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WATER RESOURCES OF WARD COUNTY, TEXAS

By

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WATER RESOURCES OF WARD COUNTY, TEXAS

ABSTRACT

Ward County is an area of 827 square miles in the Pecos River Valley of West Texas. The county consists primarily of rolling uplands which are devoted largely to ranching. The Pecos River borders the county on the south and west. The flood plain and terraces along the river are extensively cultivated and irrigated.

During 1967, pumpage of ground water from three aquifers in the county totaled 34,400 acre-feet. Of this amount, 22,600 acre-feet was from the Allurosa aquifer; 2,300 acre-feet was from the Rustler Formation; and 9,500 acre-feet was from the Capitan Limestone. Most of the pumpage, about 20,400 acre-feet, was for industry; and the principal use, 14,600 acre-feet, was for waterflooding oil fields in Ward and adjoining counties.

Water for irrigation is supplied both by pumping wells and diverting flow from the Pecos River. In 1967, pumpage for irrigation was 9,200 acre-feet. During the water year 1967, the three irrigation districts in the county diverted 75,510 acre-feet for irrigation of 9,740 acres. Less than 35,000 acre-feet was actually applied on the cropland, and more than one-half of the water diverted was lost to seepage from canals.

Pumpage for the six cities in Ward County and the city of Pecos in Reeves County was 4,698 acre-feet in 1967. Most of the public-supply wells tap alluvial deposits in the Monument Draw trough which contains most of the fresh water in the county.

Natural recharge to the Allurosa aquifer is estimated to be about 12,000 acre-feet per year. About 45,000 acre-feet was also added to the aquifer in 1967 by seepage from irrigation canals and deep percolation losses from irrigated fields. Natural discharge by transpiration of vegetation along the Pecos River is estimated at 40,000 acre-feet, or about three times the amount of natural recharge.

The quality of the water in the Allurosa aquifer ranges from fresh to brine. Potable water in this aquifer is confined largely to the eastern half of the county. Water in the Capitan reef and locally in the Rustler Formation is suitable for irrigation and limited industrial use.

Additional development of the Allurosa aquifer is anticipated, with most of the water being obtained from the 10 million acre-feet that is estimated to be in storage. However, a large part of the water in storage is too highly mineralized for drinking purposes and can be used only to irrigate the more salt-tolerant crops. Contamination of the water in the Allurosa aquifer by disposal of oil-field brines in unlined surface pits also may reduce the amount of water that can be developed for purposes other than waterflooding.

INTRODUCTION

Purpose and Scope of the Investigation

The investigation of the water resources of Ward County began in the spring of 1967 as a cooperative project of the U.S. Geological Survey and the Texas Water Development Board. The purpose of the investigation was to determine and evaluate the water resources of the county. The results of the investigation are presented in this report, which includes an analytical discussion of the occurrence and availability of the ground-water and surface-water supplies, together with a tabulation of basic data obtained during the investigation.

The scope of the investigation encompassed the collection, compilation, and analysis of data related to ground and surface water, including a determination of the location and extent of the water-bearing formations, the chemical quality of water they contain, the quantity of ground water being withdrawn, and the effects of these withdrawals on the water levels; the hydraulic properties of the principal water-bearing formations; estimates of the quantities of ground water available for development; and the availability and quality of surface-water supply.

Methods of Investigation

The following methods of investigation were used during the investigation:

1. All moderate to large capacity wells and a representative number of small capacity wells (a total of 662 wells) were inventoried. Records of wells are shown in Table 6; locations of wells are shown on Figure 24.

2. Electrical, radioactivity, and drillers' logs were collected for correlation and evaluation of subsurface characteristics of the aquifers. Maps showing the depth to and the altitude of the base of the Allurosa aquifer (Figure 9) and top of the Rustler Formation (Figure 7) were drawn. Seven geologic sections were constructed (Figures 25 through 31).

3. The quantities of ground water used for public supply, industry, and irrigation were inventoried. Quantities of water used for domestic supply and livestock were estimated. The quantity of surface water used in the county was compiled from U.S. Geological Survey surface-water records.

4. A map was prepared showing the areas of major ground-water withdrawals from the Allurosa aquifer and locations of surface-water diversions (Figure 17).

5. The results of six aquifer tests (Table 2) and 95 drawdown or recovery tests (Table 3) were used to evaluate the hydraulic characteristics of the aquifers.

6. Water levels in wells were measured and available records of past fluctuations of water levels were compiled (Tables 6 and 7 and Figure 18).

7. A map showing depth to water and altitude of water levels in wells tapping the Allurosa aquifer was constructed (Figure 11).

8. Climatological records were collected (Figures 2, 3, and 4).

9. Chemical analyses of water samples collected from wells during the present and previous investigations (a total of 620 analyses) were compiled (Table 8), and a map showing water quality in the aquifers was prepared (Figure 20).

