carlsbad city wells, in millions of gallons per month.
5. Precipitation at Carlsbad, in inches per month.

The chloride content of water from the wells, springs, and from Lake Avalon was determined from samples collected and analyzed by the Quality of Water Branch of the U. S. Geological Survey. The samples from Lake Avalon were collected at the spillway each day, and the figures given on the chart are the average for each month. The leakage from Lake Avalon was computed from the rating curve, showing the relation between gage height and leakage at Lake Avalon as determined by Theis, Sayre, and others (1942, p. 60). The leakage from the lake at gage heights lower than 15 feet is very small and has been disregarded in these computations.

Conclusions determined from the graphs in figure 9 are:

1. The fluctuations of chloride content of the water from the different wells and springs follow approximately the same pattern.

2. The combined effect of the leakage from Lake Avalon and the chloride content of the Lake Avalon water apparently determines the short-term fluctuations in the chloride content of the water from the wells and springs, which is greatest during or immediately after periods of great leakage of highly mineralized water from the lake. As hydraulic continuity almost certainly exists between the conduits carrying the highly mineralized water from Lake Avalon and those carrying the water of better quality from the Guadalupe Mountains to the west, these changes in quality of water in the wells and springs with intermittent influx of highly mineralized water from the lake are to be expected.

3. An apparent long-term correlation exists between precipitation and the chloride content of water from wells and springs. The effect of precipitation is probably twofold. Increased precipitation provides a greater recharge to the good-quality ground water in the Guadalupe Mountains west of Carlsbad and therefore increases the amount of good-quality water discharging at the Carlsbad Springs. Increased precipitation also provides more good-quality water as surface runoff to Lake Avalon, with the consequence that water leaking from Lake Avalon and discharging at the Carlsbad Springs is of better-than-normal quality.

The best check on the effect of precipitation is given by the unprecedented heavy rainfall in the summer and fall of 1941. In 1940 and early 1941 the chloride content of the water from the city wells was about 200 parts per million, as indicated by two samples from the distribution system.

Tap samples collected in 1942, 1943, and 1944 all contained less than 100 parts per million of chloride. It is possible that some of the change was the result of adding new wells to the system. Periodic sampling for chloride determination on city well 4, begun in 1945, shows an increasing trend reaching a maximum of about 160 parts per million in the summer of 1949.

4. Effects of pumping of wells in the Carlsbad limestone on the quality of water are largely masked by other effects. However, the fluctuations of chloride content of water from the Carlsbad city well 4 in 1949 do not correlate closely with the fluctuations in leakage of chloride from Lake Avalon, and it is possible that this divergence may be related to pumpage from the Carlsbad city well. It is quite possible that the effects of pumping may materially change the quality of water in time. Pumping of wells drawing water of good quality from conduits in the limestone cause a temporary lowering of the head of the water in these conduits. While the head is lowered in the conduits containing water of good quality, water of poor quality from other conduits in

the limestone or from the overlying beds can enter the conduits that produce the water of good quality. Mixing can take place in wells not properly cased to shut off the water of poor quality or where the separation between the waters of different quality if imperfect. This mixing can take place while wells are being pumped, even though static water levels in the limestone do not decline.

Although the possible changes in chloride content of the water in the Carlsbad limestone induced by heavy pumping of wells in the limestone are largely masked by changes due to other factors, the effects of pumping may be the most significant of all the factors influencing the future supply of water of good quality. Changes in the stage of Lake Avalon and in precipitation probably will not increase the chloride content of water in the limestone greatly in excess of the present amount unless Avalon Dam is raised or a prolonged drought of several years occurs. However, any increase in chloride content in the water in the Carlsbad limestone due to pumping will probably continue for many years. Pumpage from the city wells almost doubled during the period 1942-49. In addition, in 1947 many irrigation wells were drilled from which water was pumped from the Carlsbad limestone, and the International Minerals and Chemical Corp. began pumping water from the Carlsbad limestone for refinery use at the same time.

To summarize, the increase in average chloride content of water in the Carlsbad limestone from 1943 to 1949 probably represents chiefly a trend toward average conditions after the better-than-average conditions resulting from the heavy rainfall of 1941. How much, if any, of this increase due to increased pumping from the limestone cannot be determined at present. If the chloride content increases in future years of normal precipitation beyond the high point reached in early 1941, it may be assumed that part of this increase is probably due to pumping.

Possible effect of the proposed reservoir at dam site 3 on the quality of the Carlsbad public water supply.—The feasibility of reservoir site 3, between Lake McMillan and Lake Avalon, was investigated in some detail in 1925 (Meinzer and others, 1926). Earlier investigations were made by W. T. Lee in 1905 and 1923, by G. B. Richardson in 1911, and by N. H. Darton in 1922. The conclusion of each of these investigators was that leakage would probably be serious if the reservoir were constructed, as planned, to pond water at a maximum head of about 70 feet.

The U. S. Corps of Engineers and the U. S. Bureau of Reclamation drilled about 35 core-test holes during the period 1943-49 to determine the nature of the formations underlying the reservoir site. At different depths, as the holes were drilled, water levels were measured and the amount of water that could be pumped into the hole was also checked where possible.

The following discussion is concerned only with the possible effect of the reservoir on the water supply of the city of Carlsbad. This discussion is based on information from all previous investigations, including the recent core drilling, and on general ground-water information of the area obtained during the present study.

The location of the proposed reservoir is shown on the map, figure 11. The maximum proposed ponding altitude is 3,243.5 feet above sea level,• and the submerged area would include about 10 square miles. At the dam site the maximum altitude of the ponded water would be about 70 feet above the normal river level.

In reservoir site 3 the Pecos River flows in a narrow, steep-walled trench, 15 to 30 feet deep, incised in a terrace that forms the floor of most of the reservoir site. The terrace narrows abruptly about 3 miles below McMillan Dam where the Carlsbad limestone crops out in the river channel (Meinzer and others, 1926, p. 4).

The rock formations exposed in reservoir site 3, from oldest to youngest, are the Seven Rivers gypsiferous member of the Chalk Bluff formation, the Azotea tongue of the Carlsbad limestone, the Three Twins member of the Chalk Bluff formation, and Quaternary alluvium. The Quaternary alluvium consists of an older quartzose conglomerate and a younger limestone conglomerate. The general dip of the strata, excluding the alluvium, is to the southeast, and the gypsiferous member of the Chalk Bluff formation grades into the Carlsbad limestone in that direction.

The Azotea tongue of the Carlsbad limestone, which caps the Seven Rivers gypsiferous member in the Seven Rivers Hills, descends to the southeast to the river level at Major Johnson Springs, about 3 miles below McMillan Dam. Southeast of the springs the Azotea tongue of the Carlsbad limestone thickens, as gypsiferous beds of the Chalk Bluff formation grade down the dip into limestone.

It has long been recognized that the water leaking from Lake McMillan through the cavernous Seven Rivers gypsiferous member discharges at the Major Johnson Springs. On the basis of variation in chloride content of water in Lake McMillan and in the springs, Theis (Theis, Sayre, and others, 1942, pp. 55-92) computed the volume of water in storage underground between Lake McMillan and the springs to be about 50,000 acre-feet, or about 50 percent more than the capacity of Lake McMillan in 1939.

The leakage from Lake McMillan is in conduits in the easily dissolved Seven Rivers gypsiferous member. As the less permeable limestone of the Azotea tongue limits the southward flow, the springs are where the limestone crops out in the river. Earlier observers concluded that most if not all of the leakage from Lake McMillan was discharged in the Major Johnson Springs area and that little if any moved southward to discharge at a lower elevation. Recent information from the core holes drilled by the Corps of Engineers suggests that the amount

• Earlier reports used U. S. Bureau of Reclamation datum. To convert U. S. Bureau of Reclamation altitudes to mean sea level subtract 16.5 feet.

being discharged at a lower level may be somewhat larger than previously thought. Static water levels in all the completed core holes north and west of Major Johnson Springs area are at the altitude of the river or higher, whereas water levels in most of the core holes south and east of the springs are considerably lower than the river. (See fig. 10.) Thus, the ground-water levels above and below the springs appear to be discontinuous.

Water levels in core holes below the Major Johnson Springs area show definitely that the Pecos River is perched with respect to the ground water and that there is thus opportunity for the river to lose water in the stretch below Major Johnson Springs and Lake Avalon in this area. The ground-water levels also are lower than the ponding elevation of Lake Avalon, indicating that ground water from the lower part of the reservoir site 3 must discharge below Lake Avalon. The only nearby substantial discharge that occurs at a lower elevation is in the Carlsbad Springs area. Water levels in the drill holes below the Major Johnson Springs area are slightly higher than those of the Carlsbad Springs area. Thus, it appears highly probable that the lower water in drill holes at reservoir site 3 discharges at the Carlsbad Springs.

The chloride content of the water from the Carlsbad city wells and the Carlsbad Springs apparently is greatest during periods when the leakage from Lake Avalon is greatest. This leakage increases the relative amount of the highly mineralized water entering the Carlsbad limestone and discharging at the springs. Inasmuch as the lower ground water in reservoir site 3 also apparently discharges into the Carlsbad Springs, the greatly increased head of the ponded water in the lower part of reservoir 3, if it should be constructed, probably would induce additional leakage which would affect the quality of the water in the wells and springs in the Carlsbad limestone, including the Carlsbad city wells. If the quality of the water to be stored in the reservoir is similar to that now in Lake Avalon or Lake McMillan, the chloride content of the water in the wells and springs at Carlsbad would probably be increased.

A dam at site 3 has been considered both as an irrigation project and as a flood-control measure. Construction of a flood-control dam in Dark Canyon has been suggested also. Such a dam, which would impound the water of good quality from flash floods in the Guadalupe Mountains, probably would be effective in increasing the recharge of water of good quality to the Carlsbad limestone and to the alluvium in this area.

Conclusions regarding quality of water in the Carlsbad limestone.

1. Inasmuch as the quantity of water of good quality available in the Carlsbad area probably is limited and the quantity of water of poor quality is comparatively unlimited, it appears probable that any great increase in the amount of water pumped from the Carlsbad limestone may cause deterioration of the supply by more highly mineralized water.

2. Wells open in both the Carlsbad limestone and the overlying Castile-Rustler aquifer or the alluvium may permit leakage that will cause deterioration of the quality of water in the limestone.

3. Wells open in conduits containing poor water in the Carlsbad limestone may permit that water to mix with the better water in other conduits.

4. Inasmuch as ground water under the lower part of reservoir site 3 appears to discharge in the Carlsbad Springs area, construction of the proposed reservoir probably would cause leakage of water that would discharge in the Carlsbad Springs area. If the water stored in the reservoir is more highly mineralized than the water pumped from the Carlsbad city wells, deterioration of the city supply could result.

5. Construction of a reservoir to catch the flood flow of Dark Canyon, in addition to flood protection, would probably increase recharge of good-quality water to the alluvium and/or the Carlsbad limestone.

In order to understand thoroughly the characteristics, and hence to predict the future, of the Carlsbad city supply, the following investigations should be made:

1. A computation should be made of the volume and the chloride concentration of the water from the different sources discharging into the Carlsbad Springs area to re-evaluate and determine the changes since the study by Theis, Sayre, and others in 1940. It was shown in 1940 that about 13 cubic feet per second of the water discharging at the springs came from the limestone to the west. The pumpage from the limestone at that time was about 2,500 acre-feet per year or about 3.4 cubic feet per second. In 1949 the pumpage from the Carlsbad limestone was about 7,200 acre-feet per year or about 10 cubic feet per second. Inasmuch as most of the water pumped from the limestone is of such quality as to indicate that it comes largely from the Guadalupe Mountains to the west, the increased pumpage of about 6.6 cubic feet per second probably has caused nearly an equal reduction in the flow of good-quality water to the Carlsbad Springs area. It thus appears that the water now reaching the Carlsbad Springs area from the limestone to the west should be on the order of 7 cubic feet per second.

2. Careful records should be kept of all, or at least some, of the wells drilled into the Carlsbad limestone in the future. Data obtained should indude: collection of formation samples, preparation of an accurate log, determination of the static head of water from each water-bearing zone, collection and analysis of water from *each* water-bearing zone, and, if possible, determination of the specific capacity of the well at different depths.

3. Pumping tests should be made of some of the wells in the Carlsbad limestone to determine the effect on nearby wells which penetrate only the alluvium or the Castile-Rustler aquifer. This could be done at some places in La Huerta.

4. Samples of water for chemical analysis should be taken from some of the wells in the Carlsbad limestone when the pump is first started, and at intervals during a long period of pumping to determine changes in chloride content caused by drawdown of the water in the limestone and inflow from other aquifers or from other conduits in the limestone.

5. A careful continuing inventory should be made of the amount of water pumped from the Carlsbad limestone and from other aquifers in the Carlsbad area.

6. If possible, measurements of water levels and determinations of chemical quality of water in observation wells should be made during and after a flood in Dark Canyon.

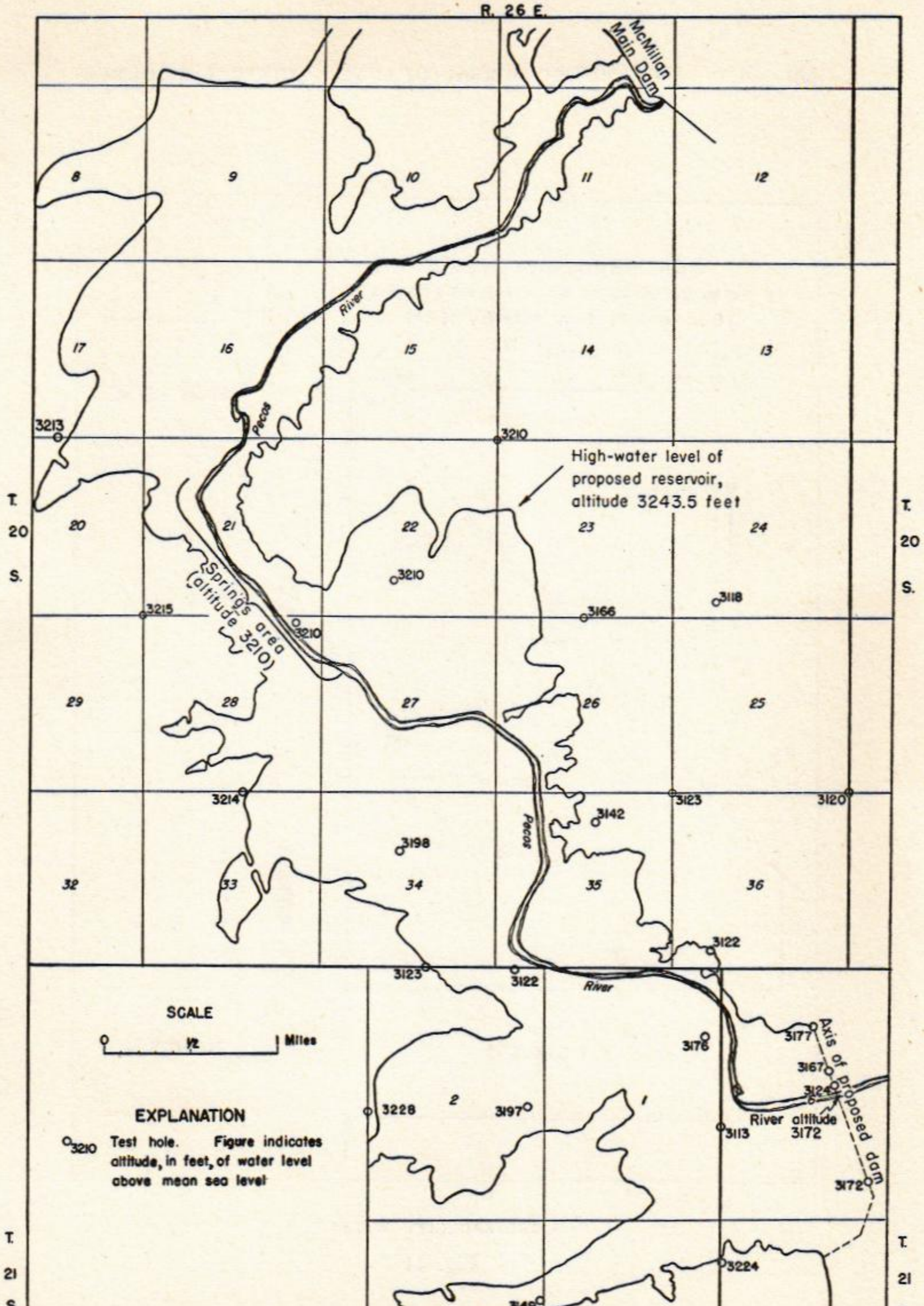
7. Periodic chemical analyses should be made of samples of water from several of the wells in the Carlsbad limestone, especially from those in the northern part of La Huerta, to determine changes and possible correlation with stages of Lake Avalon.

Specific capacities of wells.—Nearly all wells in the Carlsbad limestone are reported to produce large quantities of water. A pumping test of Carlsbad city well 4, made by Hale in 1939, indicated a transmissibility of 428,000 gallons a day per foot and a specific capacity of 275 gallons per minute per foot of drawdown (Hale, 1945, p. 43). These values are high compared with coefficients of transmissibility of 50,000 to 100,000 and specific capacities of 20 to 50 in many areas in New Mexico where successful irrigation wells are obtained.

The south well of the International Minerals and Chemical Corp. in La Huerta, 21.27.31.212, had a measured drawdown in 1950 of 25 feet while being pumped at a rate of about 1,000 gallons per minute, indicating a specific capacity of about 40 gallons per minute per foot of drawdown. The original capacity of this well was reported to be less than its present capacity, the increase having been accomplished by acidizing the well. The well supplying the Dickson addition in the western part of Carlsbad, 21.26.35.441, had a measured drawdown of 3 feet while at a pumping rate of 300 gallons per minute, indicating a specific capacity of 100 gallons per minute per foot of drawdown. The capacity of this well also was reported to have been increased by acidizing. Well 21.26.25.142, at the State Game Farm, had a drawdown of about 4 feet after being pumped at a rate of 600 gallons per minute for about 5 hours, indicating a specific capacity of about 150 gallons per minute per foot of drawdown.

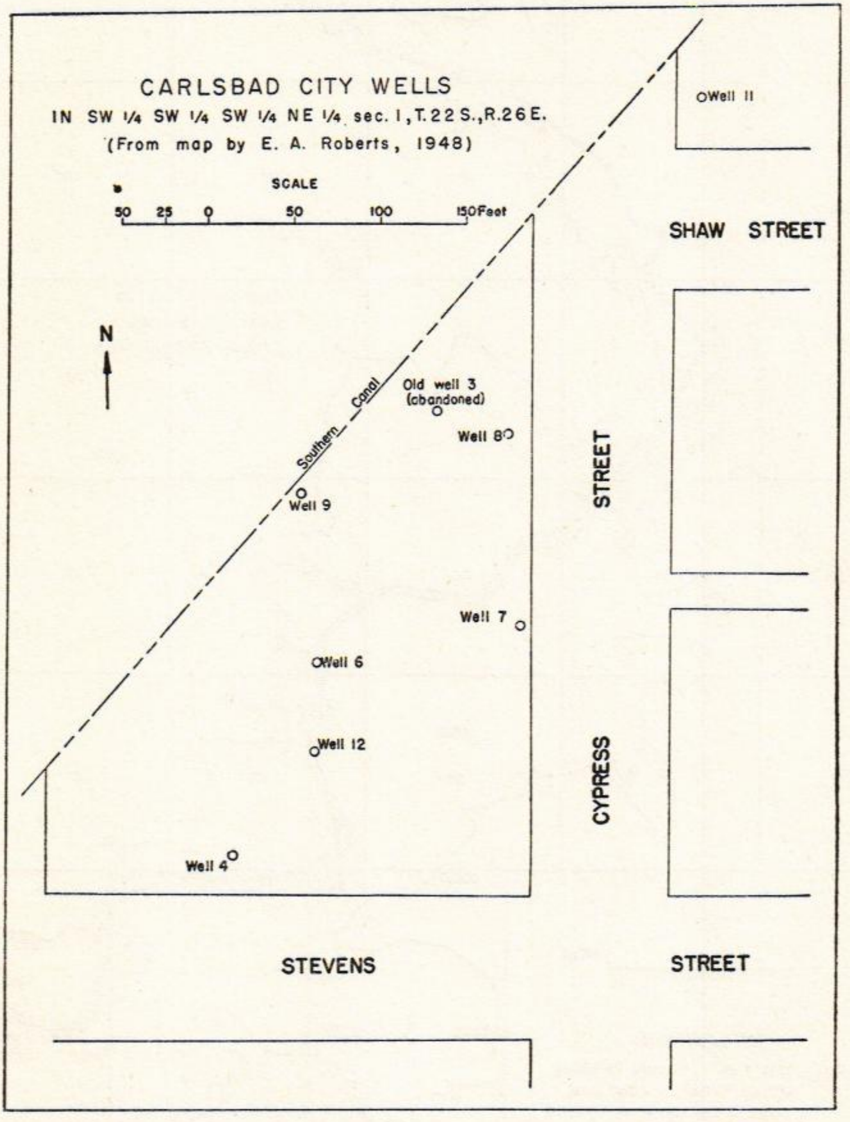
Use.—Water from the Carlsbad limestone is used for most of the Carlsbad city supply, for irrigation, for potash refining, and for stock and domestic supply. In the vicinity of Carlsbad the Carlsbad limestone is the only source of large quantities of water of good quality.