10. A map showing the specific conductance and the concentration of sulfate and chloride in water from wells tapping the Allurosa aquifer and a graph showing the relation of dissolved solids to specific conductance of water from wells and salt-water disposal pits were prepared (Figure 21).

11. Chemical analyses of oil-field brines (Table 9) and reported 1961 and 1967 oil-field brine production and disposal data were compiled (Table 5).

12. A map was drawn showing areas of oil-field brine production and disposal, locations of sampled disposal pits, and contaminated water wells (Figure 23).

13. The hydrologic data were analyzed to determine the quantity and quality of ground water available for development.

Location and Extent of the Area

Ward County is an area of 827 square miles in the Pecos River Valley of West Texas (Figure 1). It is bordered by Loving, Winkler, and Ector Counties on the north, Crane County on the east, and Pecos and Reeves Counties on the south and west. Monahans, the largest town and county seat, is 55 miles southwest of Midland. The estimated populations in 1967 were: Ward County, 12,927; Barstow, 789; Grandfalls, 981; Monahans, 9,476; Pyote, 315; Royalty, 196; and Wickett, 831.

Figure 1.—Location of Ward County

Previous Investigations

The water resources of Ward County were first studied in 1939-40 as part of a joint investigation of the Pecos River basin in New Mexico and Texas by federal and state agencies (U.S. National Resources Planning Board, 1942 and 1942a).

The development of ground water for irrigation in the Pecos-Barstow area in Reeves and Ward Counties during the years 1947-51 was summarized by Hood and Knowles (1952). Ogilbee, Wesselman, and Irelan (1962) included the southwestern part of Ward County in their study of the ground-water resources of Reeves County.

Follett (1954) compiled records of water-level measurements in observation wells in Ward County. As of January 1, 1970, water levels in 25 wells in the county were being measured annually as part of the Texas Water Development Board's observation well program.

A reconnaissance report by Brown and others (1965) provides a generalized evaluation of the ground-water conditions in the Rio Grande basin in Texas, which includes Ward County and most of the adjacent counties.

The water supplies of Barstow, Grandfalls, and Monahans were described by Broadhurst, Sundstrom, and Weaver (1951) in their inventory of the public water supplies of 81 counties in West Texas.

Reports on the ground-water resources of areas adjacent to Ward County are, by county: Crane (Shafer, 1956); Ector (Knowles, 1952); Pecos (Armstrong and McMillion, 1961); Reeves (Knowles and Lang, 1947; Ogilbee, Wesselman, and Irelan, 1962); and Winkler (Garza and Wesselman, 1959).

The geologic formations in Ward County were described by Sellards and others (1932) and Jones (1953). A "Bibliography of Permian Basin geology, west Texas and southeastern New Mexico," published by the West Texas Geological Society in 1967, lists the numerous papers pertaining to the regional geology.

Economic Development

The economy of Ward County is dependent largely upon the production of oil and gas and the irrigation of cropland, but is also supported by income from ranching and the mining of sodium sulfate and sodium chloride brines. The water resources of the county are basic to the economy. All water used for public supply, industry, and domestic supply is pumped from wells. Water for irrigation is supplied by diversion of flow from the Pecos River and from pumping of wells.

Water was instrumental in the founding of the first settlement in Ward County. In 1881, John Thomas Monahan, a surveyor for the Texas and Pacific Railroad, dug and curbed "two natural holes of milky but splendid water in the sands" (Haley and Milton, 1949). The railroad was constructed across the county in the same year, and the town of Trueheart, later renamed Monahans, was established at Monahan's wells.

Irrigation of cropland in the county began in the late 1880's. By 1914, about 16,000 acres were irrigated from canals supplying four projects: the Barstow project, organized in 1888; the Grandfalls project, organized in 1890; the Big Valley project, constructed in 1906 and later incorporated with the Grandfalls project; and the Cedarvale project, organized in 1906 (U.S. National Resources Planning Board, 1942). The Barstow, Grandfalls, and Cedarvale projects were subsequently reorganized as Ward County Irrigation District No. 1, and Ward County Water Improvement Districts Nos. 2 and 3, in respective order.

Irrigation from wells started in the vicinity of Barstow shortly after 1900. However, most of the wells in use have been drilled since the end of World War II.

In 1967, 12,760 acres were irrigated in the county. Of this amount, 9,740 acres were irrigated in the districts with surface water, and 3,020 acres were

irrigated from wells both within and outside the districts. The principal crops are cotton, alfalfa, oats, barley, grain, forage sorghum, and pasture grasses.

The discovery of oil in the county on November 2, 1928, was of major importance to the economy. Since that date, nearly 400 million barrels of oil have been produced. In 1966, production of oil and gas amounted to 23.4 million barrels and 20 billion cubic-feet, respectively (Railroad Commission of Texas, 1967). Secondary recovery of oil by the waterflood process, initiated in the county in 1948, has greatly increased oil production but has also put increased demand upon the ground-water resources of the county.