The approximate amounts of water pumped from the Carlsbad limestone as determined by Hale (1945, p. 39) in 1939 and by the



WATER LEVELS IN TEST HOLES DRILLED IN THE VICINITY OF RESERVOIR SITE 3, EDDY COUNTY, N. MEX. BY THE U. S. BUREAU OF RECLAMATION AND THE U. S. CORPS OF ENGINEERS.

Fig. 10



CARLSBAD CITY WELLS.

Fig. 11

present study in 1949 are listed below. Most of the figures given are those reported by the owners of the respective wells, although some are estimated:

	Acre-feet per year	
	1939	*1949*
Carlsbad city	921	3,400
International Minerals and Chemical Corp.	——	1,600
Happy Valley farms (Bluebird Water Co.)	517	500
Other irrigation wells	820	1,500
Domestic wells	230	200
Total	2,488	7,200

Carlsbad city wells.—Information concerning the Carlsbad city wells obtained from E. A. Roberts, City Clerk of Carlsbad, is tabulated below. The city wells are shown on the map (fig. 11), which was also supplied by Mr. Roberts.

CARLSBAD CITY WELLS

Source of water	City well no.	Year constructed	Rated capacity *(g.p.m.)*	Depth of well *(ft.)*	Diameter of casing *(in.)*	Casing depth *(ft.)*
Carlsbad limestone	4	1935	1,200	233	12	116
do.	6	1942	1,600	135	13	120
do.	7	1944	700	143	13	118
Gravel and conglomerate	8	1944	1,250	152	13	110
Carlsbad limestone	9	1945	1,200	225[1]	15½	110
do.	11	1947	1,300	163	18	118
do.	12	1948	3,000	245	18	108

1 Plugged back to 115 feet.

As indicated above and in the well logs that follow, city well 8 apparently produces from gravel and conglomerate in the alluvium, whereas all other city wells produce from the Carlsbad limestone and are cased through the alluvium. The logs of city wells 4, 9, and 11 indicate a shaly or clayey material just above the limestone, but the logs of wells 6 and 7 indicate sand and gravel above the limestone. Therefore, no continuous impermeable material separates the water in the limestone from that in the overlying alluvium, and it appears probable that the water in the limestone and in the lower part of the alluvium is more or less continuous, at least in places, in the city well field. The quality of the water from well 8 is about the same as that from city wells in the limestone.

Water at shallower depths in the alluvium may be of poorer quality than that pumped from the city wells. Alkali water was reported in well 4 in sandstone at a depth of 79 to 97 feet. This sandstone is separated from the Carlsbad limestone by 11 feet of material reported as gypsum and shale. Separation between the water of poor quality in the alluvium and the water of good quality in both the alluvium and limestone may be imperfect, and some of the water of poor quality may enter the deeper aquifers when water levels are lowered by pumping.

The gypsum and shale reported in well 4 may indicate that the Castile or Rustler formation overlies the Carlsbad limestone, but the absence of record of this material in the logs of the other city wells suggests that the alluvium directly overlies the Carlsbad limestone over most, if not all, of the city well field.

DRILLER'S LOG OF CARLSBAD CITY WELL 4

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Surface conglomerate	2	2
Gray gypsum	25	27
Yellow gypsum (good water flow)	10	37
Gray gypsum (water)	16	53
Sandstone	5	58
Yellow gypsum	4	62
Gray shale	13	75
Gray gypsum	4	79
Gray sandstone (alkali water)	18	97
Gypsum and shale	11	108
Hard limestone (bottom of casing)	8	116
Soft limestone	4	120
Shale and limestone (some alkali water)	31	151
Blue limestone (good flow of water)	42	193
Yellow limestone (good flow of water)	32	225
Blue limestone	8	233

DRILLER'S LOG OF CARLSBAD CITY WELL 6

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Caliche	7	7
"Conglomerated" rock (water at 38 feet)	31	38
Sand and lime rock (water at 70 feet in sand)	32	70
Lime rock	10	80
Shale	5	85
Sand	25	110
Lime rock	13	123
Water	–	128

DRILLER'S LOG OF CARLSBAD CITY WELL 7

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Caliche	15	15
Clay and gravel	20	35
Boulders	5	40
Gravel and sand	30	70
Yellow clay	5	75
Gravel and sand	44	119
Yellow limestone	10	129
Gray limestone	14	143

DRILLER'S LOG OF CARLSBAD CITY WELL 8

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Surface	1	1
Yellow clay	19	20
Sand and gravel	17	37
Water sand	3	40
Boulders and gravel	13	53
Sand and gravel	43	96
Clay	4	100
Water sand and gravel	15	115
Lime (lots of water)	3	118
Gravel	1	119
Lime (water)	6	125
Lime and gravel	10	135
Yellow clay and gravel	17	152

DRILLER'S LOG OF CARLSBAD CITY WELL 9

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Surface clay	1	1
Dolomite (caliche?)	29	30
Sand, gravel, some clay	6	36
Cemented gravel (water at 39 feet)	9	45
Dolomite (caliche?)	5	50
Dolomite (caliche?) and gravel	5	55
Brown weathered shale	20	75
Gray shale	20	95
Clay and gravel	5	100
Lime shale	4	104
Gray-white limestone	6	110
Dark-blue limestone	2	112
Light-gray limestone	3	115
Gray limestone	20	135
Blue limestone	30	165
Blue and gray limestone	25	190
Hard gray limestone	10	200
Hard blue limestone	25	225

DRILLER'S LOG OF CARLSBAD CITY WELL 11

MATERIAL	THICKNESS (feet)	DEPTH (feet)
Boulders and soft limestone	14	14
Gravel and clay (water at 35 feet)	21	35
Sand and gravel	5	40
Gravel and sand	12	52
Sand and gravel	19	71
Sand and gravel	9	80
Red and gray shale	30	110
Gray sand limestone	1	111
Brown lime	1	112
Brown porous lime	3	115
Hard gray lime	21	136
Limestone (water)	15	151
Gray limestone	12	163

AREA BETWEEN THE GUADALUPE MOUNTAINS AND THE PECOS RIVER AND GENERALLY SOUTH OF LATITUDE 32°15'

This area containing about 14 townships in the south-central part of Eddy County is shown on plate 3 as areas 3a and 3b.

PRINCIPAL AQUIFERS

The Capitan limestone crops out in the reef escarpment that marks the west boundary of this area. At the base of the escarpment the Capitan limestone interfingers with sandstone and limestone of the Bell Canyon formation. The Lamar limestone member of the Bell Canyon formation crops out over a narrow belt at the base of the reef escarpment. Away from the escarpment, the Lamar limestone member is overlain by the gypsum of the Castile formation and by alluvium. The area between the reef escarpment and the Black River is covered by alluvium and slopes southeast 100 feet to the mile. Southeast of the Black River the gypsum of the Castile formation crops out in an escarpment of the Gypsum Hills. Farther east, near the Pecos River, the Castile formation is overlain in places by redbeds, limestone, and gypsum of the Rustler formation.

RECHARGE, MOVEMENT, AND DISCHARGE

In the alluvium-covered area between the reef escarpment and the Black River, recharge is from (1) local precipitation on the alluvium, and (2) upward percolation from the underlying limestone beds that crop out in the Guadalupe Mountains to the west. Southeast of the Black River, recharge is probably from local precipitation and, in the eastern part, losses from the Black River. Near the reef front ground water moves northeast nearly parallel to the drainage lines of the Black River and its tributaries. Farther downstream, ground water apparently moves toward the Black River and, in the lower reaches of the stream, it moves away from the river. (See pl. 3.) Southeast of the Black River, ground water flows generally northeastward and eastward to the Pecos.

Ground water moves eastward from the Guadalupe Mountains through the Capitan limestone and its basinal equivalent, the Bell Canyon formation, to discharge to the alluvium and to the gypsum of the Castile formation in the basin. Near the base of the reef front some water probably moves directly from the Capitan limestone and the Bell Canyon formation into the alluvium, but farther east the water moves through the gypsum of the Castile before entering the alluvium or discharging to springs.

Discharge from this alluvium-covered area is largely to springs and seeps which contribute much of the base flow of the Black River. The largest of these springs, Geyser Springs, Rattlesnake Springs, and **Blue** Spring, each flow several cubic feet per second and probably are fed largely by ground water derived from precipitation in the Guadalupe Mountains, as the recharge area at the base of the reef front does not seem sufficient to produce the large flow of these springs. The hydraulic system supplying the springs probably consists largely of solution channels in the gypsum of the Castile formation and, to some extent, solution channels in cemented gravels or interstices of uncemented gravels in the overlying alluvium. Water from wells in the alluvium may come from local recharge, from the limestone of the Guadalupe Mountains, or from both sources.

CHEMICAL QUALITY

The ground water is generally of good quality in the western part of this area but becomes progressively more highly mineralized to the east. (See tables 3 and 4.) The water from the limestone of the Guadalupe Mountains is of very good quality. As it moves from the limestone through conduits in the Castile formation it dissolves some of the gypsum and salt in that formation. Analyses of water from three of the larger springs, Geyser Springs, 26.23.35.121, Rattlesnake Springs, 25.24.23.343, and Blue Spring, 24.26.33.122, between the reef escarpment and the Black River show an increase in sulfate content northeastward in the direction of ground-water movement.

In the outcrop area of the gypsum of the Castile formation, south and east of the Black River, nearly all springs and wells yield water that is high in calcium and sulfate derived from the gypsum. The sulfate content of the ground water increases from about 1,500 parts per million in the western part of the gypsum outcrop area to as much as 2,500 parts per million near the Pecos River, and the chloride content increases from about 20 to more than 900 parts per million. The abrupt increase in the chloride content of the ground water near the Pecos may be due in part to mixing with the water from a brine aquifer at the base of the Rustler formation near Malaga Bend.

A saturated brine containing about 40,000 parts per million of magnesium, 230,000 parts per million of sulfate, 14,000 parts per million of chloride, and 377,000 parts per million of dissolved solids occurs in beds of weathered gypsum in Cottonwood Draw in secs. 25 and 26, T. 25 S., R. 26 E., and in sec. 30, T. 25 S., R. 27 E. This brine has been produced on a small scale commercially as a source of sodium sulfate. Theis, in a memorandum concerning the brine wells of the Emro Corp. in 1942, suggested that the concentration of the brine may be the result of loss of water from solution during the conversion of anhydrite to gypsum. The brine probably is formed in traps which are more or less cut off from the general ground-water circulation of the area, and at or near the contact between gypsum and unweathered anhydrite below.

SPECIFIC CAPACITIES OF WELLS

Wells in the alluvium between the reef escarpment and the outcrop area of the gypsum of the Castile formation generally have larger yields than those in the gypsum of the Castile to the east. Well 26.24.28.413 had a measured drawdown of about 0.1 foot after being pumped about 6 hours at the rate of 2 gallons per minute, or a specific capacity of about 20 gallons per minute per foot of drawdown. Other wells in the alluvium are reported to have a high capacity, and some reportedly cannot be pumped dry with a pump jack and gasoline engine.

Wells in the alluvium are used successfully for irrigation on the north side of the Black River near Black River Village. Information on two of the wells show discharge rates of 400 and 700 gallons per minute. The specific capacities were not determined but are believed to be on the order of 20 gallons per minute per foot of drawdown.

In the outcrop area of the Castile formation, well 25.27.12.100 had a drawdown of about 5 feet after yielding 2 gallons per minute for more than 4 hours, or a specific capacity of about 0.4 gallon per minute per foot of drawdown. The C. P. Ranch well, 26.25.17.240, had a drawdown of about 3 feet after being pumped about half an hour at the rate of about 3 gallons per minute, or a specific capacity of about 1 gallon per minute per foot of drawdown. All wells visited in this area were reported adequate for stock or domestic use.

USE

Ground water in this area is used for stock and domestic supply, for the public supply at the Carlsbad Caverns, and for irrigation, and a little (the brine mentioned previously) was formerly used as a commercial source of sodium sulfate. The amount of ground water used for stock and domestic supply is small, but it is essential to the livestock industry of the area. Most of the stock and domestic wells are less than 200 feet deep and are equipped with windmills. The depth to water in most of the area is less than 100 feet. About 450 acres is irrigated near Black River Village by irrigation wells. Part of the flow of Blue Spring and Geyser Springs is used for irrigation and part of the flow of the Black River is diverted to Willow Lake for irrigation. Part of the flow of Rattlesnake Springs is used for the public supply at the Carlsbad Caverns National Park.

ROSWELL BASIN

The area in northwestern Eddy County extending east from the west county line to the Pecos River and south from the north county line to about latitude 32°30' is the southern part of the Roswell basin and is included in this report under the Roswell basin and designated on plate 4 as areas 4a and 4b. This area, except the townships in

R. 21 E. and the western half of Tps. 17 to 20 S., R. 23 E., is in the Roswell Artesian Basin as declared by the New Mexico State Engineer. Both the artesian and shallow waters are fully appropriated and applications for new development are not approved by the State Engineer.

The geology and ground-water conditions in the Roswell basin have been studied more thoroughly than those of any other area in New Mexico. The information obtained from these studies has been published in several reports (see references cited). The most comprehensive report is that by Fiedler and Nye (1933), and it is largely responsible for the sound conservation practices in the area. The most complete summary of ground-water conditions is given in the report of the Pecos River Joint Investigation (Theis, Sayre, and others, 1942). Morgan (1938) gives a complete description of the shallow water in the irrigated area bordering the Pecos River on the west. Most of the following discussion is based on these reports, to which the reader is referred for a more complete treatment.

PRINCIPAL AQUIFERS

The geologic units important to the ground-water supply in the Roswell basin are the San Andres formation, the Chalk Bluff formation, and the Quaternary alluvium.

San Andres and Chalk Bluff formations

Character, extent, and thickness.—The San Andres formation, about 1,000 feet thick in this area, is composed of limestone and dolomite, and it contains solution cavities ranging from a fraction of an inch to several feet in diameter. The cavernous zones are not confined to certain beds but are extremely irregular and erratic. The San Andres formation crops out in the western highlands and dips eastward under younger sedimentary rocks in the irrigated area. This formation is the chief artesian aquifer in the Roswell basin.

The Chalk Bluff formation consists of redbeds, gypsum, and limestone and overlies the San Andres formation. It crops out in a broad area east of the outcrop of the San Andres. The limestone of the basal part of the Chalk Bluff formation is an important artesian aquifer in the southern part of the Roswell basin.

The Chalk Bluff has a total thickness of more than 1,000 feet; however, erosion has removed much of the formation in the lowland part of the basin. The thickness of the Chalk Bluff increases rapidly from west to east across the basin, for the dip of the beds is greater than the surface slope. The maximum thickness of the Chalk Bluff, in the irrigated area, about 800 to 900 feet, is between Hagerman and Lake Arthur north of Artesia. The thickness near Lakewood, west of Lake McMillan, is about 400 to 600 feet (Morgan, 1938, p. 173).

Occurrence, recharge, movement, and discharge.—The San Andres crops out over a small area in northwestern Eddy County and over an area of several thousand square miles to the west and northwest. Through-flowing streams are absent over much of the outcrop area and all precipitation on the outcrop area that is not evaporated or transpired contributes to the ground-water supply. The Rio Penasco, which has a perennial flow in the highlands, loses large amounts of water by seepage in the intake area of the San Andres formation and only during floods has a flow to the Pecos. Occasional floods on other streams that cross the intake area contribute water to the San Andres formation. It is possible that some of the water entering the Goat Seep limestone in the Guadalupe Mountains percolates downward to the underlying San Andres formation. The basal part of the Chalk Bluff formation in the artesian basin changes southward to limestone and in Eddy County these limestone beds yield much of the artesian supply (Theis, Sayre, and others, 1942, p. 43). In Eddy County the upper shaly beds of the Chalk Bluff formation confine the water in the underlying limestones.

The water in the San Andres formation and overlying Chalk Bluff formation moves eastward to discharge indirectly into the Pecos River. The altitudes of water levels in wells and general direction of movement of ground water in the area are indicated on plate 2. Except for a few wells drawing water from perched zones, the altitudes of water levels decline fairly uniformly eastward. The slope is about 3 feet per mile near the north boundary of the county and about 10 feet per mile near Seven Rivers, at the south boundary of the artesian basin. Unlike the Guadalupe Mountains area to the south, a wide range in water levels in nearby wells is not apparent here, and the depth to water at a given location can be predicted with a fair degree of accuracy.

Discharge from the artesian aquifer is by wells, by upward percolation through the shaly beds of the Chalk Bluff into the alluvium and to springs, and by leakage through poorly cased wells. The lowering of artesian pressures due to discharge of wells probably has decreased the discharge by the other methods and discharge by wells is now greater than that by all other methods. The discharge of artesian wells in Eddy and Chaves Counties has almost stopped the flow of the large artesian springs near Roswell, which formerly discharged most of the water from the artesian aquifer. As a result of the lowering of artesian pressures few artesian wells flow in the summer.

The amount of water that can be obtained from storage per unit of area in an artesian aquifer depends in part on the compressibility of the aquifer. The compressibility of limestone is generally very small, and the amount of water available from storage represented by a reduction in pressure is correspondingly small. Because of the small amount of water available from storage, pumping from a well affects the water levels in other wells over a large area. Water discharged by artesian wells in this area must eventually be balanced by a decrease in the natural discharge and/or a reduction in storage in the outcrop area of the aquifer where the water is unconfined.

As the water in the San Andres formation moves chiefly through cavities in the limestone, which are irregularly distributed, the yield of wells differs greatly within short distances. However, yields large enough for irrigation can generally be obtained from wells penetrating the artesian aquifers in most of the Roswell basin.

West of the irrigated area most wells obtain water from the San Andres formation or Chalk Bluff formation, although a few shallow wells may obtain perched water in alluvium. The depth to water in wells increases westward from about 100 feet at the west edge of the irrigated area to more than 600 feet near the west boundary of the county. In the vicinity of Hope most wells penetrated minor seeps above the main water table, but these were generally lost as drilling continued. Some wells have been completed in one of these perched water-bearing zones, but most continue to the main ground-water reservoir. Some of the wells that relied on perched zones are reported to have dried up and water levels in others are reported to be lowering. Wells 17.21.17.410 and 17.21.20.230, less than a mile apart and at about the same ground altitude, have a difference in depth to water of about 100 feet. Well 17.21.17.410, drilled to a depth of 750 feet, has a reported depth to water of 660 feet. Well 17.21.20.230, drilled to a depth of 576 feet, had a depth to water of about 560 feet. The deeper well reportedly could not be lowered with a bailer, whereas the shallower well is reported to have a comparatively small yield. The decline of water level in the shallower well made it necessary to lower the pump cylinder 8 feet during the summer of 1949.

An oil test drilled near Hope in the NENSE1/4 sec. 4, T. 18 S., R. 23 E., is reported to have penetrated two zones of perched water before striking the main water at 452 feet. The two perched zones were at depths between 230 and 255 feet and together produced only about half a gallon per minute. The water at 452 feet rose in the hole to 436 feet below the surface where it escaped into a crevice (Renick, 1926, pp. 134, 135).

As a general rule it probably is not advisable to complete a well in any of the perched zones in this area. Even though the well will produce the minimum amount of water needed when drilled, it is likely to fail in periods of deficient rainfall. Also, if a new well is drilled deeper nearby, it may dry up the well relying on perched water.

Fluctuation of water levels.—The permitted irrigated acreage and the number of wells drawing water from the artesian aquifer have been held approximately constant for nearly 2 decades, under the New Mexico ground-water law. The discharge from the artesian wells has caused a decline of water levels in them. Since 1931 a continuous record has been obtained of water levels in an artesian well, 18.26.5.330, about 4 miles south of Artesia. The altitude of the highest mean monthly water levels reached in the well each winter from 1931 to 1940 was about 3,390 feet. The highest mean monthly water level reached in the well in the winter 1940-41 was at an altitude of 3,385 feet; the highest level in the winter 1941-42 was 3,401 feet, the rise being due to decreased withdrawals and increased recharge resulting from the exceptionally heavy rains of 1941. The highest mean monthly level on record, 3,402 feet, occurred January 1943. Since that time the water level has consistently declined, the highest mean monthly level reached in the winter of 1948-49 being 3,372 feet. Part of this decline is due to stabilization after the heavy rains of 1941, but, inasmuch as the winter maximum water level in 1948-49 was about 13 feet lower than the lowest winter maximum during 1931 to 1940, part of the lowering is almost certainly due to discharge from wells in the artesian aquifer.

Bimonthly measurements of water levels in wells in the intake area of the aquifer also show a decline in water levels. The Runyan well, 16.23.15.323, showed a net decline in winter maximum water level of about 10 feet in the period 1945 to 1948, and the Clements well, 18.23.5.333, showed a decline of about 11 feet from 1946 to the winter of 1948-49. How much of this decline indicates an actual withdrawal from storage caused by pumping of the artesian wells about 20 miles to the east is not clear. Part of the decline is almost certainly due to stabilization after the unusually heavy rains in 1941.