Topography and Drainage

Ward County is in the Pecos Valley section of the Great Plains physiographic province (Fenneman, 1931). More than three-fourths of the surface of the county is rolling uplands. The uplands, which are mantled by caliche and thin sandy soils, are sparsely vegetated with semidesert shrubs and grasses and are devoted largely to ranching. The uplands slope toward the Pecos River and merge with the terraces or lowlands that border the river. The terraces are mantled by fine- to medium-textured gypsiferous soils that are extensively cultivated in the Barstow and Grandfalls areas. The slope of the terraces, which is to the southeast nearly parallel to the river, ranges from 6 to 8 feet per mile.

A belt of sand dunes, which covers about 50 square miles in northeastern Ward County, is one of the more prominent topographic features of the uplands. In the Monahans Sandhills State Park, near the northeastern corner of the county, the high migrating dunes rise as much as 50 feet above the surrounding land surface. The belt of dunes is a regional feature that extends southeastward from the southeastern corner of New Mexico through parts of Andrews, Winkler, Ward, Ector, Crane, and Upton Counties. Because of the lack of vegetation and the high permeability of the sand, the dunes are an important site of recharge of the underlying ground-water reservoir.

The most prominent feature in western Ward County is the southwest-facing Quito Escarpment that rises 100 to 300 feet above the lowlands bordering the Pecos River to the southwest. The rim of the escarpment forms a topographic divide that extends southeastward from Loving County through Ward County, terminating about 10 miles south of Pyote. Locally, resistant beds of ledge-forming sandstone are exposed in the face of the escarpment below the divide. In other areas, the divide is completely mantled with alluvium and is not easily recognized.

All of Ward County is in the drainage basin of the Pecos River which flows southeastward along the western and southern borders of the county. Surface drainage in the county is largely closed. After periods of heavy precipitation, runoff collects in the swales, sinks, and playas on the upland surface where most of the water is subsequently lost to evapotranspiration. Runoff to the Pecos River by way of the ephemeral streams or draws is small or negligible.

Climate

The climate of Ward County is semiarid and is characterized by a wide range in temperatures and a high rate of evaporation.

The records of the U.S. Weather Bureau at Pecos in Reeves County, which date from 1934, provide the most complete climatological data for Ward County and adjacent areas.

Annual precipitation at Pecos during the period 1935 through 1967 (Figure 2) averaged 9.06 inches. The period maximum, 21.04 inches, occurred in 1941; the period minimum, 2.36 inches, occurred in 1956. Normally about 75 percent of the annual precipitation falls in the 6-month period from May through October (Figure 3). The highest recorded precipitation for one month was 7.41 inches in August 1966.

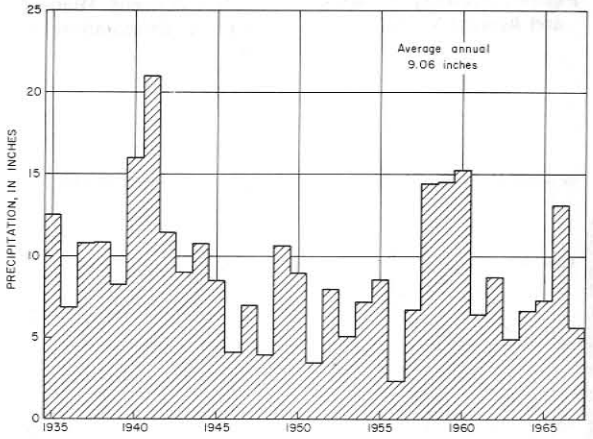


Figure 2.—Annual Precipitation at Pecos, 1935-67

The average annual gross lake-surface evaporation for Ward County is about 84 inches (Kane, 1967), or more than 9 times the average annual precipitation. The evaporation rates are highest during the summer when the soil moisture demand of plants is also large (Figure 3).

For the period 1935 through 1960, the average monthly temperature at Pecos ranged from 44.4°F (6.9°C) in January to 84.1°F (28.9°C) in July (Figure 4). The average daily minimum temperature in January was 27.9°F (-2.3°C); and the recorded extremes were -5°F (-21°C) and 116°F (47°C).

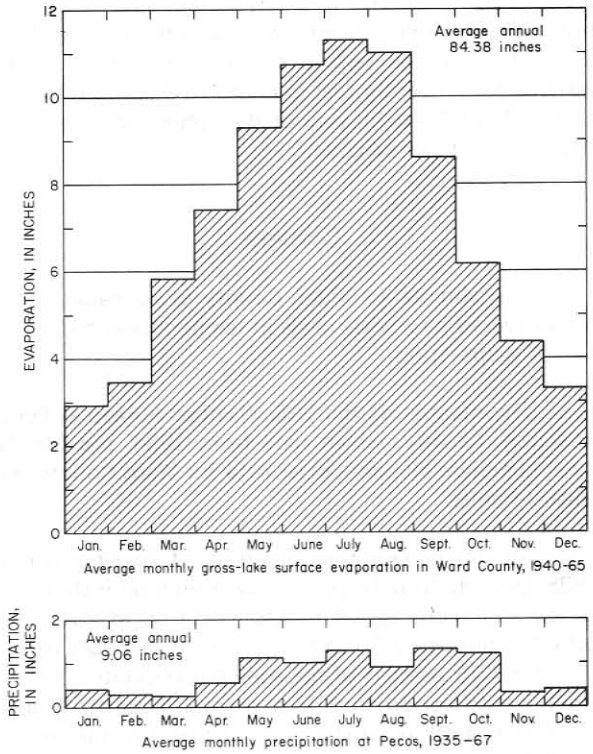


Figure 3.—Average Monthly Precipitation at Pecos 1935-67 and Average Monthly Gross Lake-Surface Evaporation in Ward County

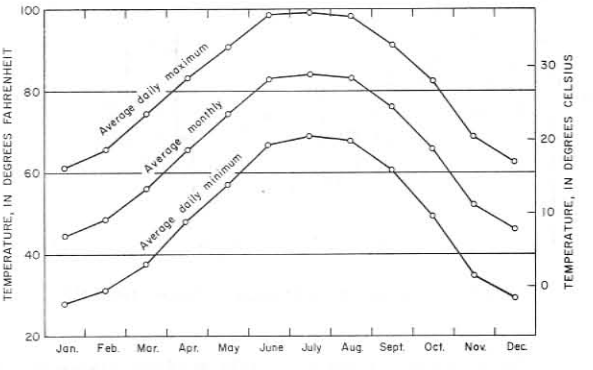


Figure 4.—Average Monthly and Average Daily Maximum and Minimum Temperatures at Pecos, 1935-60

The growing season is about 223 days. The approximate dates for the last and first killing frosts are April 1 and November 10, respectively.

Well-Numbering System

The well-numbering system used in this report was adopted by the Texas Water Development Board for use throughout the State (Figure 5). Under this system, each 1-degree quadrangle in the State is given a number consisting of two digits; Ward County includes parts of quadrangles 45 and 46. These are the first two digits in the well number. Each 1-degree quadrangle is divided into 7½-minute quadrangles which are given 2-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each 7½-minute quadrangle is subdivided into 2½-minute quadrangles given a single digit number from 1 to 9. This is the fifth digit of the well number. Finally, each well within a 2½-minute quadrangle is given a 2-digit number in the order in which it was inventoried, starting with 01. These are the last two digits of the well number.

In addition to the seven-digit number, a two-letter prefix is used to designate the county. The prefixes for Ward and adjacent counties are as follows:

COUNTY	PREFIX	COUNTY	PREFIX
Crane	HH	Reeves	WD
Ector	JH	Ward	YX
Loving	SL	Winkler	ZP
Pecos	US		

Thus, well YX-46-29-601, which is owned by the J. C. Dunagan Estate, is in Ward County (YX), in the 1-degree quadrangle 46, in the 7½-minute quadrangle 29, in the 2½-minute quadrangle 6, and was the first well (01) inventoried in that 2½-minute quadrangle (Figure 5).

Acknowledgments

The author is indebted to many ranchers, farmers, and oil company personnel for supplying information about their wells and permitting access to their properties; to the well drillers for logs and other information about water wells; to the local utility companies for power-consumption data; and to the water superintendents of the cities of Grandfalls, Monahans, Pecos, Pyote, and Wickett for data on wells and municipal pumpage.

Considerable information about ground-water conditions in the Monahans and Monument Draw areas was furnished by the Texas Electric Service Company. The Layne-Texas Company and Ed L. Reed, consulting hydrologist, Midland, provided data for two pumping tests included in Table 2.

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

General Stratigraphy and Structure

The geologic units discussed in this report range in age from Permian to Holocene. The thickness, lithology, and water-bearing properties of these units are discussed