Alluvium

Character, extent, and thickness.—The Quaternary alluvium, consisting of day, silt, sand, gravel, and conglomerate, is at the surface over the entire irrigated area and is the source of shallow water used for irrigation in the area. The alluvium, unconformably overlies both the San Andres and the Chalk Bluff formations and locally is slumped and distorted owing to solution and collapse of underlying rocks. The material varies widely in composition both vertically and horizontally. The thickness of the alluvium ranges from a feather edge in the west to more than 300 feet in places a short distance west of the Pecos River (Morgan, 1938, p. 171). The ground-water conditions in the shallow aquifer have been discussed in detail by Morgan (1938). Morgan's report includes maps showing the thickness of the alluvial fill, the depth to water, the altitude of the water table in the fill, and changes in water levels.

Recharge, movement, and discharge.—The water in the alluvium is from five sources: local precipitation, surface water, losses from leaky artesian wells, natural leakage of artesian water from the underlying artesian aquifers, and irrigation return. The amount of water from each source is variable and indeterminate; however, the importance of the various sources of shallow ground water can be inferred from the conditions governing each (Morgan, 1938, p. 181). Morgan concludes that much the greater part of the shallow ground-water supply is derived directly or indirectly from the artesian supply and that contributions from direct precipitation and from surface drainage on the whole contribute only a small part of the total recharge. Of the recharge from the artesian supply, natural leakage is believed to be the more important.

The movement of the shallow ground water is in general to the east toward the Pecos River where it discharges. Shallow ground water also discharges into most of the lower courses of tributary streams where their channels are cut below the water table; hence, ground water locally moves toward those streams (Morgan, 1938, p. 186).

There are a great number of shallow irrigation wells in the irrigated area which discharge large quantities of water in addition to the artesian irrigation wells. Introduction of this artificial discharge has altered locally the movement of shallow ground water, inducing it to flow to the wells.

Fluctuation of water levels.—Pumping of the shallow ground water has caused a significant lowering of the water level in the areas of concentrated development. Morgan (1938, pl. 5) shows that from 1927 to 1938 water levels declined from 10 to 15 feet in two areas, respectively northwest and southwest of Artesia. Additional development since that time has caused larger additional declines, as described below.

General discussions of the changes in water levels, records of measurements of water level, and maps showing changes in shallow water level have been published annually since 1937 by the U. S. Geological Survey in the series of water-supply papers entitled "Water levels and artesian pressures in observation wells in the United States." These reports show that, after the heavy rains of 1941, the shallow water table rose to record high levels, but since that time the water levels have declined at such a rate that by the winter of 1948-49 they reached the lowest levels on record in most of the area. Since 1938, the main areas of decline of water levels have been west of Artesia, near Dayton, and southwest of Lakewood. The water levels have declined in these areas from 1938 to 1949 as much as 26 feet, 13 feet, and 20 feet, respectively. In the period from 1927 to 1949 the water levels west of Artesia have declined as much as 35 to 40 feet.

Specific capacities of wells.—The capacities of the wells taking water from the alluvium vary widely because of the erratic occurrence of the sand and gravel beds that supply the water. However, sufficient water for irrigation is available from wells in the valley fill in most of the area. Measured specific capacities of 13 wells distributed throughout the valley in Chaves and Eddy Counties ranged from 12 to 78 gallons per minute per foot of drawdown (Theis, Sayre, and others, 1942, p. 49). The average transmissibility of the alluvium has been estimated at 100,000 to 150,000 and the average coefficient of storage at about 10 percent (Theis, Sayre, and others, 1942, p. 49). The coefficient of storage in the alluvium is much greater than that in the artesian aquifer.

CHEMICAL QUALITY

The quality of ground water in the irrigated area is generally fair to good and is much better than the ground water in the irrigated area southeast of Carlsbad. The water from most wells, in both the shallow and the artesian aquifers, is suitable for irrigation, stock, and domestic use. The city of Artesia obtains water that is hard but otherwise of good quality from wells in the artesian aquifers.

An analysis of water from an artesian well near Artesia in the NEIANWIA sec. 1, T. 16 S., R. 24 E., shows a hardness as calcium carbonate of 554 parts per million, 329 parts per million of sulfate, and 14 parts per million of chloride. An analysis of water from another artesian well near Lakewood in the SWIASE1/4 sec. 6, T. 20 S., R. 26 E., shows a hardness as calcium carbonate of 1,540 parts per million, 1,290 parts per million of sulfate, and 32 parts per million of chloride. The hardness and high sulfate content of this water make it undesirable for domestic use. Analyses of water from other artesian wells in the Roswell basin in Eddy County in general indicate water ranging in quality between the two cited above (Fiedler and Nye, 1933, p. 173).

The quality of the water in the alluvium in the irrigated area in Eddy County is about the same as that in the artesian aquifer. An analysis of water from a shallow well at the Lakewood School, 19.26.27.233, shows a hardness as calcium carbonate of 1,040 parts per million, 829 parts per million of sulfate, and 30 parts per million of chloride. (See table 3.) This well is near the east edge of the irrigated area, about 1 mile west of Lake McMillan. Shallow wells near the west edge of the irrigated area generally produce water of slightly better quality. A few additional analyses of waters from the shallow aquifer are given by Fiedler and Nye (1933, pp. 161-178).

The quality of water in all wells visited west of the irrigated area was reported to be good. Analyses of water from two of the wells, 16.21.33.200 and 17.24.24.210, show water low in chloride, low and moderate, respectively, in sulfate, and moderate in calcium bicarbonate. (See table 3.)

USE

Ground water is used in the Roswell basin for irrigation, public supply, and stock and domestic supplies. The amount of ground water, both artesian and shallow, used for irrigation in this area in Eddy County, estimated from the approximate acreage irrigated, was about 110,000 acre-feet in 1949. The city of Artesia, which has the only municipal supply in this area, uses about 1,500 acre-feet per year. Water used for stock and domestic supplies probably does not exceed 500 acre-feet per year.

AREA EAST OF THE PECOS RIVER

The area east of the Pecos River is a large area and includes approximately half of Eddy County. It is designated on plate 4 as 5a, 5b, 5c, and 5d.

PRINCIPAL AQUIFERS

The strata east of the Pecos River dip gently to the east and southeast. As a consequence the strata crop out in north-south bands as shown in plate 1. The Chalk Bluff formation crops out in a band 5 to 10 miles wide east of the Pecos River extending from Lake Avalon north to the county line and beyond. East of the Chalk Bluff formation and extending from the Texas State line to the Chaves County line is a band 2 to 10 miles wide in which the Rustler formation crops out, and east of the outcrop area of the Rustler is a band 12 to 20 miles wide, extending to the Lea County line, in which redbeds of the Dockum group of Triassic age crop out. In the extreme northeast corner of the county, the Ogallala formation crops out in an area of a few square miles coextensive with the High Plains physiographic area. A veneer of dune sands covers most of the area, and in a few places, especially in a narrow band along the east side of the Pecos extending from Malaga to north of Carlsbad, relatively thin deposits of Quaternary alluvium are present.

Only alluvium, near the river, and the cavernous limestone and gypsum of the Rustler formation produce large quantities of water. Much of the water in the area east of the Pecos River is highly mineralized. Moderately large quantities of rather highly mineralized water are used by the potash companies for some industrial purposes, but in most of the area the ground water is used only for stock and domestic purposes.

Chalk Bluff and Castile formations

East of the Pecos the limestone, redbeds, and gypsum of the Chalk Bluff formation crop out in a belt 5 to 10 miles wide from Lake Avalon north to beyond the county line. The ground water in the area immediately east of the river between Lake Avalon and Carlsbad has been discussed under the heading "Ground water in the Carlsbad area."

In the outcrop area of the Chalk Bluff formation east of Lake McMillan water of fair to good quality is available in most places at depths less than 200 feet. The water probably is in solution channels in limestone and gypsum, and the quantity and quality available range widely within short distances. Two wells on the Neatherlyn place in the SVANE1/4 sec. 14, T. 19 S., R. 27 E., illustrate the complex ground-water conditions in this area. The wells are about 20 feet apart. The north well is reported to be about 152 feet deep and to yield moderate supplies of hard water. The measured depth to water in this well is

108 feet. The south well is reported to be 100 feet deep and to yield a small supply of soft water. The reported depth to water in this well is 75 feet.

In the outcrop area of the Chalk Bluff formation north of Lake McMillan water can also be obtained from wells at depths generally less than 200 feet, but the water is likely to be more highly mineralized than that in the area farther south. The limestone of the Chalk Bluff formation grades into gypsum and anhydrite to the north, and as a result the water in that area contains a comparatively high concentration of sulfate. Water from well 17.27.11.110 (see table 3), about 8 miles east of Artesia, contained 1,780 parts per million of sulfate but only 33 parts per million of chloride.

Water in the Chalk Bluff also becomes more highly mineralized to the east. East of the outcrop area of the Chalk Bluff formation the Whitehorse group, the subsurface equivalent of the Chalk Bluff formation, probably contains water of quality similar to that in the Rustler formation.

The Castile formation, overlying the Whitehorse group and overlain by the Salado formation in the Delaware basin in the southeastern part of Eddy County, is absent north and west of the buried reef front. The extent of the Delaware basin in Eddy County is shown in the sketch map (fig. 4). The Castile formation probably is not a source of ground water anywhere in the county east of the Pecos.

Salado and Rustler formations

Character, extent, and thickness.—*The* Salado formation, consisting chiefly of halite and small amounts of anhydrite, polyhalite, and red sandy shale, does not crop out in Eddy County, but it underlies most of the area east of the Pecos.

The top of the salt of the Salado is an irregular surface, owing chiefly to solution and removal of the salt by ground water moving in the basal beds of the Rustler. The local relief on top of the Salado is as much as 300 feet in 1 mile. Over much of Nash Draw and parts of Clayton Basin the surface depressions coincide with relatively low parts of the surface of the salt. Figure 5 is a map of the potash-mines area showing contours on top of the salt of the Salado formation. This map is based on records of potash core tests that were made available by R. H. Allport, Regional Engineer of the Conservation Branch, U. S. Geological Survey, at Carlsbad. The depth to the top of the salt in any given spot can be determined by subtracting the altitude of the top of the salt from that of the land surface.

The Rustler formation consists of anhydrite, gypsum, interbedded sandy clay and shale, and irregular beds of dolomite. It unconformably overlies the Salado formation in most of the area east of the Pecos River and ranges in thickness from about 200 feet in northern Eddy County to about 500 feet southeast of Carlsbad. Indicated on plate 1 is the approximate area of outcrop of the Rustler formation, including places where the Rustler is mantled by the wind-laid so-called Mescalero sands.

Occurrence of ground water.—*The* salt of the Salado is impermeable, primarily because the weight of the overburden is sufficient to cause plastic flow of the salt and hence prevent the development of cracks and crevices through which water might move. The extensive potash mines in this formation, although several hundred feet below the water table, are entirely dry except where water enters the shafts through the overlying Rustler formation. The Salado formation is important, however, as the lower confining strata to the basal aquifer in the overlying Rustler formation.

The Rustler formation, throughout most of its outcrop area, is the only possible source of ground water. Water may be obtainable from the underlying Whitehorse group in a small area in the northeast part of the outcrop area. Where the Rustler is underlain by the Salado, drilling below the Rustler for potable water would be useless.

Several water-bearing zones in the Rustler have been penetrated in the numerous potash test holes drilled into the underlying Salado formation. The basal beds of the Rustler consist of porous gypsum in a large part of Nash Draw and southwest to Malaga Bend. These beds, which are in contact with the underlying salt of the Salado formation in some places and separated from it by a few feet of clay in others, contain a brine saturated with sodium chloride, as shown by a number of samples taken during drilling (Robinson and Lang, 1938, pp. 87, 88). The brine in this aquifer moves southwest in Nash Draw past Salt Lake (Laguna Grande de la Sal) to discharge into the Pecos River at Malaga Bend. Calculations based on the increase in chloride content of the Pecos River water in the vicinity of Malaga Bend show that the brine aquifer probably discharges about 340 tons of salt a day to the river (Theis, Sayre, and others, 1942, p. 69).

The most important aquifer above the basal brine aquifer in the Rustler is the 35-foot unit of dolomitic limestone at the top of the lower part of the Rustler as defined by Lang. This limestone unit yields water to most wells penetrating it in the potash mines area (Theis, Sayre, and others, 1942, p. 67). However, a test hole at the site of the No. 2 shaft of the International Minerals and Chemical Corp., 22.29.11, on Quahada Ridge found no water in the Rustler above the basal brine aquifer.

Water is generally confined in the limestone aquifer where it is overlain by the upper beds of the Rustler. Water in it is under water-table conditions where the limestone is near the surface, as in the lower part of Nash Draw and in the vicinity of Salt Lake. This limestone aquifer is the chief source of the water in the shafts of the potash mines. (See p. 76.)

Three wells in Nash Draw produce water from the limestone aquifer for sluicing mine tailings at the mine of the International Minerals and Chemical Corp. Water well 19 (22.30.5.431) yields 260 gallons per minute; water well 20 (22.30.5.443), 286 gallons per minute; and water well 11 (22.30.6.344), 700 gallons per minute. Two wells at the Potash Co. of America plant site (records not given in table **1)** are reported to yield about 650 million gallons per year of brackish water which is used to sluice tailings. Most of this water comes from the limestone aquifer, although a small amount comes from beds of the Rustler above the limestone.

The dolomitic gypsum near the top of the Rustler yields small quantities of water to the drainage holes around the shaft of the U. S. Potash Co. mine and to the two wells at the plant site of the Potash Co. of America. Farther south, in the vicinity of the mine of the International Minerals and Chemical Corp., the dolomitic gypsum is reported dry in most wells and test holes and is probably dry in most of

Quahada Ridge.

Water is penetrated locally at nearly all horizons in the Rustler formation, but, except for the aquifers described above, the quantities obtained are usually insignificant.

Chemical quality.—All water below the top of the salt of the Salado formation is useless for stock or domestic purposes, and, in general, all the ground water is impotable in areas where the top of the salt is near the surface. Also, in much of the area immediately northeast of Malaga, water circulating through the basal beds of the Rustler formation has dissolved salt from the underlying Salado formation and consequently contains a high concentration of sodium chloride, as discussed above. The quality of water available from the Rustler ranges widely within short distances, and in some wells the quality varies with the quantity pumped. Analyses were made of water from 15 wells east of the Pecos that probably derive all or part of their water from the Rustler. (See table 3.) Only six of these samples contained less than 200 parts per million of chloride, and it is probable that some of the water produced from these was from alluvium overlying the Rustler. The water from each of these six wells is high in sulfate and has a hardness as calcium carbonate of more than 1,000 parts per million, but in this area it is considered usable for domestic purposes. All other samples are too high in chloride for drinking and have a hardness as calcium carbonate of 1,000 to 4,000 parts per million. One of the wells, 25.29.32.211, yielded water containing 9,360 parts per million of chloride. This water was being developed for stock, but it is doubtful if it can be used for that purpose. Most other wells in the Rustler produce water usable for stock.

Dockum group

Sandstone beds in the Triassic Dockum group and possibly in the Permian Dewey Lake redbeds are the chief sources of ground water in a belt 10 to 20 miles wide along the east border of the county. The depth to water in this area is generally less than 300 feet, and the quantity of water available from wells is generally sufficient for stock or domestic use. None of the wells visited in this area was reported to be weak or inadequate.

Most of the wells in the outcrop area of the Dockum group yield water of better quality than the wells to the west that produce from the Rustler formation. Analyses were made of 21 samples of water from wells probably taking all or part of their water from the Triassic redbeds. The hardness as calcium carbonate in the 21 samples ranged from 201 to 3,590 parts per million and was more than 1,000 parts per million in 14 of the 21. The chloride content ranged from 17 to 785 parts per million and was more than 200 parts per million in 10 of the samples. Probably about half the wells in the Triassic redbeds produce water that is considered usable for domestic purposes. The water from well 20.30.20.130, which contains 388 parts per million of chloride and has a hardness as calcium carbonate of 1,980 parts per million, is used for domestic purposes but is of very poor quality for such use. None of the wells in the Triassic redbeds produces water too highly mineralized for stock.

Ogallala formation

In the small area of the High Plains in the northeast corner of the county, water of satisfactory quality is obtained from a few stock wells. One of these, 16.31.2.122, is reported to be 320 feet deep and the depth to water is reported to be about 300 feet. This well may obtain water from the sand and gravel of the Ogallala formation or possibly from the underlying Triassic redbeds. The water from this well contained only 47 parts per million of sulfate and 14 parts per million of chloride, and its hardness as calcium carbonate was 330 parts per million.

Because this area is close to the escarpment marking the edge of the High Plains, the thickness of water-saturated material is probably small. However, the wells in this area appear to be adequate for stock supplies.

Alluvium

East of the Pecos between Salt Lake (Laguna Grande de la Sal) and Malaga Bend is an area of several square miles of Quaternary alluvium. In April 1950 a test well, 23.28.13.131, was drilled by the U. S. Potash Co. in the alluvium in this area. The well penetrated 78 feet of clay, silt, sand, gravel, and conglomerate, and was bottomed in redbeds of the Rustler formation. The well was pumped for a few hours on May **1,** 1950, at the rate of 1,200 gallons per minute. (See p1. 6, ***B.)*** A later pumping test lasting several days indicated a maximum capacity under continuous pumping of about 800 gallons per minute. Other wells of similar capacity might be obtained here or in the small patches of alluvium along the east side of the river between Salt Lake (Laguna Grande de la Sal) and Carlsbad. However, pumping from the alluvium would soon reduce the flow of the Pecos River, and new development is not permitted by the State Engineer.

Away from the Pecos River the Quaternary alluvium east of the river consists chiefly of silt, clay, and sand of the Gatuna formation which occurs in scattered patches in the sink depressions. Little is known of the ground-water conditions in these areas. Probably in only a few places is the alluvium thick enough to contain water. Where recharge to the alluvium is from local precipitation water of fair quality may be obtained. In Clayton Basin, wells 20.30.3.223 and 20.30.3.424 yield water from the alluvium. The water is hard but otherwise of fair quality. Water from 20.30.3.424 contains 2.9 parts per million of fluoride, which is more than would be considered desirable in a drinking-water supply. Water from well 22.30.10.310, which prob- ably is at least in part from the alluvium, is of only fair quality, containing 2,280 parts per million of dissolved solids, but is used for drinking and other domestic purposes. The water from this well contained only 8 parts per million of chloride, whereas water from nearby well 22.30.6.344, which definitely is in the Rustler, contained 9,920 parts per million of chloride. Well 22.29.33.240, in Nash Draw about **1** mile north of Laguna Grande de la Sal, yields water, probably from the alluvium, containing 602 parts per million of sulfate and 406 parts per million of chloride, and having a hardness of 1,060 parts per million as calcium carbonate. This is not considered potable water, but it is better than that produced from most wells in the Rustler in this vicinity.

A thin zone of saturation may exist in places at the base of the thin mantle of dune sands which covers much of the area east of the Pecos. Favorable conditions for the occurrence of water are depressions in underlying impermeable rocks and places where the dunes are extensive and thick. No wells are known to have encountered such zones of saturation.

DEWATERING OF POTASH-MINE SHAFTS

Little or no water enters the potash mines through the salt of the Salado formation, but water-bearing zones in the overlying Rustler formation and redbeds are encountered by the mine shafts. At the present time this water is kept out of the shafts by two general methods:

1. By draining and pumping the water from the water-bearing zones around the mine shaft.
2. By cementing off the water-bearing horizons around the mine shaft.

The shaft of the U. S. Potash Co. is kept dry by a number of vertical drilled holes surrounding the shaft which bleed the water from the Rustler into a collecting ring tributary to a sump from which the water is pumped to the surface. When the shaft was sunk in 1930 it produced about 70 to 85 gallons per minute from the limestone of the Rustler. At the present time the shaft produces only about 25 to 30 gallons per minute.

Prior to 1949, water from the No. 1 shaft of the International Minerals and Chemical Corp. was similarly drained to a sump and pumped to the surface. In 1948 most of the wells in Nash Draw east of the shaft were shut down, and the water level in water well 1, about 100 feet northeast of the shaft, began to rise. In March 1948 the amount of water draining into the sump at the 300-foot level of the shaft became so great that the pump could no longer handle the flow, and water was allowed to overflow into the man way. Additional pumps were installed, and the water was soon brought under control again. Consideration was then given to the possibility of some other means of controlling the water, and it was decided to attempt to cement off the water-bearing horizons around the shaft.

In April and May 1949, several holes were drilled into the Rustler formation in two concentric rings around the shaft, and grouting was begun. The procedure was to inject the cement under pressure into one of the holes and then to bail out the cement which had not entered the rock cavities. After the cement had set, the holes were drilled deeper and the process repeated, As grouting of the holes proceeded, the flow of water from the Rustler formation into the sump decreased from 750 gallons per minute until it stopped completely. The movement of the cement between the different grout holes illustrates the complexity of the channels carrying water in the Rustler. Cement introduced into one of the holes would in many instances show up in a distant hole, whereas intervening holes would not be affected.