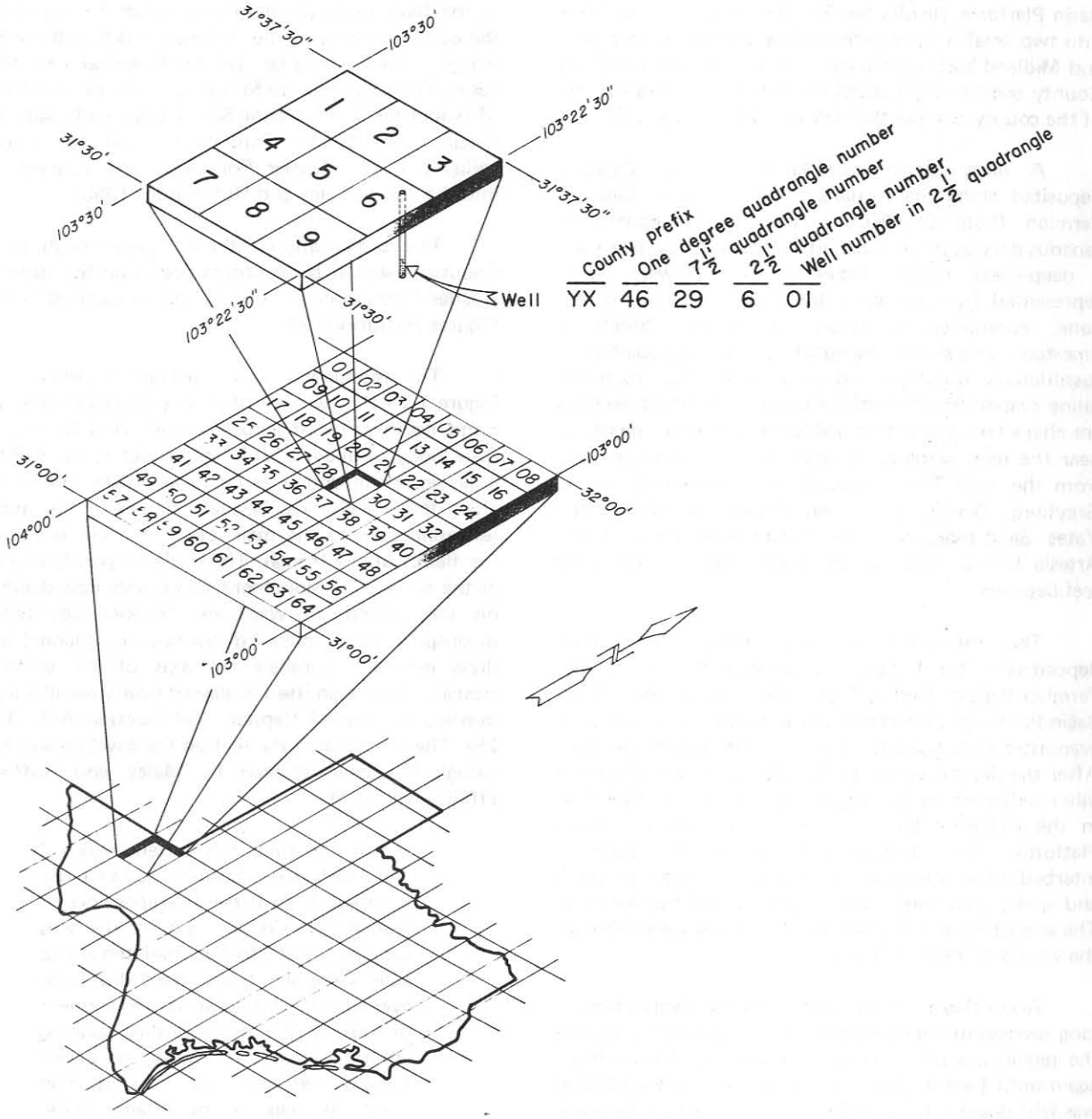


Figure 5

Well-Numbering System

in detail in the following section and are summarized in Table 1. The areal extent of the units (outcrops) and the locations of selected wells are shown on Figure 24; the subsurface relationships of the units are shown by geologic sections A-A', B-B', C-C', D-D', E-E', F-F', and G-G (Figures 25 through 31).

A southward-trending structural high, the Central Basin Platform, divides the Permian Basin of west Texas into two smaller basins—the Delaware basin on the west and Midland basin on the east. The eastern third of Ward County overlies the Central Basin Platform, and the rest of the county overlies the Delaware basin (Figure 6).

A large barrier reef known as the Capitan, deposited along the margins of the Delaware basin in Permian (Late Guadalupe) time, caused contemporaneous deposition of three different sequences of rocks: a deep-water marine facies in the Delaware basin, represented by sandstone, shale, and limestone; a reef zone, represented by massive crystalline dolomite or limestone; and shelf or lagoonal deposits, represented by fossiliferous limestone and shale, dolomitic limestone, saline evaporites, and onshore clastics. The shelf deposits are characteristically thin-bedded dolomite or limestone near the reef, grading into evaporites and clastics away from the reef. These deposits are represented by the Grayburg, Queen, and Seven Rivers Formations; the Yates Sandstone; and the Tansill Formation of the Artesia Group. The Capitan Limestone represents the reef deposits.

The formations of the Ochoa Series were deposited in the Delaware basin near the end of the Permian Period. During Castile time, while the Central Basin Platform was slightly above sea level, a sequence of evaporites was deposited on the basin side of the reef. After the deposition of the Castile Formation, the more saline sediments of the Salado Formation were deposited in the Delaware basin and across the Central Basin Platform. This widespread deposition of evaporites, interbedded at intervals with limestone, dolomite, sand, and shale, continued through Salado and Rustler time. The evaporites are overlain by the Dewey Lake redbeds, the youngest rocks of the Ochoa Series.