Test holes for the new shaft of the International Minerals and Chemical Corp. in sec. 11, T. 22 S., R. 29 E., encountered no water in the limestone beds of the Rustler, but some water was found at 395 feet in gypsum just above the top of the salt. The water rose to 278 feet below the land surface. Bailing tests in one of the holes indicated a specific capacity of less than 1 gallon per minute per foot of drawdown. Before sinking of the shaft began, the Rustler was grouted in the basal aquifer at the top of the salt and also in the higher limestone beds.

Sinking of a new shaft for the Potash Co. of America was halted as a result of large quantities of ground water in the redbeds overlying the Rustler formation. The shaft was being sunk by grouting the bottom of the shaft and blasting out the grouted material. The blasting exposed fine sand and silt which had not been penetrated by the grout, and water reportedly rose in the shaft from 135 feet to about 85 feet in 15 minutes. The water could not be controlled by pumping, and in 1949 the possibility of controlling the water by freezing was being considered.

SUMMARY OF AVAILABILITY OF GROUND WATER IN EDDY COUNTY, BY AREAS

Insofar as possible, Eddy County has been divided into areas in each of which the ground-water conditions are essentially uniform. (See pl. 4.) Boundaries of these areas are of necessity somewhat arbitrary and should not be understood to indicate a sudden change in ground-water conditions. The major ground-water features of each area are summarized in the following descriptions and, in a more abbreviated form, on plate 4.

1. GUADALUPE MOUNTAINS

la. Azotea Mesa: Over most of this area a sufficient quantity of water of good quality for stock and domestic supplies can generally be obtained from wells as much as about 300 feet deep in the Carlsbad limestone. Perched water can be obtained locally from shallow wells in arroyo gravels. Near Carlsbad, in La Huerta and Happy Valley, a sufficient quantity of water for irrigation can be obtained from the Carlsbad limestone and from the overlying alluvium. Water in the shallower wells in the irrigated areas is generally unsuitable for domestic use.

lb. Guadalupe Ridge and Guadalupe Mountains proper: In the broad uplands in this area wells must generally be drilled to depths of several hundred feet to obtain water. Shallower wells can be obtained locally in arroyo gravels. Depths to water along the reef escarpment from Dark Canyon to White City range from 100 to 800 feet. Southwest of White City on Guadalupe Ridge several small springs flow from perched-water bodies.

Water in nearly all wells and springs in this area is hard but potable, and the quantity available is generally sufficient for stock and domestic use.

1c. Seven Rivers embayment: Depth to water in this area ranges from less than 50 to more than 900 feet and cannot be accurately predicted. Depth to water is generally greatest in the west and southwest. Shallow wells can be obtained locally from perched water bodies along arroyos. Most wells produce from the Queen sandstone member of the Chalk Bluff formation or from the Goat Seep limestone. Some of the shallower wells produce from arroyo gravels, and a few of the deeper wells may produce from the limestone of the San Andres formation. Water in sufficient quantities for stock and domestic use is generally available and the water is generally potable, although moderately hard.

2. ALLUVIUM SOUTH OF CARLSBAD

2a In this area water in sufficient quantity for irrigation generally can be obtained from wells in the alluvium at depths ranging from about 20 feet near the Pecos River to about 100 feet at the southwest margin of the area. The water is generally too high in chloride and sulfate for domestic use.

2b In this area water for stock and domestic use can be obtained from wells in the alluvium at depths ranging from 100 to 225 feet. Water is generally of suitable quality for domestic use.

3. AREA BETWEEN GUADALUPE MOUNTAINS AND PECOS RP/ER AND GENERALLY SOUTH OF LATITUDE 32°15'

3a. In this area water in sufficient quantities for stock and domestic use and locally for irrigation can be obtained from wells in the alluvium at depths generally less than 200 feet. A few of the larger springs produce enough water for irrigation. Water in most wells and springs is potable.

3b. In this area water in sufficient quantities for stock and domestic use can generally be obtained from wells in the gypsum of the Castile formation at depths less than 100 feet. Quality of water is fair in the western part of the area but becomes increasingly high in sulfate and chloride to the east. Over most of the eastern part of the area it is impotable but is usable for stock.

4. ROSWELL BASIN

4a In this area water for stock and domestic use can be obtained from wells in the limestones of the Chalk Bluff or the San Andres formation, or from the overlying alluvium, at depths ranging from less than 50 feet at the east to about 400 feet at the west margins of the area. Enough water for irrigation is available in the eastern part. Water is generally potable, although hard.

4b In this area water for stock and domestic use can be obtained from wells in the limestone of the San Andres formation at depths ranging from 400 feet at the east to more than 800 feet at the west margins of the area. Water is generally potable but hard.

5. AREA EAST OF THE PECOS RIVER

5a. In this area, water for stock and domestic use generally can be obtained from wells in limestone, gypsum, and redbeds of the Chalk Bluff formation or Whitehorse group at depths as great as 200 feet. Water is generally potable but locally contains chloride and sulfate in objectionable amounts.

5b In this area, water for stock use generally can be obtained from wells in limestone, gypsum, or redbeds of the Rustler formation at depths as great as 250 feet. Water is generally too high in chloride and sulfate for domestic use and locally is undesirable even for livestock.

5c In this area, water for stock and domestic use generally can be obtained from wells in the Triassic redbeds at depths up to 300 feet. Water is generally of fair quality but locally is impotable.

5d In this small area of the High Plains, potable water for stock and domestic use can be obtained from wells in sand and gravel or from underlying redbeds at a depth of about 300 feet.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO

EXPLANATION OF COLUMN HEADINGS

LOCATION NUMBER: See p. 5 for explanation.

ALTITUDE ABOVE SFA LEVEL: Determined with aneroid barometer.

WATER LEVEL: Measured depth to water given to nearest 0.1 foot, reported depth given to nearest foot.

YIELD (gallons per minute) : R. after figure indicates reported yield; E. indicates estimated yield; others measured at time of measurement of water level unless otherwise noted.

METHOD OF LIFT: C, centrifugal; E, electric lift; G, gasoline lift; J, jet; N, none; T, turbine; W, windmill.

USE OF WATER: D, domestic; F, fish hatchery; In, industry; I, irrigation; ***N***, none; PR, potash refining; P, public supply; S, stock; T, test hole.

REMARKS: All wells are drilled unless indicated otherwise in Remarks column.

See tables that follow:

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
16.21.33.200	Robert J. Parks	1948	Blackdom Terrace	4,200	650	7	Limestone	San Andres
16.23.15.323	D. W. Runyan	–	–	–	–	–	Limestone (?)	Chalk Bluff (?)
27.120	–	–	Shallow draw	3,775	200	6	Limestone or alluvium	Chalk Bluff or Quaternary
16.24.11.340	Roy Fry	–	Orchard Park Terrace	3,565	750	10	Limestone (?)	Chalk Bluff
12.300	Jess Funk	1947	do.	–	800	13⅜	do.	do.
21.200	–	–	Shallow draw	3,595	108	4	Alluvium	Quaternary
16.25.6.313	Frank Childress	–	Orchard Park Terrace	–	–	20	Alluvium or limestone	Quaternary or Chalk Bluff
10.333	Orval Gray	1949	do.	–	340+	16	Limestone	Chalk Bluff
14.213	L. T. Lewis	–	do.	–	135	12½	Alluvium	Quaternary
24.212	Monroe Howard	–	Orchard Park Terrace (?)	–	148	12½	do.	do.
16.26.5.331	S. L. Taylor	–	Orchard Park Terrace	–	111	12½	do.	do.
18.331	Monroe Howard	–	do.	–	160	12½	do.	do.
31.413	T. F. Wilson	–	do.	–	168	14	Alluvium (?)	Quaternary (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
16.21.33.200	600	–	10 R.	W	S & D	See analysis, Table 3.
16.23.15.323	222.4	Jan. 1950	–	W	S	Drilled as oil test.
27.120	195.3	Jan. 13, 1950	2	W	S	
16.24.11.340	Flows	do.	900 R.	T	I	Does not flow in summer.
12.300	0	–	–	T	I	Driller: Pierson Bros.
21.200	99.5	Jan. 13, 1950	–	W	S	
16.25.6.313	27.8	Jan. 1950	–	N	–	
10.333	56.2	do.	–	T	I	
14.213	43.1	do.	–	T	I	
24.212	50.0	do.	–	T	I	
16.26.5.331	21.2	do.	–	T	I	
18.331	32.6	do.	–	T	I	
31.413	59.3	do.	–	T	I	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
16.26.35.113	J. T. Fulton	–	Lakewood Terrace	–	–	–	Alluvium (?)	Quaternary (?)
16.31.2.122	Hal Bogle	–	High Plains	–	320	7	do.	Ogallala (?)
14.300	–	–	Base of escarpment	–	–	6	Redbeds (?)	Dockum (?)
17.21.15.340	Sam Hunter	–	South slope	4,215	633	8	Limestone	San Andres
17.410	E. F. Harris	1948	N. side Rio Penasco	4,260	750	7	do.	do.
20.230	G. S. Teel	1947	S. side Rio Penasco	4,260	576	–	do.	do.
17.23.19.300	T. E. Potter	1948	Blackdom Terrace	4,085	500	5½	do.	do.
30.100	School Dist. #8	1931	do.	4,085	530	–	do.	do.
17.24.11.430	–	–	do.	3,710	275 (?)	6	Alluvium or limestone	Quaternary or Chalk Bluff
24.210	Ralph Collins	1948	Lakewood Terrace	3,680	300	–	do.	do.
25.240	–	–	do.	–	200 (?)	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL		YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
	BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT				
16.26.35.113	13.7	Jan. 1950	–	N	N	
16.31.2.122	290+	Dec. 9, 1948	3.2	W	S	See analysis, Table 3.
14.300	113.4	do.	–	N	S	
17.21.15.340	620	–	12+ R.	E	S & D	2 g.p.m. at 300 ft., 3 g.p.m. at 500 ft., "main water" at 620 ft.; could not lower with bailer. Cased to 52 ft. Driller: Geiser.
17.410	660	–	10 R.	E	S & D	Encountered water at 720 ft.; water then rose to 660 ft.; could not lower with bailer. Cased to 130 ft. Driller: Paul Stevenson.
20.230	560	–	–	W	S & D	Small yield well. Lowered cylinder 8 ft. in 1949 when well failed. Cased to 10 ft.
17.23.19.300	492	–	2 R.	–	D	Driller: H. Evertts.
30.100	500	–	10 R.	E	P	Driller: Stevenson.
17.24.11.430	250.8	Jan. 11, 1950	2	W	S & D	Pumping 2 g.p.m. when measured.
24.210	229.2	do.	1	W	S	Driller: Curtis Wilson. See analysis, Table 3.
25.240	190	do.	1	W	S	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
17.25.1.143	Fred Savoie	–	Blackdom Terrace	–	245	8	Limestone (?)	Chalk Bluff (?)
12.211	Artesia Country Club	–	do.	–	–	–	Alluvium (?)	Quaternary (?)
14.120	–	–	do.	–	–	6	Alluvium or limestone	Quaternary or Chalk Bluff
24.433	J. M. Jackson	–	Blackdom Terrace (?)	–	–	–	Limestone (?)	Chalk Bluff (?)
17.26.2.113	Fred Savoie	–	Lakewood Terrace	–	83	8	Alluvium	Quaternary
4.331	Joe Nunn	–	Orchard Park Terrace	–	–	12½	do.	do.
10.333	V. L. Gates	–	Orchard Park Terrace (?)	–	247+	12½	do.	do.
29.131	C. E. Martin	–	Orchard Park Terrace	–	201	20	do.	do.
17.27.3.120	–	–	Rolling upland	–	–	8	Redbeds, limestone, gypsum	Chalk Bluff
11.110	–	–	do.	–	–	8	do.	Chalk Bluff (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
17.25.1.143	119.6	Jan. 1950	–	G	I	
12.211	94.0	do.	–	T	I	
14.120	145.7	Aug. 28, 1948	–	W	S & D	
24.433	109.3	Jan. 1950	–	W	D & S	
17.26.2.113	8.6	do.	–	C	I	
4.331	15.1	do.	–	T	I	
10.333	15.8	do.	–	T	I	
29.131	49.0	do.	–	T	I	
17.27.3.120	130+	Dec. 1, 1948	–	W	N	Abandoned stock well.
11.110	18.1	do.	3 E.	W	S	Depth to water measured while pumping. See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
17.28.2.240	Hal Bogle	–	Flat between mesas	–	–	6 (?)	Redbeds (?)	Dockum (?)
14.220	do.	–	Rolling	–	–	7	do.	do.
19.200	do.	–	do.	–	–	8	Redbeds, gypsum (?)	Chalk Bluff or Rustler
22.230	–	–	Flat between mesas	–	–	6	Redbeds (?)	Rustler or Dockum (?)
17.29.22.110	–	–	Bear Grass draw	3,550	–	6	do.	Dockum (?)
29.400	Bishop (?)	–	Flat	–	–	7	do.	do.
17.31.34.000	–	–	Rolling	–	–	6 (?)	Redbeds	Dockum
18.21.13.310	Andy Teel	1915	–	4,100	520	8	Limestone	San Andres
27.440	do.	1947	Broad valley	4,200	667	10	do.	do.
32.430	George Teel	1946	Rolling	4,300	815	6	do.	do.
18.23.6.140	Couhape Bros.	1941	S. of Rio Penasco	4,060	500	10	do.	do.
18.25.23.111	G. M. Phelps	–	Blackdom Terrace	–	–	–	Alluvium (?)	Quaternary (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
17.28.2.240	27.6	Dec. 1, 1948	3	W	S	Depth to water measured while pumping.
14.220	80	–	6[1]	W	S & D	Driller: Cy Hinshaw. See analysis, Table 3.
19.200	224.3	Dec. 2, 1948	1.2	W	S	Depth to water measured while pumping.
22.230	45.5	Dec. 1, 1948	–	N	N	Abandoned stock well.
17.29.22.110	79.7	Nov. 29, 1948	3 E.	W	S	Depth to water measured while pumping.
29.400	210	Dec. 3, 1948	1.1	W	S	do.
17.31.34.000	271+	Dec. 6, 1948	3.5	W	S	do. See analysis, Table 3.
18.21.13.310	505	–	10 R.	W	S & D	Formerly C.C.C. well. Cased to 30 ft.
27.440	530	–	–	W	S	Cased to 120 ft.
32.430	800 (?)	–	12 R.	W	S & D	Lowered cylinder 5 ft. in 1948 because water level declined. Cased to 380 ft.
18.23.6.140	440	Jan. 12, 1950	–	W	S & D	
18.25.23.111	117.8	Jan. 1950	–	W	S	

See explanation at beginning of table.

1 Measured Dec. 3, 1948.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
18.26.2.333	S. O. Higgins	–	Lakewood Terrace	–	202	10	Alluvium (?)	Quaternary (?)
18.323	Wm. B. McCrary	–	Blackdom Terrace	–	240	12	do.	do.
24.131	Angeline Mackey	–	Orchard Park Terrace	–	80	12½	Alluvium	Quaternary
18.28.8.330	–	–	Rolling	–	–	6	Redbeds, gypsum, limestone (?)	Chalk Bluff or Rustler
30.110	Hal Bogle	–	do.	3,560	–	7	do.	Chalk Bluff (?)
18.29.24.300	Millman Ranch	–	–	3,430	–	6	Redbeds	Dockum
19.23.6.130	Frank Runyan	1933	Rolling	4,100 (?)	516	8	Limestone	San Andres
9.430	do.	1941	do.	–	326	6	do.	do.
27.110	T. V. Coffin	1923 (?)	Gentle E. slope	3,946	410 (?)	8	do.	San Andres (?)
30.330	Bunning	–	–	–	520	8	do.	San Andres
19.24.17.410	T. V. Coffin	1908 (?)	Orchard Park Terrace	3,745	300 (?)	10	Limestone (?)	Chalk Bluff (?)
21.140	Ed Parrish	1937	–	3,685	–	6	Limestone	Chalk Bluff

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
18.26.2.333	14.5	Jan. 1950	–	T	I	
18.323	56.8	do.	–	T	I	
24.131	19.2	do.	–	T	I	
18.28.8.330	81.6	Dec. 3, 1948	–	W	S	
30.110	137.1	Dec. 2, 1948	4 R.	W	S & D	Depth to water measured while pumping. Driller: Vernon Derrick.
18.29.24.300	158.3	Apr. 28, 1950	3 E.	W	S	Depth to water measured while pumping. See analysis, Table 3.
19.23.6.130	430	–	–	W & G	S & D	Cased to 86 ft.
9.430	270	–	4[1]	W	S	
27.110	374.9	Jan. 1950	–	W	S	Sulfur taste.
30.330	500	–	2[1]	W	S	
19.24.17.410	295	–	–	W	S & D	
21.140	300	–	–	W	S	

See explanation at beginning of table.
1 Measured Oct. 5, 1948.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED: CHARACTER OF MATERIAL	PRINCIPAL WATER-BEARING BED: GEOLOGIC UNIT
19.24.35.440	Foster	–	Gentle E. slope	3,635	1,500+	12 (?)	Limestone	San Andres (?)
19.25.15.442	–	–	S. of 4-Mile draw	3,460	80	7	Alluvium or limestone	Quaternary or Chalk Bluff
17.130	J. MacSpaddon	1948	N. 7 Rivers Valley	–	200+	6	do.	do.
31.440	Foster	–	Gentle E. slope	3,535	150	5	do.	do.
19.26.12.323	Forest Lee	–	Orchard Park Terrace	–	–	–	Alluvium	Quaternary
20.210	Jerry Mann	–	–	3,360	100	7	Alluvium or limestone	Quaternary or Chalk Bluff
27.233	Lakewood school	–	Orchard Park Terrace	–	127	8	Alluvium	Quaternary
19.27.13.310	Ray Neatherlyn	–	Williams Hollow	3,450	75	–	Redbeds, gypsum, limestone	Chalk Bluff
14.242	do.	–	do.	3,450	95 (?)	5	do.	do.
14.242a	do.	–	do.	3,455	152	6 (?)	do.	do.
14.242b	do.	–	do.	3,455	100	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
19.24.35.440	230	–	–	W	S	
19.25.15.442	59.4	Jan. 16, 1950	–	W	S	
17.130	83.8	Oct. 1, 1948	2	W	S	Driller: Everts.
31.440	140	–	3[1]	W	S	
19.26.12.323	24.0	Jan. 1950	–	N	N	
20.210	52.9	Jan. 16, 1950	–	W	S	
27.233	49.6	Jan. 1950	–	W	D	See analysis, Table 3.
19.27.13.310	60.7	Sept. 3, 1948	–	N	N	Reported very small yield. Dug well.
14.242	82.4	Jan. 20, 1950	–	W	S & D	North well of three.
14.242a	107.7	Sept. 3, 1948	5–10 R.	W & G	S & D	Reported adequate yield. Middle well of three.
14.242b	75	–	–	W	S & D	Reported small yield. South well of three.