According to King (1942), "After Ochoa time, a long interval of nondeposition ensued in west Texas, and the region was probably land. Deposition did not begin again until Late Triassic time, when the Dockum Group was laid down." In Ward County, the Dockum Group is represented by the terrestrial deposits of the Tecovas Formation, the Santa Rosa Sandstone, and the Chinle Formation equivalent.

The "basal sandstone" of the Cretaceous System has been recognized along the rim of Quito Escarpment 10 miles north of Barstow. Elsewhere in Ward County, rocks of Cretaceous age have not been identified either at the surface or in the subsurface. Because the Cretaceous rocks have small areal extent and do not contribute to the water resources of the county, they are not shown on the geologic map (Figure 24) and are not discussed in succeeding sections of this report.

During the Cenozoic Era, which was primarily one of erosion of the older rocks, a thick sequence of alluvial deposits accumulated in two large slumpage depressions in Ward County. These depressions are herein referred to as the Monument Draw trough, which developed along the eastern margin of the Delaware basin, and the Pecos trough, which occupies the south-central part of the basin. The troughs were formed by solution and removal of evaporites in the Ochoa Series, principally salts in the Castile and Salado Formations, and the resultant collapse of the Rustler Formation and younger rocks into the voids (Maley and Huffington, 1953).

The configuration of the slumpage troughs in Ward County is shown by contours drawn on the top of the Rustler Formation (Figure 7) and in sectional view by Figures 25 through 29.

The Monument Draw trough is delineated on Figure 7 by the two sets of closely spaced contours that trend northwestward across central Ward County. The main body of alluvial fill in the trough is about 8 to 12 miles in width and is as much as 1,000 feet in depth along the trough axis. Several tongues of fill, more or less connected to the main body, occupy local sags in the flanks of the trough. The trough is poorly expressed at the surface by Monument Draw, a shallow depression on the uplands of Ward and Winkler Counties. An inconspicuous, in places discontinuous, channel in the draw generally parallels the axis of the underlying trough. The trough itself is aligned nearly parallel to, and overlies the buried Capitan reef (section A-A', Figure 25). The influence of the reef on the development of the trough has been studied by Maley and Huffington (1953), who wrote:

> "...at the time this eastern area (of the Delaware basin) permanently emerged from beneath epicontinental seas in Late Cretaceous time, the beds overlying the Capitan Reef tended to have some slight basinward dip, however small. This basinward increment of dip caused downward-percolating ground waters to move westward toward and over the Capitan Reef front. As suggested by Adams (1944, p. 1623), probable slight warping over the Capitan Reef tended to open fractures in the overlying bedrock by which water could gain access to the evaporite section. The exceptionally thick salt deposits encountered in the reef vicinity were readily soluble in the apparently unsaturated waters. With a gradually accelerated rate of solution due to concentration of subsurface

Table 1.—Geologic Units and Their Water-Bearing Characteristics

ERA	SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	APPROXIMATE MAXIMUM THICKNESS (FT)	CHARACTER OF ROCKS	WATER-BEARING CHARACTERISTICS
Cenozoic	Quaternary			Dune sand	100	Windblown silt and sand.	Principally a recharge facility for underlying formations. Supplies small quantities of fresh water to pits and shallow wells. Uppermost unit in the Allurosa aquifer.
	Quaternary and Tertiary			Alluvium	1,050	Clay, sand, gravel, and caliche.	Yields small to large quantities of fresh to very saline water, and locally brine. Principal unit in the Allurosa aquifer.
Mesozoic	Triassic		Dockum	Chinle Formation equivalent	220	Brick-red to maroon and purple shale and lenticular beds of fine-grained red or gray sandstone.	Yields small quantities of fresh to slightly saline water to a few wells in the eastern part of Ward County.
				Santa Rosa Sandstone	520	Reddish-brown to gray, medium to coarse-grained micaceous well-cemented sandstone interbedded with red shale and siltstone.	Yields small quantities of fresh to slightly saline water to wells on a structural high that crosses the western half of Ward County. Basal unit in the Allurosa aquifer.
Paleozoic	Permian	Ochoa		Tecovas Formation and Dewey Lake Redbeds, undifferentiated	760	Red shale, siltstone, and very fine-grained sandstone with gypsum and anhydrite cement in the lower part.	Known to yield water to only one well in Ward County.
				Rustler Formation	500	Anhydrite and dolomite with a basal zone of shale. Locally contains minor amounts of salt and limestone.	Yields moderate to large quantities of moderately to very saline water.
				Salado Formation	1,700	Mostly salt (halite), subordinate amounts of anhydrite, sylvite, and polyhalite.	Water is injected into the formation for recovery of brine used to drill oil and gas wells. Otherwise not known to yield water to wells in Ward County.
				Castile Formation	2,300	Calcareous anhydrite, halite, and minor amounts of sandstone.	Not known to yield water to wells in Ward County.
		Guadalupe	Artesia (Delaware Group in basin)	Capitan Limestone[1/] — Tansill Formation	200	Mostly dolomite near the Capitan reef, but grades to anhydrite and salt away from the reef.	Do.
				Capitan Limestone[1/] — Yates Sandstone	300	Gray and red sandstone, a few thin beds of dolomite, and red and gray shale.	Yields very saline water and brine in conjunction with oil production.
				Capitan Limestone[1/] — Seven Rivers Formation	300	Anhydrite, dolomite, and minor amounts of sandstone and shale.	Yields small to moderate quantities of moderately saline water from flowing oil wells adjacent to the Capitan reef.
				Capitan Limestone[1/] — Queen Formation	450	Red and gray sandstone interbedded with dolomite and anhydrite.	Yields small amounts of brine from oil wells in the Shipley (Queen) Field east of Royalty.
				Capitan Limestone[1/] — Grayburg Formation	400	Tan and brown dolomite, sandy dolomite interbedded with fine- to medium-grained sandstone.	Yields small quantities of moderately to very saline water to oil wells in southeastern Ward County.