See explanation at beginning of table.
1 Measured Jan. 16, 1950.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
19.28.2.122	Herman Lindley	–	Base of Fade-Away ridge	3,460	160	6	Redbeds, gypsum	Rustler (?)
13.210	West well	–	Shallow draw	3,370	–	8 (?)	do.	do.
18.120	–	–	Small depression	3,502	–	7	Redbeds, gypsum, limestone (?)	Chalk Bluff (?)
33.210	–	–	Shallow draw	3,345	170	5	Redbeds, gypsum (?)	Rustler (?)
19.29.13.410	–	–	Large closed depression	3,310	250	6	Redbeds (?)	Rustler or Dockum
13.410a	North Lake well	–	do.	3,310	250+	6	do.	do.
20.220	Rattlesnake well	–	Small closed depression	3,305	–	6	Redbeds, gypsum, limestone	Rustler (?)
19.31.28.330	John Lusk	–	South slope	3,480	–	8	Redbeds	Dockum
33.110	do.	–	Small depression	3,450	160	5	do.	do.
33.110a	do.	–	do.	3,450	–	6	do.	do.
33.110b	do.	–	do.	3,450	–	6	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
19.28.2.122	128.3	Dec. 13, 1948	1 E.	W & G	S	Depth to water measured while pumping. See analysis, Table 3.
13.210	154.5	Dec. 3, 1948	3	W	S	See analysis, Table 3.
18.120	82.8	Sept. 3, 1948	–	W	S	See analysis, Table 3.
33.210	123.1	Dec. 21, 1948	–	N	N	Abandoned stock well.
19.29.13.410	123.2	do.	–	N	N	West well of two. Abandoned stock well.
13.410a	123.2	do.	1 E.	W	S	East well of two. See analysis, Table 3.
20.220	62.9	Dec. 13, 1948	2 E.	W	S	Depth to water measured while pumping. See analysis, Table 3.
19.31.28.330	180	Nov. 29, 1948	–	W & G	D	See analysis, Table 3.
33.110	100.7	do.	–	N	N	Abandoned. North well of three.
33.110a	103.0	do.	–	G	S	Southwest well of three.
33.110b	–	–	3 E.	W	S	Southeast well of three. See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
20.21.26.420	Armstrong	–	–	–	870	8	Limestone	San Andres
20.24.1.100	Foster	–	Gentle E. slope	3,590	140	6	Limestone (?)	Chalk Bluff
22.310	do.	–	do.	3,750	305	6 (?)	Limestone	do.
32.110	do.	–	do.	–	365	6	do.	do.
20.25.15.200	Price	–	do.	3,435	100	6	do.	do.
16.300	–	1949	do.	3,490	–	4	do.	do.
20.26.7.340	–	–	–	–	–	5	Alluvium	Quaternary
17.330	Truitt	–	Valley	3,270	–	6	Limestone, gypsum (?)	Chalk Bluff (?)
32.220	do.	1943	Gentle E. slope	3,280	85	6	Limestone	Carlsbad
36.411	Westerfall	–	–	3,240	–	6	do.	do.
20.27.1.110	–	–	Head of shallow draw	3,367	200+	6	do.	do.
29.440	Westerfall	–	–	3,190	125	5½	do.	do.
20.28.28.200	–	–	Rolling	3,225	–	6	Redbeds, gypsum (?)	Rustler (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
20.21.26.420	850	–	2 R.	W	D & S	
20.24.1.100	131.9	Jan. 16, 1950	–	N	N	Abandoned stock well.
22.310	300	–	–	W	D & S	
32.110	350	–	–	W	S	
20.25.15.200	67.9	Jan. 16, 1950	–	W	S	
16.300	129.0	do.	–	W	S	
20.26.7.340	5.4	Sept. 13, 1948	–	W	S	
17.330	51.7	Aug. 27, 1948	–	W	S	See analysis, Table 3.
32.220	66.1	do.	–	W	S	
36.411	120.0	Oct. 6, 1948	1½	W	S	
20.27.1.110	186.0	Sept. 7, 1948	1	W	S	Depth to water measured while pumping.
29.440	75.5	Oct. 6, 1948	2½	W	S	
20.28.28.200	30.5	Jan. 20, 1950	–	W	S	See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
20.28.36.140	Dinwitty	–	Scanlon draw	3,210	–	8	Redbeds, gypsum (?)	Rustler (?)
20.29.3.433	–	–	Shallow depression	3,300	–	6	do.	Dockum or Rustler
20.30.3.223	"Clayton Wells"	–	Clayton basin	3,175	–	–	Sand and silt	Quaternary
3.424	do.	–	do.	3,185	–	6 (?)	do.	do.
5.310	"Chimney Well"	–	do.	3,184	–	–	do.	do.
16.420	–	–	do.	3,220	–	6	Redbeds (?)	Dockum (?)
20.120	Wood Ranch	–	do.	3,210	90	6	do.	do.
20.130	do.	–	do.	3,210	60	7	do.	do.
33.440	–	–	Rolling	3,380	240+	9	do.	do.
20.31.13.440	–	–	Williams sink	3,450	–	–	do.	do.
15.130	–	–	do.	3,450	70 (?)	6	do.	do.
16.240	–	–	do.	3,460	110+	6	do.	do.
21.21.7.440	Armstrong	–	–	4,760	1,300	–	–	–
36.213	Frank McWilliams	1941	Draw	4,550	962	6	Limestone	San Andres (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
20.28.36.140	19.1	Dec. 27, 1948	–	W	S	
20.29.3.433	91.9	Dec. 13, 1948	–	W	S	See analysis, Table 3.
20.30.3.223	6.0	Dec. 23, 1948	–	W	S	do.
3.424	8.5	do.	–	W	S	do.
5.310	3.5	do.	–	W	S	
16.420	29.9	May 1, 1950	–	W	S	See analysis, Table 3.
20.120	29.3	Dec. 22, 1948	5 E.	W	D	Depth to water measured while pumping.
20.130	45.3	do.	–	W	D	do. See analysis, Table 3.
33.440	203.8	Dec. 27, 1948	–	W	S	See analysis, Table 3.
20.31.13.440	45	Dec. 22, 1948	4 E.	W	S	do.
15.130	63.1	do.	–	W	S	
16.240	61.2	do.	1 E.	W	S	Depth to water measured while pumping. See analysis, Table 3.
21.21.7.440	1,100	–	–	W	D & S	
36.213	942	–	–	W	S	Driller: T. Hillyer.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.22.19.433	Bates & McWilliams	1939 (?)	Draw	4,505	162	7½	Limestone	Chalk Bluff (?)
36.413	McWilliams	1946	–	4,080	211	6	Limestone (?)	do.
36.431	Bates & McWilliams	–	–	4,075	165	6	Limestone	Chalk Bluff
21.23.30.444	do.	–	Terrace above draw	3,997	377	–	do.	do.
21.24.20.440	Wm. M. Jones	–	Valley	3,675	75	7	Alluvium	Quaternary
23.400	Ernest Shafer	1915	–	3,550	60	6	Gravel and limestone	Quaternary and Chalk Bluff
21.25.3.300	Truitt	1941	Valley	3,296	47	6	Alluvium	Quaternary
9.331	Gerald Ellmore	–	do.	3,363	60	6	do.	do.
9.334	do.	1948	do.	3,363	250 (?)	12	Limestone	Carlsbad
9.342	do.	1940	do.	3,360	1,400	12	do.	do.
11.341	–	1946 (?)	Draw	3,275	55 (?)	–	Gravel or limestone	Quaternary or Carlsbad
18.413	R. A. Shafer	1925 (?)	Edge of terrace	3,450	110	6⅞	Alluvium (?)	Quaternary (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.22.19.433	140	–	–	W	S	Three wells here. Goes dry after few hours pumping. Driller: T. Hillyer.
36.413	184	–	–	W	D & S	Driller: R. Davis.
36.431	162	–	–	W	D & S	
21.23.30.444	225+	Jan. 20, 1948	–	W	S	Water coming into well above 120 ft.
21.24.20.440	36.1	do.	–	W	S	Driller: T. Hillyer.
23.400	47.7	do.	–	W	D	Well goes dry when ditch washes out. Cased 10 to 12 ft. Driller: Langford.
21.25.3.300	26.1	Aug. 27, 1948	–	W	D & S	Cased 20 ft. Driller: Frank Gentry.
9.331	33.8	Dec. 17, 1947	–	W	D & S	
9.334	35	–	–	–	–	Bailed at 60 g.p.m. (reported). Not completed when visited. Driller: A. H. Moreland.
9.342	132.8	Dec. 17, 1947	–	N	N	Abandoned.
11.341	34.4	do.	–	W	S	
18.413	20.1	Jan. 20, 1948	3 R.	W	S	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.25.19.114	J. Joyce	1910	Hillside	3,459	200+	6	Limestone	Carlsbad
26.144	Glen Bobbit	–	do.	3,432	70	8	do.	do.
26.233	do.	–	do.	3,425	70 (?)	6	do.	do.
33.224	Denny Ranch	–	do.	3,500	–	6	do.	do.
21.26.13.330	–	–	South slope	3,185	–	5	do.	do.
15.114	Judson Boyd	–	–	3,200	152	6	do.	do.
16.100	Arch Lewis	–	Shallow draw	3,260	–	5	do.	do.
17.412	–	–	Draw	3,290	181 (?)	6	do.	do.
18.311	–	–	do.	3,280	–	8	do.	do.
19.423	–	–	Flat area	3,365	–	–	do.	do.
23.131	Judson Boyd	1945	Lakewood Terrace	3,148	144	15½	Redbeds, gypsum	Rustler (?)
23.133	do.	1947	do.	3,150	418	16	Limestone	Carlsbad
23.311	do.	–	do.	3,150	168	–	Limestone (?)	Carlsbad (?)
23.311a	do.	–	–	3,150	64	24 (?)	Sand and silt (?)	Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.25.19.114	39.5	Jan. 20, 1948	–	N	N	Abandoned.
26.144	38.7	Dec. 5, 1947	–	W	N	
26.233	31.6	do.	–	W	S	
33.224	8	–	–	W	S	
21.26.13.330	76.4	Nov. 15, 1949	–	W	S	
15.114	93.6	May 23, 1949	–	N	N	Abandoned.
16.100	139.0	Sept. 7, 1948	–	W	S	Pump not in working order.
17.412	174.0	Dec. 15, 1947	–	W	S	
18.311	149.5	do.	–	N	N	Abandoned.
19.423	254.2	Dec. 23, 1947	–	W	D & S	
23.131	37.7	Jan. 7, 1948	1,200 R.	T	S & I	Cased to 70 ft. Driller: A. H. Orland.
23.133	36.9	May 23, 1949	1,400	T	I	Water becomes hard after pumping several days. Driller: A. H. Orland.
23.311	35.8	do.	–	N	N	Abandoned.
23.311a	36.1	do.	–	W	D	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.26.24.424	L. F. Rayroux	1931 (?)	Base of hill	3,160	214	8	Limestone	Carlsbad
24.424a	do.	1946	do.	3,160	320	18	do.	do.
24.424b	do.	1943	do.	3,160	63	10	Limestone (?)	Carlsbad (?)
24.424c	do.	1943	do.	3,145	120	6½	do.	do.
25.142	State Game Farm	1931	South slope hill	3,153	450	8	Limestone	Carlsbad
25.220	–	–	Southeast slope	3,140	–	5	do.	do.
25.231	State Game Farm	–	South slope hill	3,150	250	5 (?)	do.	do.
25.323	Country Club	1946	Lakewood Terrace	3,125	–	12	Alluvium (?)	Quaternary (?)
25.344	–	–	do.	3,120	–	–	Alluvium	do.
25.443	D. H. Pearson	1950	do.	3,122	350	7	Limestone	Carlsbad
28.233	E. M. Hoose	1947	Hillside	3,300	155+	–	do.	do.
31.241	Bobbit	1949	Happy Valley	3,320	618	18	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.26.24.424	49.7	Oct. 10, 1947	350 R.	T	I	Cased to 90 ft. Driller: T. Hillyer.
24.424a	50.3	Jan. 6, 1948	1,350[1]	T	I	Cased to 87 ft.
24.424b	49.0	Nov. 14, 1949	–	W	S	Hit rock at 8 ft. Cased to 10 ft.
24.424c	36.7	Nov. 15, 1949	–	J	D & S	Impotable water. Cased to 100 ft. Driller: Gentry. See analysis, Table 3.
25.142	41.6	do.	600 R.	T	I	Cased to 40 ft. See analysis, Table 3.
25.220	32.7	do.	–	N	N	Abandoned.
25.231	40	–	–	–	I	Encountered caves when drilling East well. See analysis, Table 3.
25.323	23.0	Oct. 10, 1947	–	T	I	Depth to water measured while pumping.
25.344	18.9	Oct. 9, 1947	–	T	I	
25.443	13.1	Jan. 13, 1950	–	N	D	Encountered sulfate water at 142 ft., good water at 260 ft. Cased to 150 ft. Driller: Brennenstool.
28.233	74.6	Dec. 15, 1947	–	W	S	
31.241	211.9	Nov. 21, 1949	1,600+ R.	N	N	Encountered water in crevice at 611 ft. Water rose to 217 ft. below surface. Cased to 618 (?) ft. Water analysis by private party showed 110 parts per million chloride and 1,238 parts per million sulfate.

See explanation at beginning of table.
1 Measured Oct. 10, 1947.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.26.31.243	Bobbit	–	Happy Valley	3,305	250	6	Limestone	Carlsbad
33.441	–	–	do.	3,240	–	6 (?)	Alluvium (?)	Quaternary (?)
35.122	E. M. Hoose	1932	Hillside	3,190	87.5	–	Limestone	Carlsbad
35.223	U. S. Govt. (?)	–	Terrace above river	3,150	146	8	Conglomerate or limestone	Quaternary or Carlsbad
35.343	C. F. Mongomery	–	E. edge Ocotilla Hills	3,250	200	6	Limestone	Carlsbad
35.441	Blake Spruill	1943	Terrace	3,175	200	12	do.	do.
36.212	–	–	Lakewood Terrace	3,122	–	12	–	–
21.27.1.420	Dinwitty	–	Draw	3,180	30	6	Redbeds and gypsum, or sand	Rustler or Quaternary
6.140	–	–	Gentle S. W. slope	3,190	–	–	Limestone (?)	Carlsbad (?)
9.330	–	–	Shallow depression	3,220	–	6	Alluvium (?)	Quaternary (?)
19.334	F. R. Dickson	–	Edge of terrace	3,136	320	–	Limestone	Carlsbad

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.26.31.243	194.0	Nov. 21, 1949	–	W	S	See analysis, Table 3.
33.441	45	do.	–	W	S	
35.122	78.3	Dec. 15, 1947	3 E.	W	D & S	
35.223	52.9	Jan. 23, 1950	–	N	N	Abandoned. See analysis, Table 3.
35.343	135.5	May 22, 1949	1	W	S	Sulfur taste. See analysis, Table 3.
35.441	70.0	Oct. 7, 1948	300	T	P	Supplies 55 families. See analysis, Table 3.
36.212	23.0	Jan. 6, 1948	–	T	I	
21.27.1.420	12.7	Dec. 27, 1948	1 E.	W	S	Depth to water measured while pumping.
6.140	34.1	Sept. 3, 1948	–	W	S	
9.330	81.4	Jan. 25, 1950	2 E.	W	S	See analysis, Table 3.
19.334	30.1	Oct. 10, 1947	1,200 R.	T	I	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.27.20.220	W. W. Simpson	1942	–	3,210	126	–	Redbeds, gypsum	Rustler (?)
28.331	–	1947	Hillside	3,150	350	16	Limestone	Carlsbad
29.311	T. Ives	–	Lakewood Terrace	3,112	236	16	Redbeds, gypsum	Rustler (?)
29.321	do.	–	do.	3,115	269	4 (?)	Limestone	Carlsbad (?)
29.331	P. H. Wailes	–	do.	3,110	268	5	do.	Carlsbad
29.343	O'Chesky	–	do.	3,109	–	18	Alluvium (?)	Quaternary (?)
29.423	Simpson	1916	Top Hill	3,150	150	6	Redbeds and gypsum	Rustler (?)
29.434	O'Chesky	1947	Terrace	3,120	324	8	Limestone (?)	Carlsbad (?)
30.341	H. H. Brahn	–	do.	3,117	–	12	–	–
30.431	C. S. McCasland	–	–	3,115	186	8	Limestone	Carlsbad
30.440	T. Ives	1947	Terrace	3,113	76	16	Alluvium	Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.27.20.220	–	–	–	W (?)	S	Sulfate water at 80 ft., better water at 126 ft.
28.331	40	–	–	T	D, S, & I	Limestone at 25 ft., water at 350 ft. Driller: Brennenstool.
29.311	11.5	Jan. 6, 1948	–	N	I	
29.321	7.5	Oct. 15, 1947	–	T	D, S, & I	
29.331	1.1	Feb. 6, 1947	–	G	D & I	From surface to 229 ft. in caving redbeds, limestone 229-268 ft.
29.343	13.7	Oct. 13, 1947	–	C	S & I	
29.423	41.3	Nov. 15, 1949	–	N	S	Water at 40 ft., 80 ft., and 120 ft.
29.434	19.8	Oct. 13, 1947	400 R.	C	S & I	Driller: Frank Gentry.
30.341	16.0	Oct. 10, 1947	–	T	D, S, & I	
30.431	7.0	–	1,000 R.	C	I	Redbeds at 55 ft., limestone at 160 ft. Cased to 135 ft.
30.440	14.7	Oct. 20, 1947	–	N	–	Driller: Spencer.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.27.30.442	T. Ives	1941	Terrace	3,115	256	7	Limestone	Carlsbad
30.442a	J. F. Lumsford	1947	do.	3,115	68	12	Alluvium	Quaternary
30.443	G. Wiley	1942 (?)	do.	3,115	–	16	Alluvium (?)	Quaternary (?)
31.111	J. Stagner	–	do.	3,115	–	9	Limestone (?)	Carlsbad
31.130	–	–	do.	3,120	150 (?)	10 (?)	Alluvium (?)	Quaternary (?)
31.211	G. A. Blitch	–	do.	3,115	220	9	Limestone (?)	Carlsbad (?)
31.212	Int. Potash Co.	–	do.	3,120	250	5 3/16	Limestone	Carlsbad
31.212a	do.	1947	do.	3,120	315	18	do.	do.
31.212b	do.	1947 (?)	do.	3,120	315	18	do.	do.
31.214	Denhoff	–	do.	3,112	–	8	Alluvium (?)	Quaternary (?)
32.111	L. E. Loman	–	do.	3,113	70	12	Alluvium	Quaternary
32.112	do.	1947	do.	3,112	305	6	Limestone	Carlsbad
32.112a	S. Tracy	1949	do.	3,112	105	15	Alluvium	Quaternary
21.28.18.130	Bybee	–	Lone Tree draw	3,150	–	7	Alluvium (?)	Quaternary (?)
21.29.3.120	Wayne Cowden	–	–	3,380	302	6	Redbeds (?)	Dockum

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.27.30.442	10.7	Oct. 20, 1947	–	C	D	
30.442a	15.0	Oct. 10, 1947	–	C	–	Driller: Spencer.
30.443	15.5	do.	–	C	I	
31.111	8.4	Oct. 20, 1947	–	C	I	
31.130	22.7	Nov. 14, 1949	–	T	I	
31.211	11.0	Oct. 10, 1947	–	C	D & I	
31.212	10.4	Oct. 9, 1947	–	C	D & I	
31.212a	7.6	Jan. 17, 1950	1,000 R.	T	PR	South well of two.
31.212b	–	–	1,000 R.	T	PR	North well of two.
31.214	15.8	Oct. 10, 1947	–	C	I	
32.111	13.7	Oct. 13, 1947	–	C	I	
32.112	7.5	do.	180 R.	C	D & I	
32.112a	15.0	Jan. 24, 1950	–	T	I	No limestone encountered. Driller: Gentry.
21.28.18.130	18.9	Jan. 21, 1950	–	W	S	See analysis, Table 3.
21.29.3.120	210+	Dec. 23, 1948	–	W	S	Cased to 37 ft.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
21.29.18.130	"Lusk east well"	—	Shallow draw	3,290	160	6	Redbeds (?)	Rustler (?)
22.22.15.122	McWilliams	—	Edge of draw	4,260	160	6	Limestone or sandstone	Chalk Bluff
20.442	National Live-stock Co.	—	Draw	4,385	165	—	do.	do.
20.444	do.	—	do.	4,385	150	7	do.	do.
26.223	do.	1944	—	4,350	814	9	Limestone	Chalk Bluff or San Andres
32.344	do.	1940	Edge of draw	4,580	925	7	do.	do.
22.23.14.444	C. D. Fuller	1933	Plains	4,125	487	9	Limestone or sandstone	Chalk Bluff
20.213	Bates & McWilliams	—	Rolling up-land	4,175	—	7	Alluvium or limestone	Quaternary or Chalk Bluff
26.413	C. D. Fuller	—	Wide draw	4,130	—	—	Gypsiferous sand and silt	Quaternary
26.431	do.	—	do.	4,130	62 (?)	7½	Gypsum	Chalk Bluff
27.333	do.	—	Flat upland	4,260	—	8	Redbeds and gypsum	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
21.29.18.130	135.1	Dec. 30, 1948	–	W	S	See analysis, Table 3.
22.22.15.122	151	–	–	W	S	
20.442	75 (?)	Mar. 15, 1948	–	W	S	See analysis, Table 3.
20.444	63.9	Mar. 16, 1948	–	W	S	
26.223	752	–	–	W	S	See analysis, Table 3.
32.344	900	–	–	W & G	S	Two-foot cavity at 898 ft. No water above 900 ft.
22.23.14.444	472	Feb. 4, 1948	–	W	S	Cased to 12 ft.
20.213	98	Feb. 6, 1948	–	W	S	
26.413	10.7	Feb. 4, 1948	8	W	S	
26.431	59.0	do.	–	W	S	See analysis, Table 3.
27.333	169.5	Feb. 6, 1948	2	W	S	do.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.23.31.443	National Live-stock Co.	–	Flat	4,277	68	–	Limestone and sandstone	Chalk Bluff
22.24.7.112	Wm. M. Jones	–	Draw	3,950	73.5	8	Alluvium	Quaternary
7.112a	do.	–	do.	3,950	–	–	do.	do.
7.121	do.	–	do.	3,935	5	–	do.	do.
24.211	Rain Spring Ranch	–	do.	3,900	144+	6	Limestone	Carlsbad
27.434	John Hair	–	do.	3,980	175+	10	do.	do.
27.434a	do.	–	do.	3,980	255+	8	do.	do.
31.142	C. D. Fuller	–	do.	4,300	240 (?)	7	do.	do.
36.131	Beardon Well	–	do.	3,850	35 (?)	8	do.	do.
36.332	John Hair	–	do.	3,880	17	–	do.	do.
22.25.8.441	L. A. Campbell	1919 (?)	Near draw	3,593	43	8	Limestone or gravel	Carlsbad or Quaternary
9.241	Frank Jones	1947	do.	3,560	220 (?)	6	Limestone and sand-stone	Carlsbad
13.333	–	–	Valley flat	3,425	135 (?)	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.23.31.443	55.3	Mar. 8, 1948	–	W	S	
22.24.7.112	49.3	Feb. 4, 1948	½ E.	W	S	Three wells here. See analysis, Table 3.
7.112a	18	–	1 E.	W	S	
7.121	1	–	–	W	S	Dug well.
24.211	137.1	Jan. 15, 1948	–	W	S	
27.434	21.2	Dec. 29, 1947	–	W	S	Northeast well of two.
27.434a	156.0	do.	–	W	S	Southwest well of two.
31.142	217.8	Feb. 6, 1948	–	W	S	
36.131	23.7	Dec. 29, 1947	–	W	S	
36.332	16.1	do.	–	W	S	Dug well.
22.25.8.441	25.8	Dec. 8, 1947	–	W	D & S	Driller: T. Hillyer.
9.241	151.2	do.	–	W	S	Driller: Joe Donohue.
13.333	117.6	do.	–	W	S	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.25.19.214	Miller Ranch	–	Near draw	3,750	75 (?)	6	Limestone or gravel	Carlsbad or Quaternary
27.114	Kee & McIver	1947	Valley	3,550	330	10	Limestone and sandstone	Carlsbad
22.26.1.113	C. M. Beal	1948	Terrace	3,160	88	5	Limestone	do.
1.313	Collins	–	do.	3,150	–	10	do.	do.
1.144	Carlsbad City well No. 4	–	do.	3,140	233	12	do.	do.
1.144a	do. No. 6	–	do.	3,140	135	13	Conglomerate and limestone	Quaternary and Carlsbad
1.144b	do. No. 7	–	do.	3,140	143	13	Sand, gravel and limestone	do.
1.144c	do. No. 8	–	do.	3,140	147	13	Sand, gravel and con-glomerate	Quaternary
1.144d	do. No. 9	–	do.	3,140	225	15½	–	–
1.144e	do. No. 11	–	do.	3,140	163	18	Limestone	Carlsbad

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL		YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
	BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT				
22.25.19.214	58.2	Jan. 15, 1948	–	W	S	
27.114	229.0	Dec. 23, 1947	–	W	S	Driller: Joe Donohue.
22.26.1.113	47.8	Oct. 7, 1948	–	N	D	First water at 47 ft., second water at 76 ft.
1.313	38.6	Oct. 24, 1947	–	T	I	
1.144	–	–	1,000 R.	T	P	Plugged at 130 ft. Cased to 116 ft. Driller: Pennsylvania Drilling Co. See analysis, Table 3.
1.144a	–	–	1,600 R.	T	P	Cased to 120 ft. Driller: A. M. Brennen-stool.
1.144b	–	–	700 R.	T	P	Cased to 118 ft. Driller: Hemler & Goad.
1.144c	–	–	1,250 R.	T	P	Cased to 110 ft. Driller: Hemler & Goad. See analysis, Table 3.
1.144d	–	–	1,100 R.	T	P	Plugged at 115 ft. Cased to 110 ft. Driller: Martin and Hurley.
1.144e	–	–	1,300 R.	T	P	Cased to 118.5 ft. Driller: Martin and Hurley.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED: CHARACTER OF MATERIAL	PRINCIPAL WATER-BEARING BED: GEOLOGIC UNIT
22.26.1.144f	Carlsbad City well No. 12	–	Terrace	3,140	245	18	Limestone	Carlsbad
2.144	–	1949 (?)	do.	3,230	–	7	do.	do.
2.144a	G. Bonds	–	do.	3,220	125	–	do.	do.
2.211	City of Carls-bad	1948	East slope	3,230	400	(?)	do.	do.
3.121	Denny	1949	N. side Happy Valley	3,240	160	6	Limestone and gypsum	Castile, Rustler and Carlsbad (?)
3.133	–	do.	Happy Valley	3,210	–	6	Gypsum and redbeds	Castile and Rustler
3.214	Bluebird Water Co.	–	N. side Happy Valley	3,250	1,800	35 (?)	Limestone	Carlsbad
3.241	do.	–	do.	3,255	345	10	do.	do.
3.312	A. W. Dougherty	1949	Happy Valley	3,190	245	6	do.	Carlsbad (?)
3.344	O. G. Willis	1947	do.	3,180	360	14	do.	Carlsbad

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.26.1.144f	32	Sept. 14, 1948	3,000 R.	T	P	Depth to water measured by airline. Cased to 108 ft.
2.144	120.2	Nov. 16, 1949	—	N	D	East well.
2.144a	108.3	do.	—	W	D	West well. Cased to 120 ft.
2.211	120	—	—	N	N	300 g.p.m. Good water at 200 ft. to 280. ft. Large quantity bad water at 350 ft. to 400 ft. Driller: W. H. Martin and Bud Brennenstool.
3.121	135.6	May 22, 1949	5	J	S	Cased to 20 ft. Driller: W. R. Watson. See analysis, Table 3.
3.133	26.0	Nov. 21, 1949	—	U	D (?)	
3.214	—	—	2,500 R.	T	I	Oil test. West well of two. See analysis, Table 3.
3.241	145.8	Sept. 11, 1946	—	T	I	East well of two.
3.312	80	—	—	J	D, S, & I	Bottomed in limestone. Driller: Frank Gentry.
3.344	71.6	Jan. 17, 1950	600 R.	T	I	Limestone at 150 ft. Cased to 110 ft. Driller: Emmit Barron.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.26.3.344a	O. G. Willis	–	Happy Valley	3,180	150	–	Gypsum	Castile and Rustler
4.240	Klien	1949	do.	3,210	204	–	Gypsum and limestone	Castile, Rustler and Carlsbad (?)
8.110	Leck	–	Valley	3,400	–	–	Limestone	Carlsbad
9.110	do.	–	Happy Valley	3,275	–	8	do.	do.
9.120	V. L. Ohmart	–	N. E. slope	3,240	–	14	Alluvium (?)	Quaternary (?)
11.121	C. A. Reed	1930 (?)	Terrace	3,160	–	12	Alluvium	Quaternary
11.140	–	–	do.	3,162	262	–	Limestone (?)	Carlsbad (?)
11.340	S. J. Elliot	1935	do.	3,175	–	–	Alluvium (?)	Quaternary (?)
11.411	Pedro V. Sosa	–	do.	3,150	–	–	Alluvium	Quaternary
11.443	–	–	do.	3,160	–	–	do.	do.
12.111	–	–	do.	3,135	–	–	Alluvium (?)	Quaternary (?)
12.112	Boyd & Stevenson	–	do.	3,133	206	–	Limestone	Carlsbad (?) and Rustler (?)
12.311	A. J. Bradley	1942	do.	3,140	–	–	Alluvium	Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.26.3.344a	–	–	–	J	D & S	Located 50 ft. south of deep well.
4.240	–	–	100 R.	T	D, S, & I	Cased to 204 ft. Driller: H. M. Curtiss. See analysis, Table 3.
8.110	3.2	Mar. 17, 1949	2	W	S	Dug well. See analysis, Table 3.
9.110	123.1	do.	–	W	S	
9.120	73.7	Jan. 7, 1948	–	T	I	
11.121	51.1	Oct. 14, 1947	600 R.	T	I	Driller: F. Gentry.
11.140	60.6	do.	1,250 R.	T	I	
11.340	68.4	Oct. 24, 1947	–	T	I	
11.411	51.2	Oct. 27, 1947	–	T	I	
11.443	50.2	Jan. 7, 1948	–	T	I	
12.111	32.7	Oct. 23, 1947	–	T	I	
12.112	28.7	Jan. 7, 1948	3,000 R.	T	I	
12.311	39.8	do.	680 R.	T	D, S, & I	Driller: F. Gentry.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.26.12.331	A. H. Moreland	1943	Terrace	3,140	–	–	Alluvium	Quaternary
12.443	A. B. Campbell	1947	do.	3,120	–	–	do.	do.
13.240	G. C. Dunn	–	S. of Dark Canyon	3,135	56	6	do.	do.
14.213	H. E. Stevenson	1945	Terrace	3,180	200+	–	Limestone (?)	Carlsbad (?) and Rustler (?)
14.323	J. R. Plowman	1940	Hillside	3,200	–	–	Limestone	Carlsbad and Rustler
20.312	J. S. Windham	–	McKittric Canyon	3,340	257	10	do.	Carlsbad
20.323	do.	–	do.	3,325	200	6	do.	do.
24.224	D. N. Vest	1947	Terrace	3,157	200	10¾	Alluvium	Quaternary
31.413	G. F. Newman	1947	Valley flat	3,420	130	6	Alluvium and limestone	Quaternary and Carlsbad
35.222	Airbase, No. 3	–	Orchard Park Terrace	–	200	–	Alluvium	Quaternary
22.27.1.210	Bond Ranch	–	Broad Valley	3,095	–	6	Gypsum and redbeds or alluvium	Rustler or Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.26.12.331	–	–	120[1]	–	D & I	Driller: J. T. Goad.
12.443	–	–	–	–	N	Abandoned; insufficient water for irrigation.
13.240	45	–	–	T	D & I	Reported pumps 50 g.p.m. for a few minutes, then yield declines.
14.213	68.4	Oct. 23, 1947	1,200 R.	T	D, S, & I	Driller: Hillyard.
14.323	95.6	do.	1,200 R.	T	D, S, & I	Driller: Joe Ossley.
20.312	180	Dec. 10, 1947	–	W	S	Cavern 7 ft. deep at 200 ft. Water rose 50 ft. Driller: Tom Ernest.
20.323	196	–	–	W & G	S	Driller: Bill Marlow.
24.224	85.3	Jan. 7, 1948	–	N	N	Automatic water-level recorder installed, Nov. 10, 1948.
31.413	104.5	Dec. 30, 1947	½ E.	W	S	Driller: Himmler & Goad.
35.222	149.3	Jan. 1950	–	T	P	Three wells here. Original depth 256 ft. See analysis, Table 3.
22.27.1.210	39.9	Dec. 23, 1948	6	W	D & S	Depth to water measured while pumping. See analysis, Table 3.

See explanation at beginning of table.
1 Measured Oct. 23, 1947.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.27.4.211	C. E. Wersell	–	W. side Esperanza draw	3,145	55	5	Gypsum and redbeds or alluvium	Rustler or Quaternary
5.141	J. Joyce	1939	Hagerman Heights	3,165	400	8 (?)	Gypsum and redbeds	Rustler
8.313	G. McShaw	1947	Lakewood Terrace	3,100	90	18	Conglomerate (?)	Quaternary (?)
8.314	do.	1945	do.	3,100	110	10	Conglomerate	Quaternary
8.333	Joe Bryan	–	do.	3,098	300	13½	Alluvium and gypsum	Quaternary and Rustler (?)
9.333	M. Enifer	–	Hillside	3,110	–	–	Alluvium	Quaternary
9.433	–	1947	do.	3,090	–	–	do.	do.
10.333	M. Enifer	1947	Lakewood Terrace	3,080	–	–	do.	do.
15.113	Cecil Ginanni	1947	do.	3,080	119	18	do.	do.
15.233	W. J. Bindel	–	do.	3,080	135	–	do.	do.
15.333	Fred Forni	–	Orchard Park Terrace	3,101	174	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.27.4.211	46.1	Jan. 24, 1950	1 E.	W	S	Depth to water measured while pumping.
5.141	85.5	do.	–	T	I	Owner reports all gypsum to 400 ft., no limestone.
8.313	22.7	Nov. 3, 1947	3,000 R.	T	S & I	Driller: Himmler & Goad.
8.314	18.6	do.	500 R.	T	S & I	
8.333	24.8	Sept. 29, 1947	500 R.	N	I	
9.333	40.6	do.	–	T	I	
9.433	17.2	do.	–	U	I	
10.333	11.1	do.	–	T	I	
15.113	12.7	do.	1,900[1]	T	I	Cased to 50 ft. Driller: Tuck Hillyer. See analysis, Table 3.
15.233	12.0	Dec. 21, 1948	3,000[2]	T	I	
15.333	42.7	Oct. 9, 1947	400 R.	N	N	Abandoned because not enough water for irrigation.

See explanation at beginning of table.

1 Measured Aug. 2, 1948.

2 Measured Aug. 5, 1948.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.27.15.411	Fred Forni	–	Lakewood Terrace	3,085	140	18	Alluvium	Quaternary
17.123	W. W. Glaze	1947	Orchard Park Terrace	3,120	123	16	do.	do.
17.344	Calvani Bros.	–	do.	3,124	160	–	Alluvium anhydrite (?)	Quaternary and Rustler (?)
17.344a	do.	–	do.	3,130	–	–	Alluvium anhydrite	Quaternary and Rustler
18.310	New Mexico Packing Co.	–	do.	3,155	90	8	Alluvium	Quaternary
20.111	E. C. Walterschied	1934	do.	3,130	146	–	do.	do.
20.313	Frank Zugary	–	do.	3,148	212	–	do.	do.
21.344	Dr. Pate	1947	do.	3,125	200	16	do.	do.
22.421	E. M. Grandi	–	do.	3,100	150	16	do.	do.
26.114	C. Grandi	1946	do.	3,093	70	16	do.	do.
26.331	do.	1948	do.	3,095	158	16	do.	do.
26.333	Place	1946	do.	3,097	113	13	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.27.15.411	15.1	Jan. 7, 1948	–	T	I	Cased to 90 ft. Driller: Tuck Hillyer.
17.123	29.0	Nov. 5, 1947	–	–	I	Cased to 78 ft. Driller: Tuck Hillyer.
17.344	–	–	1,300 E.	T	I	South well of two. Water can be heard running in.
17.344a	–	–	500 E.	T	I	North well of two. Water can be heard running in.
18.310	84.6	Mar. 21, 1949	9½	J	In	Cased to 80 ft. See analysis, Table 3.
20.111	53.9	Nov. 3, 1947	200 E.	C	I	
20.313	77.4	Oct. 3, 1947	1,200 R.	T	I	
21.344	54.9	Jan. 9, 1948	–	T	I	Driller: Himmler & Goad.
22.421	34.8	do.	1,500 E.	T	I	
26.114	34.3	Oct. 9, 1948	–	T	I	Cased to 70 ft.
26.331	35.8	Aug. 9, 1948	2,600	T	I	Pumps sand and silt. Cased to 100 ft. See analysis, Table 3.
26.333	38.9	do.	1,700 R.	T	I	Cased to 113 ft. Driller: Martin & Hurley.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.27.27.113	Hubert Grandi	–	Orchard Park Terrace	3,117	93	–	Alluvium	Quaternary
27.213	E. Grandi	–	do.	3,109	132	–	do.	do.
27.231	Pixler	1947	do.	3,105	–	18	do.	do.
28.133	Skein	–	do.	3,137	–	–	do.	do.
28.421	do.	–	do.	3,122	–	–	do.	do.
28.440	do.	–	do.	3,122	–	–	do.	do.
29.111	Frank Gentry	–	do.	3,153	249	–	Conglomerate or limestone	Quaternary or Rustler (?)
29.131	do.	–	do.	3,160	–	–	Alluvium	Quaternary
29.133	do.	1945	do.	3,167	185	18	do.	do.
29.143	do.	1947	do.	3,155	230	16	Alluvium and gypsum (?)	Quaternary and Rustler
29.311	H. Himler	–	do.	3,167	–	–	Alluvium	Quaternary
29.413	Rogers	–	do.	3,152	–	–	do.	do.
30.133	W. H. Marchant	–	do.	3,190	207	8	Limestone conglomerate	do.
30.243	Yarbro	1947	do.	3,170	–	14	Alluvium	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.27.27.113	47.4	Sept. 29, 1947	2,000 R.	T	I	
27.213	47.3	Oct. 9, 1947	1,750 R.	T	I	
27.231	52.0	do.	–	N	I	
28.133	66.5	Oct. 1, 1947	–	T	I	
28.421	54.3	do.	–	T	I	
28.440	56.4	Dec. 21, 1948	–	T	I	
29.111	81.7	Oct. 2, 1947	–	T	I	Cased to 140 ft. Driller: Frank Gentry.
29.131	85.4	do.	–	–	I	Driller: Frank Gentry.
29.133	95.4	do.	–	T	I	do.
29.143	84.9	Dec. 20, 1948	–	T	I	do.
29.311	95.2	Oct. 13, 1947	–	T	I	See analysis, Table 3.
29.413	82.2	Oct. 2, 1947	–	T	I	
30.133	114.4	Nov. 10, 1947	–	N	N	
30.243	98.5	Jan. 8, 1948	–	T	I	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.27.31.233	R. Spencer	1947	Orchard Park Terrace	3,185	217 (?)	13	Alluvium	Quaternary
31.433	Lewis Allen	1948	do.	3,190	200	–	Dry hole	Dry hole
32.224	Joe McKinney	1946	do.	3,145	175	16	Alluvium	Quaternary
32.233	Brennenstool	1947	do.	3,155	–	–	do.	do.
33.131	–	–	do.	3,145	–	14	do.	do.
33.143	–	–	do.	3,140	–	16	do.	do.
33.224	Gear	1947	do.	3,120	205	16	do.	do.
33.444	do.	1946	do.	3,130	180	8¼	do.	do.
34.111	L. T. Lewis	–	do.	3,121	300	16	Sand, gravel and lime-stone (?)	Quaternary and Rustler (?)
35.111	W. Craft	–	do.	3,096	150 (?)	18	Alluvium	Quaternary
35.233	–	–	do.	3,085	–	–	do.	do.
35.321	–	1947	do.	3,090	–	–	do.	do.
35.433	Munoz Methola	–	do.	3,085	245	16	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.27.31.233	112.7	Nov. 5, 1947	–	T	I	Driller: D. A. Spencer.
31.433	–	–	–	N	N	Blue clay 40 ft. to 200 ft. No water. Driller: Brennenstool.
32.224	59.7	Feb. 6, 1947	–	T	I	Driller: Frank Bonn.
32.233	81.4	Jan. 14, 1948	–	T	I	
33.131	71.0	Oct. 1, 1947	–	T	I	
33.143	66.9	do.	–	T	I	
33.224	50.7	do.	–	T	I	Water pouring into well from above water level. Cased to 143 ft.
33.444	64.8	Feb. 6, 1947	–	T	I	Cased to 108 ft. Driller: Frank Bonn.
34.111	53.0	Oct. 1, 1947	700 R.	T	I	
35.111	38.6	Jan. 12, 1948	1,500 R.	T	I	
35.233	57.0	Oct. 1, 1947	1,200	T	I	Depth to water measured while pumping.
35.321	34.6	do.	–	T	I	
35.433	36.5	Jan. 13, 1948	–	T	I	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
22.27.35.444	Munoz Methola	–	Orchard Park Terrace	3,075	107	–	Alluvium	Quaternary
36.133	Brantley & William	–	do.	3,077	190	–	do.	do.
22.28.4.130	Andrews well	–	Shallow draw	3,142	–	6	Redbeds, limestone, gypsum	Rustler (?)
30.443	–	–	Lakewood Terrace	3,045	–	18	Alluvium	Quaternary
22.29.11.000	International M. & C. Corp.	–	Hill	3,230	400	–	Gypsum	Rustler
12.224	do.	–	Nash draw	3,140	–	12	Redbeds, gypsum, limestone	do.
33.240	–	–	Closed depression	3,020	65	6	Alluvium (?)	Quaternary (?)
22.30.5.431	International M. & C. Corp.	–	Nash draw	3,120	–	–	Redbeds, gypsum, limestone	Rustler
5.443	do.	–	do.	3,100	–	–	do.	do.
6.344	do.	–	do.	3,145	–	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.27.35.444	–	–	–	T	I	Water pouring into well from above water level.
36.133	27.8	Dec. 21, 1948	4,000 R.	T	I	
22.28.4.130	130.6	Dec. 17, 1948	1	W	S	Depth to water measured while pumping.
30.443	10.6	Oct. 15, 1947	–	N	I	
22.29.11.000	278	May 21, 1949	–	N	–	Test hole for No. 3 shaft. Water just above salt. No water found in limestone.
12.224	119.1	May 18, 1949	–	N	N	
33.240	56.2	Dec. 17, 1948	–	W	S	See analysis, Table 3.
22.30.5.431	87.5	May 18, 1949	260 R.	T	In	
5.443	68.0	do.	–	T	In	
6.344	110.3	May 20, 1949	700 R.	T	In	Depth to water measured while pumping. See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED: CHARACTER OF MATERIAL	PRINCIPAL WATER-BEARING BED: GEOLOGIC UNIT
22.30.6.424	International M. & C. Corp.	–	Nash draw	3,150	–	–	Redbeds, gypsum, limestone	Rustler
6.444	do.	–	do.	3,155	–	20	do.	do.
7.244	do.	–	do.	3,120	–	12	do.	do.
7.311	do.	–	do.	3,134	250	12	do.	do.
8.241	do.	–	do.	3,155	–	24	do.	do.
10.310	C. Johnson	–	do.	3,130	77	6	Redbeds, gypsum and limestone or alluvium	Rustler or Quaternary
30.240	J Bar F well	–	do.	3,000	75	8	do.	do.
23.22.2.242	National Livestock Co.	1948	Pediment	4,345	124	7	Alluvium (?)	Quaternary (?)
2.242a	do.	–	do.	4,345	340	–	Limestone	Chalk Bluff
16.220	do.	1947	Wagontire draw	4,595	975	7	do.	San Andres (?)
23.130	do.	1936	Red Bluff draw	4,450	630	–	do.	San Andres
24.222	do.	–	Pediment	4,290	296	7	Limestone and sandstone	Chalk Bluff