1/ The Capitan Limestone (reef facies) has an approximate maximum thickness of 2,000 feet and consists mainly of porous limestone and dolomite, bedded limestone, and reef talus. The formation yields large quantities of moderately to very saline water to wells in Ward County.

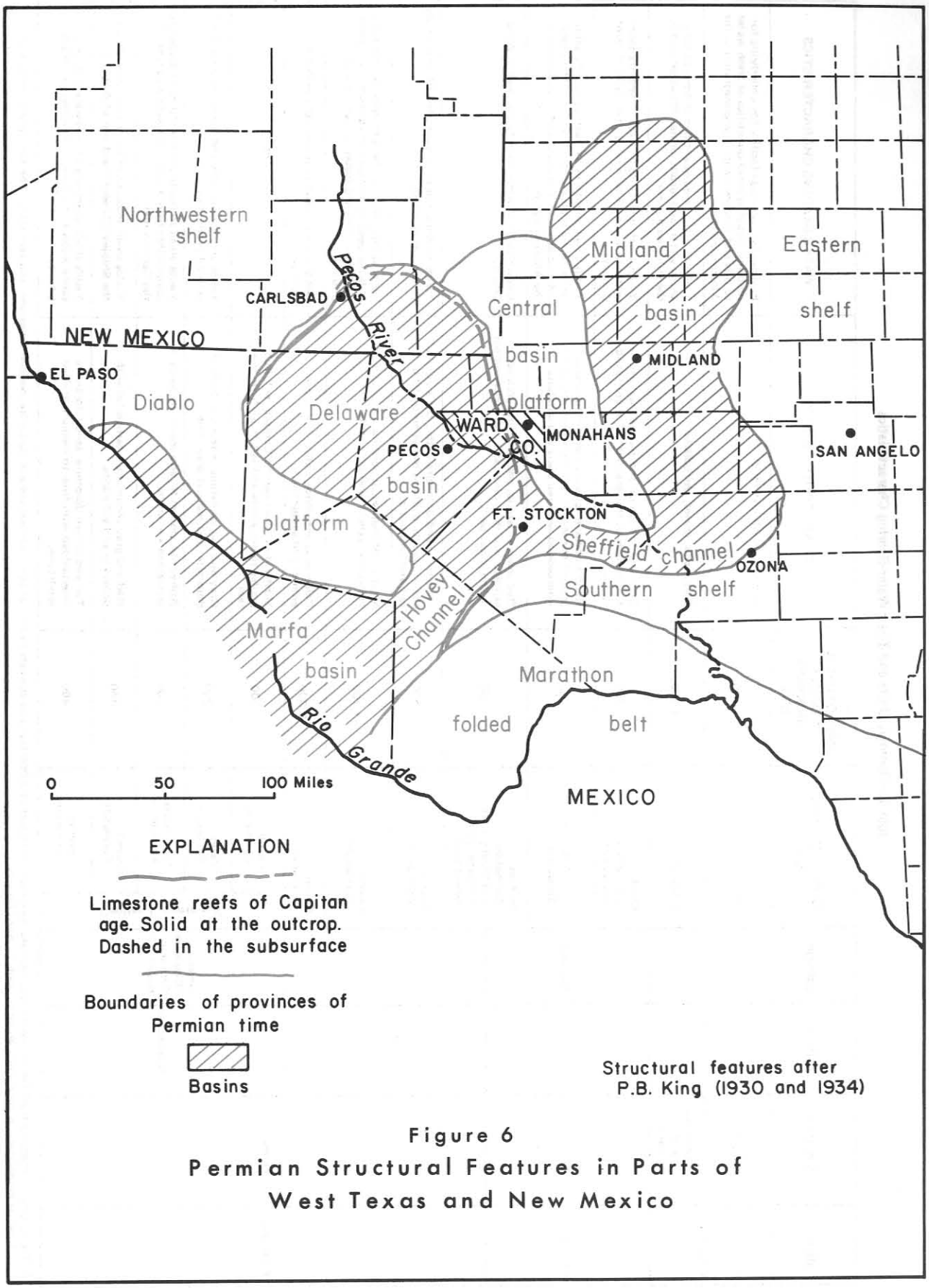


Figure 6

Permian Structural Features in Parts of West Texas and New Mexico

drainage, increased amounts of salt were removed, until today there is little or no salt remaining in this narrow belt."

The Pecos trough, separated from the Monument Draw trough to the east by a structural high, underlies western Ward County and extends north to Orla, west to Toyah, and south to Balmorhea in Reeves County. Measured from its eastern rim near Barstow to its western rim near Toyah, the trough is about 30 miles wide; and measured along its north-south axis, the trough is about 75 miles long (Ogilbee, Wesselman, and Irelan, 1962).

The pronounced deformation of the Rustler Formation along the sides of the slumpage troughs in Ward County indicates that faulting has likely occurred. Because the mapping of fault traces was beyond the scope of this report, faults are not shown on the geologic sections and structural maps, which portray only the broad aspects of the present structural trends.

Physical Characteristics and Water-Bearing Properties of the Geologic Units

In the description of the water-bearing properties of geologic units, the yields of wells are described according to the following rating:

DESCRIPTION	YIELD (GALLONS PER MINUTE)
Small	Less than 50
Moderate	50 to 500
Large	More than 500

In general, the chemical quality of the water is classified according to the following:

DESCRIPTION	DISSOLVED-SOLIDS CONTENT (MILLIGRAMS PER LITER)
Fresh	Less than 1,000
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

Permian System

Guadalupe Series

In the following discussion of formations in the Guadalupe Series, only the Capitan Limestone and its shelf or back-reef equivalents in the Artesia Group are considered. The fore-reef or basin equivalents in the Delaware Mountain Group, which yield small amounts of brine in conjunction with oil production (Table 9) are not discussed.

Capitan Limestone