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
22.30.6.424	112.4	May 18, 1949	–	N	N	
6.444	117.3	do.	–	N	N	Abandoned.
7.244	85.7	do.	–	N	N	
7.311	106.0	do.	–	N	N	
8.241	115.1	do.	–	N	N	
10.310	56.0	Dec. 23, 1948	–	W	D & S	See analysis, Table 3.
30.240	134.0	Dec. 17, 1948	–	W	S	See analysis, Table 3.
23.22.2.242	80.7	Mar. 12, 1948	–	N	S	West well of two. Driller: Roy Freek.
2.242a	300	–	–	W	D & S	East well of two. Driller: Roy Freek.
16.220	775	–	–	–	S	Encountered water at 840 ft., water rose to 775 ft.
23.130	600	–	–	–	S	
24.222	250	–	–	W	S	See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
23.22.27.000	National Livestock Co.	1935	–	4,700	714	–	Limestone	San Andres
36.113	do.	–	Draw	4,350	312	–	Limestone and sandstone	Chalk Bluff
23.23.8.113	do.	–	Pediment	4,200	265	5	do.	do.
9.344	Pipkin	–	do.	4,150	200+	9	do.	do.
14.234	Jim Davidson	1904	Draw	4,025	84	–	Limestone and sandstone or alluvium	Chalk Bluff or Quaternary
16.133	S. S. Well	Before 1912	Wagontire draw	4,157	225	8	Limestone and sandstone	Chalk Bluff
28.440	National Livestock Co.	1937	Walker draw	4,190	270	–	do.	do.
29.331	do.	–	Anderson Canyon	4,250	60	6	do.	do.
23.24.14.442	Gerry Smith	1927	Kirkendall draw	3,800	50	–	Limestone or alluvium	Chalk Bluff or Quaternary (?)
25.214	do.	1938	Side of draw	3,750	167	10	Dolomite and sandstone	Chalk Bluff
29.241	G. H. Peveler	Before 1940	Valley flat	3,900	150 (?)	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
23.22.27.000	685	–	–	–	S	
36.113	163	Mar. 17, 1948	–	W	S	Driller: Roy Freek. See analysis, Table 3.
23.23.8.113	–	–	–	W	S	
9.344	182	May 17, 1948	–	W	S	
14.234	76	–	–	W	D & S	
16.133	150.0	Mar. 8, 1948	–	W	S	See analysis, Table 3.
28.440	140	–	–	W	S	
29.331	50.9	Mar. 17, 1948	–	W	S	
23.24.14.442	–	–	–	W	D & S	Cased to 20 ft. Driller: Roy Simmons.
25.214	27.0	Feb. 24, 1948	–	W	D & S	Cased to 40 ft. Driller: H. Everets.
29.241	140 (?)	–	–	W	D & S	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
23.24.29.242	G. H. Peveler	–	Valley flat	–	77	–	Sand	Quaternary
23.25.10.331	G. F. Newman	–	Sheep draw	3,675	120	–	Alluvium, limestone	Quaternary or Carlsbad (?)
23.26.3.443	S. Gibson	–	Terrace	3,285	–	8	do.	Quaternary or Carlsbad
8.344	G. F. Newman	–	do.	3,375	290 (?)	–	Limestone	Rustler (?)
22.233	King	–	do.	3,310	304	–	Sand and gravel	Quaternary
30.244	G. F. Newman	–	Wide draw	3,480	230 (?)	–	Redbeds (?)	Rustler
32.111	H. White	–	Hillside	3,500	460	6	Limestone (?)	Carlsbad
23.27.1.342	M. P. Wiseman	1947	Cass draw	3,055	128	8	Alluvium	Quaternary
2.122	J. Derrick	–	Orchard Park Terrace	3,085	186	18	do.	do.
4.331	M. Burch	Before 1942	do.	3,155	168	14 (?)	do.	do.
4.333	A. C. Bindel	1935	do.	3,155	125	13⅜	do.	do.
4.433	E. Shields	1947 (?)	do.	3,140	–	14	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
23.24.29.242	Dry	–	–	–	N	Abandoned because filled in with quicksand.
23.25.10.331	75	–	–	W	S	
23.26.3.443	220.6	Dec. 11, 1947	–	W	D & S	
8.344	266.7	Dec. 10, 1947	–	W	S	
22.233	224	–	–	W	D	Driller: Gentry.
30.244	99.4	Nov. 12, 1947	–	W	D & S	Driller: Himmler & Goad.
32.111	223+	do.	–	W	S	
23.27.1.342	17.4	Dec. 21, 1948	–	T	I	
2.122	70.2	Sept. 26, 1947	500	T	I	
4.331	109.2	Nov. 10, 1947	–	T	I	
4.333	89.7	Dec. 6, 1946	1,200 R.	T	I	
4.433	90.4	Nov. 10, 1947	–	N	I	

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
23.27.5.333	Jack Williams	1949	Orchard Park Terrace	3,183	–	20	Alluvium	Quaternary
6.212	Ashbury Bros.	–	do.	3,188	200	8½	do.	do.
6.213	do.	1947	do.	3,195	190	12	do.	do.
10.143	–	–	Cass draw	3,105	–	–	do.	do.
10.413	W. B. Rodgers	–	Orchard Park Terrace	3,108	185	–	do.	do.
12.233	Bird Bros.	–	do.	3,070	160	18	do.	do.
14.124	A. M. Hoose	–	do.	3,102	230	16	do.	do.
23.211	–	–	do.	3,120	–	12	do.	do.
24.313	–	–	do.	3,125	–	18	do.	do.
24.342	–	–	do.	3,125	–	18	do.	do.
24.343	–	–	do.	3,130	–	–	do.	do.
29.120	–	–	do.	3,190	120 (?)	5	do.	do.
23.28.6.131	–	–	North side Cass Draw	3,045	–	–	do.	do.
7.113	G. Brantly	–	Orchard Park Terrace	3,052	165	–	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	WATER LEVEL DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
23.27.5.333	82.7	Sept. 20, 1949	–	N	I	Driller: A. M. Brennenstool.
6.212	109.2	Feb. 6, 1947	–	T	I	Cased to 130 ft.
6.213	123.2	Jan. 14, 1948	–	T	I	Cased to 165 ft. Driller: J. Donahue. See analysis, Table 3.
10.143	9.6	Oct. 15, 1947	–	N	I	
10.413	50.4	Sept. 30, 1947	600 R.	T	I	
12.233	39.9	Oct. 9, 1947	1,800 R.	T	I	
14.124	74.8	Oct. 15, 1947	500 R.	N	I	
23.211	22.8	Nov. 10, 1947	–	N	I	
24.313	90.3	Sept. 30, 1947	–	N	I	
24.342	93.4	do.	–	N	I	
24.343	90.0	do.	–	N	I (?)	Abandoned (?)
29.120	103	Dec. 22, 1948	–	W	S	
23.28.6.131	16.5	Jan. 12, 1948	–	T	I	
7.113	26.6	do.	–	T	I	Water pouring into well from above water level. See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
23.28.7.333	–	–	Orchard Park Terrace	3,060	–	–	Alluvium	Quaternary
8.421	E. D. Rosson	–	do.	3,023	89	12	do.	do.
11.114	Bonny Yarbro	1946	Lakewood Terrace	3,003	100	16	do.	do.
13.131	U. S. Potash Co.	1950	do.	2,980	79	18	do.	do.
13.131a	do.	1950	do.	2,980	40	8	do.	do.
13.142	do.	1950	do.	2,976	45	8	do.	do.
14.144	Buford Yarbro	–	Orchard Park Terrace	3,005	100	–	do.	do.
15.323	do.	–	do.	3,005	145	–	do.	do.
15.411	–	–	do.	2,998	130	–	do.	do.
18.222	Carter	1947	do.	3,038	–	–	do.	do.
18.223	Purdue	–	do.	3,045	–	–	do.	do.
18.333	L. T. Lewis	–	do.	3,086	278	16	Alluvium and limestone (?)	Quaternary and Rustler (?)
20.144	Carter	–	do.	3,060	–	–	Alluvium	Quaternary
22.333	J. L. Seal	–	do.	3,030	150	16	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
23.28.7.333	44.5	Aug. 12, 1948	–	T	I	
8.421	34.0	Sept. 24, 1947	–	T	I	
11.114	30.5	do.	250	T	I	Depth to water measured while pumping. Driller: Joe Howard.
13.131	14.8	May 1, 1950	1,200 R.	T	In	Redbeds at 78 ft. Cased to 32 ft.
13.131a	14.5	do.	–	N	T	Cased to 40 ft.
13.142	9.8	do.	–	N	T	Cased to 43 ft.
14.144	31.3	Sept. 23, 1947	–	T	D, S, & I	
15.323	21.1	Sept. 19, 1947	1,500 R.	T	I	Cased to 127 ft.
15.411	14.5	Jan. 12, 1948	800[1]	T	I	
18.222	26.4	do.	–	T	I	
18.223	75.4	Sept. 24, 1947	–	T	I	Depth to water measured while pumping.
18.333	63.0	Jan. 13, 1948	1,000 R.	T	I	Cased to 195 ft.
20.144	56.1	do.	500[2]	T	I	See analysis, Table 3.
22.333	45.6	do.	–	T	I	Cased to 102 ft.

See explanation at beginning of table.
1 Measured Sept. 23, 1947.
2 Measured Sept. 25, 1947.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED: CHARACTER OF MATERIAL	PRINCIPAL WATER-BEARING BED: GEOLOGIC UNIT
23.28.22.433	J. Joyce	–	Orchard Park Terrace	3,031	174	–	Alluvium	Quaternary
23.133	Donaldson	–	Hillside	3,020	–	–	do.	do.
23.433	S. F. Williams	–	East slope	3,008	130	16	do.	do.
24.134	B. Yarbro	–	do.	2,992	96	–	do.	do.
25.213	Ray Howard	–	do.	2,990	200	18	do.	do.
29.144	Kelly-Polk	–	Orchard Park Terrace	3,100	190	18	do.	do.
29.411	–	–	do.	3,101	–	14	do.	do.
23.30.2.440	James Bros.	–	E. trending spur	3,250	300	5	Redbeds	Dockum or Rustler
6.110	do.	–	Closed depression	3,000	200	12 (?)	do.	Rustler
6.420	Nash well	–	do.	2,980	–	–	Alluvium	Quaternary
21.122	Indian well	–	Valley	3,165	–	12	Redbeds	Rustler
23.31.7.220	James Head-quarters	1900 (?)	Rolling	3,310	180	12	do.	Dockum

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
23.28.22.433	38.5	Feb. 8, 1947	1,200	T	I	See analysis, Table 3.
23.133	52.4	Sept. 22, 1947	–	T	I	
23.433	38	–	1,100[1]	T	I	
24.134	52.3	Sept. 22, 1947	1,200	T	I	Depth to water measured while pumping. See analysis, Table 3.
25.213	39.1	Sept. 23, 1947	1,000 R.	T	I	Cased to 70 ft.
29.144	28.7	Sept. 25, 1947	–	N	N	Abandoned (?)
29.411	20.7	Jan. 13, 1948	–	N	I	
23.30.2.440	250.0	Dec. 22, 1948	–	W & G	S	See analysis, Table 3.
6.110	110.0	do.	–	W	S	
6.420	–	–	–	W	S	
21.122	–	–	3	W & G	S	See analysis, Table 3.
23.31.7.220	140	–	10 E.	W	S	Two wells here.

See explanation at beginning of table.
1 Measured Sept. 23, 1947.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
24.21.14.440	Thayer	1935	Pine Canyon	5,525	232	–	Limestone, sandstone (?)	Goat seep, or Cherry Canyon (?)
23.320	do.	1935	do.	5,730	410	8	Limestone, sandstone	Goat seep, or Cherry Canyon
23.340	do.	1931	do.	5,700	371	6	do.	do.
24.22.22.130	–	1949	High plateau	5,650	704	7	do.	do.
30.130	Mr. Thayer	1949	do.	5,840	620	6	Limestone, sandstone (?)	Goat seep, and Cherry Canyon (?)
24.23.6.231	National Livestock Co.	–	Draw	4,375	225	–	Limestone and sandstone	Chalk Bluff
9.120	–	1949	Northwest edge hill	4,500	265	10	do.	do.
24.24.10.222	Gerry Smith	–	Draw	4,050	370	18	Limestone	Capitan (?)
12.123	do.	1938	South Mosely Canyon	4,025	340	8	do.	Capitan
24.25.5.442	H. White	–	Valley	3,790	–	–	Alluvium (?)	Quaternary (?)
5.443	do.	–	do.	3,785	–	–	Alluvium	Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
24.21.14.440	180	–	–	W	S	Water encountered at 230 ft., above black shaly limestone. Water rose 50 ft. Driller: T. Hillyer.
23.320	370	–	–	W & G	D & S	Water encountered at 410 ft., above black shaly limestone. Water rose 40 ft. Driller: T. Hillyer.
23.340	349.0	Nov. 18, 1949	–	N	N	
24.22.22.130	600	–	–	W	S	Water found above black shaly limestone.
30.130	595	–	–	W	S	Water at 614 ft., above black shale. Driller: Donahue.
24.23.6.231	–	–	–	W	S	
9.120	–	–	–	W	S	
24.24.10.222	250	–	–	W	S	Driller: Taylor Grazing.
12.123	27.0	Feb. 24, 1948	–	W	D & S	Driller: Harv. Everets.
24.25.5.442	9.2	do.	–	W	D	Dug well. See analysis, Table 3.
5.443	14.1	do.	–	W	D & S	Dug well.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
24.25.13.241	R. H. Judkin	–	Draw	3,660	12	–	Alluvium	Quaternary
25.130	H. White	–	Base of escarpment	3,600	150	4	Limestone	Capitan
25.413	George Burton	–	Draw	3,525	65 (?)	10	do.	do.
34.221	C. L. White	1946	Top of spur	3,900	1,200	10	do.	do.
34.243	do.	1940	Draw	3,625	1,025	7	do.	do.
24.26.6.322	H. White	–	do.	3,620	100+	6	do.	do.
8.344	do.	–	Hillside	3,500	565	–	do.	do.
23.220	A. J. Crawford	–	Terrace	3,265	–	–	Alluvium	Quaternary
23.242	R. E. Hood	–	do.	3,260	50	8	do.	do.
24.110	do.	–	do.	3,260	74	10	do.	do.
32.123	Bill Foley	–	do.	3,435	200	8	do.	do.
24.27.8.120	–	–	do.	3,190	160	6	do.	do.
24.28.7.231	L. T. Lewis	–	Flat	3,065	–	12	Alluvium (?)	Quaternary (?)
17.231	Carleton & Kraft	–	do.	3,058	265	16	Redbeds, gypsum, limestone (?)	Rustler (?)

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
24.25.13.241	7	–	–	G & E	D & S	Dug well.
25.130	136.4	Jan. 2, 1948	–	W	S	Driller: Curtis.
25.413	53.3	do.	–	W	S	
34.221	800	–	–	E	P	Supplies White's City Auto Court. Driller: Brennenstool.
34.243	500	–	–	N	N	
24.26.6.322	63.4	Feb. 24, 1948	–	N	N	Abandoned (?).
8.344	450 (?)	–	–	N	N	do.
23.220	37.1	Oct. 27, 1947	–	T	I	Driller: D. Smith.
23.242	44.2	do.	400	T	I	Cased to 40 ft. Driller: D. Smith.
24.110	30.5	do.	700	T	I	Cased to 50 ft. Driller: Bond.
32.123	109.4	Dec. 1, 1948	6	W	D & S	
24.27.8.120	65.1	Dec. 26, 1947	–	W	S	
24.28.7.231	18.0	Oct. 22, 1947	–	N	I	
17.231	23.5	do.	–	N	I (?)	Abandoned (?).

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
24.28.25.123	John E. Montgomery	–	Base of hill	2,925	100	6	Alluvium (?)	Quaternary (?)
27.422	Guy A. Reed	–	Southwest	2,975	190	8	Redbeds, gypsum (?)	Castile and Rustler (?)
25.21.10.223	Shattuck	–	Robinson draw	6,050	622	6	Limestone and sandstone	Goat seep (?) and Cherry Canyon (?)
25.310	John McGollum	–	Dark Canyon	6,220	650	6	do.	Goat seep and Cherry Canyon
25.22.6.314	Elmer Hepler	–	Valley	5,805	–	–	Limestone (?)	Goat seep (?)
20.212	Seth McGollum	–	Dark Canyon	5,820	540	6	Limestone	do.
25.23.34.444	Anna Collwell	–	Base of escarpment	4,160	130	6	Alluvium (?)	Quaternary (?)
25.24.31.331	do.	–	Arroyo	3,970	230	7	Alluvium	Quaternary
34.112	H. F. Ballard	–	Near arroyo	3,725	97	6½	do.	do.
25.25.4.144	G. R. Pipkin	–	Near base of escarpment	3,570	–	–	Alluvium or gypsum	Quaternary or Castile
4.424	Paul Beedle	–	Interdraw divide	3,550	48	7	do.	do.
6.343	–	–	Draw	3,625	10	–	Alluvium	Quaternary

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
24.28.25.123	5.0	Oct. 22, 1947	65	C	F	Depth to water measured while pumping. See analysis, Table 3.
27.422	33.2	Mar. 11, 1949	–	U	I	Driller: Donahue.
25.21.10.223	400+	Oct. 18, 1949	–	W	S	Driller: T. Hepler. See analysis, Table 3.
25.310	160	–	–	W	D & S	Water at 644 ft.
25.22.6.314	340	–	–	W	S	
20.212	340	–	–	W & G	D & S	Water at 448 ft.
25.23.34.444	129.3	Jan. 19, 1948	–	W	S	
25.24.31.331	168.2	do.	–	W	D & S	Driller: T. Hillyer.
34.112	73.7	do.	–	W & G	S	
25.25.4.144	53.1	do.	–	W	S	
4.424	36.5	do.	–	W	D	
6.343	9.0	do.	–	W	S	Dug well.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COMPLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED: CHARACTER OF MATERIAL	PRINCIPAL WATER-BEARING BED: GEOLOGIC UNIT
25.25.12.342	R. G. Ozley	—	Draw	3,410	65	4	Alluvium	Quaternary
24.222	—	—	Shallow depression	3,410	—	6	Gypsum (?)	Castile (?)
25.26.7.444	R. G. Ozley	—	Shallow draw	3,340	70±	6	Alluvium (?)	Quaternary
19.111	—	—	Shallow depression	3,410	—	8	Gypsum (?)	Castile (?)
25.27.12.100	—	—	Rolling	3,100	—	5	Gypsum	Castile
25.28.3.222	Chinaberry well	—	Flat	2,990	—	5	Gypsum (?)	Castile or Rustler (?)
5.331	—	—	Shallow draw	3,020	—	—	Gypsum	Castile or Rustler
15.230	J. Leck	—	Hillside	2,960	—	6	do.	do.
18.324	Northwest well	—	Flat	3,035	—	—	do.	do.
29.410	Frank Neymeyer	—	do.	2,970	60	6	Gypsum, alluvium (?)	Castile and Rustler (?) Quaternary (?)
25.29.32.211	Ross Bros.	—	Hillside	2,985	698.5	8	Gypsum	Rustler
25.30.2.000	—	—	Sand dunes	—	—	6	Redbeds	Dockum
9.100	Moore	—	Shallow draw	—	—	6	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL		YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
	BELOW LAND SURFACE (feet)	DATE OF MEASUREMENT				
25.25.12.342	33.1	Dec. 1, 1948	–	W	D & S	
24.222	67.6	Nov. 19, 1949	–	W	S	
25.26.7.444	47.1	Dec. 1, 1948	–	W	N	Abandoned.
19.111	69.9	Nov. 19, 1949	3	W	S	
25.27.12.100	91.7	Dec. 6, 1948	2	W	S	
25.28.3.222	32.3	do.	1	W	S	See analysis, Table 3.
5.331	59.4	do.	–	W	N	Abandoned (?)
15.230	48.9	do.	–	W & G	S	
18.324	66.9	do.	–	W	S	See analysis, Table 3.
29.410	14.9	do.	–	W	S	
25.29.32.211	115.3	Mar. 11, 1949	2	W	S	Plugged at 120 ft. See analysis, Table 3.
25.30.2.000	295+	do.	–	W	S	See analysis, Table 3.
9.100	295+	Mar. 10, 1949	–	W	S	See analysis, Table 3.

See explanation at beginning of table.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
25.30.9.100a	Moore	–	Shallow draw	–	–	6	Redbeds	Dockum
21.330	Mrs. Ross	–	do.	–	280	–	do.	do.
21.330a	do.	–	do.	–	–	6	do.	do.
25.31.21.000	C. T. Ross	–	Rolling	–	420	8	do.	do.
26.24.9.331	Thurman Ranch	–	do.	3,775	–	6	Alluvium	Quaternary
10.240	A. M. Leeman	–	Valley	3,720	100	7	Alluvium (?)	Quaternary (?)
11.314	do.	–	do.	3,730	60	5	Gypsum	Castile
19.431	do.	–	Grapevine draw	3,880	196	8	Alluvium (?)	Quaternary (?)
28.411	do.	–	Flat	3,790	96	6	Alluvium	Quaternary
28.413	do.	–	do.	3,790	90	9	do.	do.
26.25.17.240	C. P. Ranch	–	Slaughter draw	3,720	22	–	Alluvium or gypsum	Quaternary or Castile
26.27.5.440	Parisher well	–	Valley	3,185	–	6	do.	do.
13.442	Hobb's well	–	Shallow draw	3,050	–	6	Gypsum (?)	Castile (?)
26.28.2.112	Queen well	–	Hilly	2,910	–	–	Gypsum	Castile

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
25.30.9.100a	295+	Mar. 10, 1949	–	W	S	
21.330	268.0	do.	3	W	S	Northeast well of two. See analysis, Table 3.
21.330a	–	–	2	W	S	Southwest well of two.
25.31.21.000	290	Dec. 15, 1948	3	W	S	See analysis, Table 3.
26.24.9.331	65.3	Jan. 26, 1948	–	N	N	Abandoned. See analysis, Table 3.
10.240	20	–	10[1]	W	S	Driller: H. M. Curtis.
11.314	21.9	Jan. 22, 1948	5	W	S	See analysis, Table 3.
19.431	57.7	do.	5 R.	W	D & S	
28.411	–	–	–	W	S	North of highway. Driller: H. M. Curtis.
28.413	68.6	Jan. 22, 1948	2	W	S	Driller: Redman. See analysis, Table 3.
26.25.17.240	10.5	Nov. 19, 1949	3	W	S	See analysis, Table 3.
26.27.5.440	12.5	Dec. 3, 1948	3	W	S	
13.442	35+	do.	3	W	S	
26.28.2.112	21.2	Dec. 6, 1948	1½	W	S	Depth to water measured while pumping. See analysis, Table 3.

See explanation at beginning of table.
1 Measured Jan. 22, 1948.

TABLE 1. RECORDS OF WELLS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER OR NAME	DATE COM-PLETED	TOPOGRAPHIC SITUATION	ALTITUDE ABOVE SEA LEVEL (feet)	DEPTH OF WELL (feet)	DIAMETER OF WELL (inches)	PRINCIPAL WATER-BEARING BED	
							CHARACTER OF MATERIAL	GEOLOGIC UNIT
26.28.13.110	Coad tank well	After 1945	Hilly	2,940	–	6	Gypsum	Castile
26.29.16.220	–	1948	do.	2,933	1,028	8	Sandstone	Rustler (?)
26.30.8.110	C. T. Ross	–	Southwest slope	3,080	200	6	Redbeds	Dockum
26.31.1.000	Mrs. Ross	–	Shallow draw	3,265	340	–	do.	do.
8.310	C. T. Ross	1900±	Flat	3,235	338	6	do.	do.
8.310a	do.	–	do.	3,235	–	6	do.	do.

See explanation at beginning of table.

LOCATION NUMBER	WATER LEVEL: BELOW LAND SURFACE (feet)	WATER LEVEL: DATE OF MEASUREMENT	YIELD (g.p.m.)	METHOD OF LIFT	USE OF WATER	REMARKS
26.28.13.110	56.0	Dec. 15, 1948	3	W	S	See analysis, Table 3.
26.29.16.220	125.0	Mar. 11, 1949	–	W	S	
26.30.8.110	172.0	Dec. 15, 1948	3 E.	W	S	Depth to water measured while pumping. See analysis, Table 3.
26.31.1.000	287.7	Mar. 10, 1949	–	W	S	East well of two. See analysis, Table 3.
8.310	250	–	–	W	D & S	See analysis, Table 3.
8.310a	278.5	Mar. 10, 1949	–	N	N	100 ft. southwest of above well.

See explanation at beginning of table.

TABLE 2. RECORDS OF SPRINGS IN EDDY COUNTY, NEW MEXICO

EXPLANATION OF COLUMN HEADINGS

LOCATION NUMBER: See p. 5 for explanation.

YIELD (GALLONS PFR MINUTE): R. after figure indicates reported yield; E. indicates estimated yield; others measured as noted.

USE OF WATER: D, domestic; I, irrigation; P, public supply; S, stock.

LOCATION NUMBER	OWNER	NAME	TOPO-GRAPHIC SITU-ATION	ALTITUDE (feet)	KIND OF ROCK	CHARACTER OF OPENINGS	IMPROVE-MENTS; ACCOMMO-DATIONS	YIELD (g.p.m.)	USE OF WATER
21.24.27.100	—	Indian Big Springs	Rocky Arroyo	3,600	Gravel & conglom-erate	—	Diver-sion ditch	500 to 1,000 E.	I
21.26.25.333[1]	—	Carlsbad Spring	South bank of Pecos	3,105	do.	—	Concrete tank	2,000+ E.	—
22.24.2.320	—	Little Walt Spring	Little Walt Canyon	3,850	Limestone	Seep	—	1 E.	S
22.25.12.120[1]	Frank Jones	McKittrick Springs	Shallow Valley	3,520	Siltstone	Crevice	Diversion ditch	5+ E.	D, S, I
23.25.23.324	—	Yellow Jacket Spring	Draw in hills	3,650	Cavernous limestone	Small cavern	Piped to storage tank	1—[2]	S
23.27.1.400	—	Cass draw Springs	Cass Draw	3,025	Alluvium	Seep	—	450[3]	—
24.22.25.343[1]	—	Dark Canyon headwaters	Dark Canyon	5,050	Gravel & Boulders		Dam and diversion ditch	1,000 E.	D, S, I

1 Chemical analysis in Table 4.

2 Measured Nov. 12, 1947.

3 Measured 1937.

TABLE 2. RECORDS OF SPRINGS IN EDDY COUNTY, NEW MEXICO. (Continued)

LOCATION NUMBER	OWNER	NAME	TOPOGRAPHIC SITUATION	ALTITUDE (feet)	KIND OF ROCK	CHARACTER OF OPENINGS	IMPROVEMENTS; ACCOMMODATIONS	YIELD (g.p.m.)	USE OF WATER
24.25.30.430	Carlsbad Caverns National Park	—	Walnut Canyon	—	Limestone over siltstone	Seep	Bubbler for tourists	2-3 E.	P
24.26.33.122[1]	—	Blue Spring	Shallow draw	3,320	Conglomerate	—	Diversion ditch	2,000+ E.	S, I
25.24.23.343[1]	Carlsbad Caverns National Park	Rattlesnake Springs	Valley	3,635	Alluvium	Seeps	Concrete cistern piped	2,500 E.	P, S
25.25.35.442[1]	W. A. Foley, Jr.	Cottonwood Springs	Cottonwood Draw	3,515	do.	—	—	5 E.	S
26.23.29.332[1]	Mary E. Ussery	X-T Spring	Draw	4,350	do.	Seep	—	50 E.	D, S
26.23.35.121[1]	—	Geyser Spring	do.	4,120	do.	—	—	2,000 E.	D, S, I
26.24.11.122[1]	A. M. Leeman	Bottomless Lakes	Broad Valley	3,710	Gypsum	—	—	1[2]	—
26.24.11.341[1]	do.	—	Hillside	3,800	do.	—	—	¼—[2]	—
26.26.17.443[1]	Dillahunty Ranch	Jumping Springs	Slaughter Draw	3,390	do.	Crevice	—	5 E.	S

1 Chemical analysis in Table 4.
2 Measured Jan. 22, 1948.

TABLE 3. CHEMICAL ANALYSES OF WATER FROM WELLS IN EDDY COUNTY, NEW MEXICO

LOCATION NUMBERS CORRESPOND TO THOSE IN TABLE 1

Analyses by U. S. Geological Survey (Parts per million)

LOCATION NUMBER	DATE OF COLLECTION	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C.)	SILICA (SiO_2)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM AND POTASSIUM (Na+K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	DISSOLVED SOLIDS	TOTAL HARDNESS AS $CaCO_3$	PERCENT SODIUM
16.21.33.200	1-11-50	948	19	109	56	17	190	336	24	–	.5	656	502	7
16.31.2.122	12- 9-48	818	–	78	53	38	158	139	82	–	30	478	330	–
17.24.24.210	1-11-50	571	24	75	27	6	277	59	5	–	19	351	298	4
17.27.11.110	12-21-48	2,880	–	616	118	25	185	1,780	33	–	31	2,690	2,020	–
17.28.14.220	12- 6-48	5,130	–	660	161	393	150	1,810	815	–	8.2	3,920	2,310	–
17.31.34.000	do.	1,330	–	106	41	138	265	423	54	–	.1	893	433	–
18.29.24.300	4-28-50	2,150	25	397	58	43	167	911	110	1.4	98	1,730	1,230	71
19.26.27.233	2-11-44	1,680	–	249	101	20	211	829	30	–	1.5	1.330	1,040	–
19.28.2.122	12-13-48	7,280	–	412	195	987	142	1,300	1,770	–	11	4,740	1,830	–
13.210	4-28-50	4,370	32	234	101	538	202	538	1,010	1.6	18	2,570	1,000	54
18.120	1-20-50	501	32	84	15	7.1	219	78	8	–	18	350	271	5
19.29.13.410a	12-21-48	3,540	–	628	104	171	151	1,820	240	–	11	3,050	1,990	–
20.220	do.	2,460	–	628	35	53	223	1,520	33	–	18	2,400	1,710	–
19.31.28.330	5- 1-50	1,190	23	139	54	56	219	398	55	.9	21	855	569	18
33.110b	do.	3,530	40	504	303	46	191	2,160	60	2.0	136	3,340	2,500	39
20.26.17.330	5-24-49	2,810	–	515	160	24	209	1,660	64	–	6.5	2,530	1,940	3
20.28.28.200	1-20-50	3,460	35	620	124	168	153	1,710	348	3.1	22	3,110	2,060	15
20.29.3.433	4-29-50	2,460	53	656	20	7.6	155	1,490	18	1.3	35	2,360	1,720	1
20.30.3.223	5- 1-50	2,490	44	632	39	24	174	1,540	29	1.1	1.4	2,400	1,740	30
3.424	do.	3,290	71	648	105	90	160	1,670	255	2.9	10	2,930	2,050	9
16.420	do.	3,930	38	636	108	260	114	1,860	380	1.4	33	3,370	2,030	22
20.130	do.	3,560	36	680	68	177	166	1,590	388	1.1	24	3,050	1,980	16
33.440	do.	4,760	33	662	152	348	108	1,960	620	2.0	29	3,860	2,280	25
20.31.13.440	12-22-48	8,070	–	408	626	931	248	4,280	635	–	76	7,080	3,590	–
16.240	do.	4,820	–	132	190	707	301	1,190	785	–	68	3,220	1,110	–

TABLE 3. CHEMICAL ANALYSES OF WATER FROM WELLS IN EDDY COUNTY, NEW MEXICO.– (Cont.)

LOCATION NUMBERS CORRESPOND TO THOSE IN TABLE 1

Analyses by U. S. Geological Survey (Parts per million)

LOCATION NUMBER	DATE OF COLLECTION	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C.)	SILICA (SiO_2)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM AND POTASSIUM (Na+K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	DISSOLVED SOLIDS	TOTAL HARDNESS AS $CaCO_3$	PERCENT SODIUM
21.26.23.133	5-23-49	3,880	–	440	133	296	207	1,300	540	–	4.4	2,820	1,640	28
24.424c	11-25-49	4,440	16	482	188	328	174	1,490	705	–	1.8	3,300	1,980	27
25.142	do.	4,580	18	540	149	397	182	1,660	670	–	1.7	3,530	1,960	31
25.231	do.	4,020	17	472	140	323	187	1,460	555	–	.7	3,060	1,750	29
31.243	do.	986	17	118	56	20	232	330	16	–	17	688	525	8
35.223	5-24-49	3,830	–	442	128	304	204	1,280	550	–	18	2,820	1,630	29
35.343	11-25-49	1,360	14	137	82	46	374	333	90	–	.2	886	679	13
35.441	5-22-49	1,300	–	–	–	–	266	–	122	–	–	–	–	–
21.27.9.330	1-25-50	1,370	31	275	38	.5	229	608	5	.7	17	1,090	842	0
21.28.18.130	1-30-50	6,930	34	574	423	747	237	3,530	642	3.2	15	6,090	3,170	34
21.29.18.130	5- 3-50	6,220	28	694	230	571	110	2,220	1,060	2.6	20	4,880	2,680	–
22.22.20.442	3-16-48	564	–	58	32	18	312	33	13	–	8.6	316	276	–
26.223	3-15-48	775	–	98	43	9.9	342	145	8.5	–	0	473	422	–
22.23.26.413	2- 4-48	3,540	–	600	184	113	152	2,100	129	–	7.7	3,210	2,250	–
27.333	2- 6-48	859	–	98	47	8.7	312	121	50	–	6.5	485	438	–
22.24.7.112	2- 4-48	2,310	–	382	151	8.3	166	1,360	28	–	.5	2,010	1,570	–
22.26.1.144	3-21-50	1,470	–	–	–	–	–	–	149	–	–	–	–	–
1.144c	do.	1,500	–	–	–	–	–	–	154	–	–	–	–	–
3.121	11-25-49	3,880	28	672	151	150	204	1,910	330	–	3.8	3,350	2,300	12
3.214	5-24-49	1,180	–	–	–	–	273	–	102	–	–	–	–	–
4.240	do.	3,810	–	630	212	102	196	2,010	290	–	2.8	3,340	2,440	8
8.110	5-27-49	652	–	44	62	9.9	384	44	10	–	15	374	365	6
35.222	9-15-50	852	–	–	–	–	440	–	23	–	–	–	–	–
22.27.1.210	4-30-50	2,790	39	670	41	35	165	1,510	93	1.7	92	2,560	1,840	–
15.113	4-11-49	5,740	–	562	246	483	220	1,900	920	–	9.1	4,230	2,410	30
18.310	4-18-49	2,420	–	262	95	196	294	795	285	–	.8	1,780	1,040	29
26.331	4-11-49	6,340	–	–	–	–	240	–	1,080	–	–	–	–	–
29.311	do.	3,250	–	340	132	241	183	1,080	445	–	16	2,340	1,390	27

TABLE 3. CHEMICAL ANALYSES OF WATER FROM WELLS IN EDDY COUNTY, NEW MEXICO.– (Cont.)

LOCATION NUMBERS CORRESPOND TO THOSE IN TABLE 1

Analyses by U. S. Geological Survey (Parts per million)

LOCATION NUMBER	DATE OF COLLECTION	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C.)	SILICA (SiO_2)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM AND POTASSIUM (Na+K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	DISSOLVED SOLIDS	TOTAL HARDNESS AS $CaCO_3$	PERCENT SODIUM
22.29.33.240	12-48	2,580	–	230	118	168	272	602	406	–	2.2	1,660	1,060	–
22.30.6.344	5-20-49	29,600	–	1,020	395	5,950	149	2,880	9,920	–	–	20,200	4,170	76
10.310	4-30-50	2,360	33	640	21	2.5	150	1,470	8	.9	27	2,280	1,680	–
30.240	do.	3,490	42	580	222	84	132	2,150	123	2.4	22	3,290	2,360	–
23.22.24.222	3-12-48	989	–	121	52	23	272	272	36	–	10	648	516	–
36.113	3-17-48	553	–	67	33	5.5	320	38	4.5	–	8.0	314	302	–
23.23.16.133	3- 8-48	483	–	48	24	21	223	41	22	–	11	277	218	–
23.27.6.213	4-11-49	1,700	–	180	84	74	203	502	172	–	29	1,140	794	17
14.124	9-26-46	1,820	–	261	57	79	228	555	195	–	22	1,280	886	16
23.28.7.113	4-11-49	5,860	–	–	–	–	235	–	1,010	–	–	–	–	–
20.144	12-16-46	7,770	–	780	203	897	246	2,140	1,620	–	19	5,780	2,780	41
22.433	4-11-49	7,030	–	770	177	720	220	1,860	1,470	–	31	5,140	2,650	37
24.134	do.	5,280	–	–	–	–	212	–	985	–	–	–	–	–
23.30.2.440	4-30-50	4,780	31	604	146	437	114	2,150	510	1.8	2.4	3,940	2,110	–
21.122	12-48	5,080	–	624	168	473	160	2,160	620	–	27	4,150	2,250	–
23.31.7.220	do.	4,090	–	554	199	201	266	1,560	410	–	271	3,830	2,200	–
24.25.5.442	5- 1-49	893	–	–	–	–	417	–	24	–	–	–	–	–
24.28.25.123	2-10-48	36,500	–	1,140	461	3,970	36	3,780	6,670	–	–	16,000	4,740	–
25.21.10.223	5- 2-48	709	–	39	24	102	457	26	10	.4	2.5	429	196	–
25.28.3.222	12- 6-48	2,480	–	636	55	10	187	1,550	11	–	19	2,360	1,810	–
18.324	do.	2,810	–	404	211	55	262	1,640	46	–	8.8	2,490	1,880	–
25.29.32.211	5- 1-49	26,900	–	1,100	326	4,920	101	1,450	9,360	–	–	17,200	4,080	72
25.30.2.000	do.	843	–	86	31	47	175	177	78	–	6.8	512	342	23
9.100	do.	2,680	–	536	102	59	89	1,710	22	–	.9	2,470	1,760	7
21.330	do.	1,990	–	132	46	220	160	339	360	–	6.8	1,180	518	48
25.31.21.000	12-48	1,940	–	205	67	161	137	837	106	–	5.8	1,450	787	–

TABLE 3. CHEMICAL ANALYSES OF WATER FROM WELLS IN EDDY COUNTY, NEW MEXICO.– (Cont.)

LOCATION NUMBERS CORRESPOND TO THOSE IN TABLE 1

Analyses by U. S. Geological Survey (Parts per million)

LOCATION NUMBER	DATE OF COLLECTION	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C.)	SILICA (SiO_2)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM AND POTASSIUM (Na+K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	DISSOLVED SOLIDS	TOTAL HARDNESS AS $CaCO_3$	PERCENT SODIUM
26.24.9.331	1-26-48	1,520	–	232	83	14	296	647	14	–	18	1,150	920	–
11.314	1-22-48	2,540	–	638	53	5.8	215	1,560	11	–	8.7	2,380	1,810	–
28.413	1-28-48	653	–	84	36	3.7	252	134	8.0	–	10	400	358	–
26.25.17.240	11-25-49	2,540	24	624	57	8.7	165	1,570	21	–	14	2,400	1,790	1
26.28.2.112	12- 6-48	6,390	–	612	250	695	189	2,510	915	–	9.1	5,080	2,560	–
13.110	12-48	1,820	–	428	27	8.5	179	982	10	–	18	1,560	1,180	–
26.30.8.110	do.	1,110	–	81	32	109	200	199	141	–	1.7	662	334	–
26.31.1.000	5- 1-49	3,810	–	410	121	366	109	1,500	470	–	2.1	2,920	1,520	34
8.310	12-48	613	–	51	18	58	188	135	17	–	11	383	201	–

TABLE 4. CHEMICAL ANALYSES OF WATER FROM SPRINGS IN EDDY COUNTY, NEW MEXICO

LOCATION NUMBERS TO CORRESPOND TO THOSE IN TABLE 2.

Analyses by U. S. Geological Survey (Parts per million)

LOCATION NUMBER	DATE OF COLLECTION	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C.)	SILICA (SiO_2)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM AND POTASSIUM (Na+K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	DISSOLVED SOLIDS	TOTAL HARDNESS AS $CaCO_3$	PER CENT SODIUM
21.26.25.333	5-21-49	4,680	–	–	–	–	191	720	–	–	–	–	–	–
22.25.12.120	5-27-49	548	–	63	35	10	302	33	6	–	2.4	288	301	0
24.22.25.343	5- 1-49	575	–	56	48	10	345	39	5	–	.8	319	337	–
24.26.33.122	10-27-47	1,300	–	258	37	9.7	238	580	10	.1	3.9	1,020	796	–
25.24.23.343	1-26-48	651	–	99	28	4.1	287	120	6	–	2.8	401	362	–
25.25.35.442	11-25-49	2,770	17	672	75	21	135	1,810	26	–	.5	2,690	1,980	2
26.23.29.332	1-26-48	541	–	70	27	10	314	17	3	–	2.7	274	286	–
35.121	do.	480	–	65	23	5.5	299	15	4.0	–	3.0	263	256	–
26.24.11.122	1-22-48	2,540	–	640	56	3.0	238	1,560	10	–	1.1	2,390	1,830	–
11.341	do.	2,520	–	–	–	–	197	–	–	–	–	–	–	–
26.26.17.443	11-25-49	2,510	29	636	43	17	143	1,570	24	–	18	2,410	1,760	2

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