The Capitan Limestone, deposited as a reef during Late Guadalupe time, consists of massive, porous limestone and dolomite, bedded limestone, and reef talus. The reef trends north and slightly west through Ward and Winkler Counties into southeastern New Mexico (Figure 6). In Ward County, the reef is approximately 2,000 feet thick and 7 to 10 miles wide; the depth to the crest is about 3,000 feet. The reef interfingers with rocks in the Delaware Mountain Group to the west and rocks in the Artesia Group to the east.

The Capitan Limestone yields large quantities of moderately to very saline water to wells in Ward County. The water is used for secondary recovery of oil in Ward, Crane, and Upton Counties.

Artesia Group

The Artesia Group [Whitehorse Group in previous reports on Pecos County (Armstrong and McMillion, 1961) and Winkler County (Garza and Wesselman, 1959)], the back-reef equivalent of the Capitan Limestone, is divided into five formations—the Grayburg, Queen, Seven Rivers, Yates, and Tansill, in ascending order. On the margin of the reef, the group is composed of dolomite, sandy dolomite, and interbedded sandstone; shelfward the dolomite grades into anhydrite and salt.

Grayburg Formation.—The Grayburg Formation, which is about 400 feet thick, is the lowest unit in the Artesia Group. It consists mostly of tan and brown dolomite, but also contains sandy dolomite interbedded with fine- to medium-grained sandstone; subordinate amounts of anhydrite and bentonite are present. Depths to the top of the formation range from 2,800 to 3,500 feet.

The Grayburg yields small quantities of moderately to very saline water in conjunction with oil production in southeastern Ward County. Moderate quantities of saline water could probably be obtained from wells drilled to the Grayburg near the reef.

Queen Formation.—The Queen Formation, which is approximately 450 feet thick, consists of red and gray sandstone interbedded with dolomite and anhydrite.

The Queen Formation yields small amounts of brine from oil wells in the Shipley (Queen) field east of Royalty.

Seven Rivers Formation.—The Seven Rivers Formation, which is about 300 feet thick, consists of anhydrite, dolomite, and minor amounts of sandstone and shale. Toward the reef, the dolomite content increases and the anhydrite content decreases. Depths to the top of the formation range from about 2,100 to 2,900 feet.

Small to moderate quantities of moderately saline water are produced from flowing oil wells that are completed in the upper part of the formation adjacent to the reef. Part of the produced water is injected into the Yates Sandstone for secondary recovery of oil. Properly constructed water wells tapping the Seven Rivers Formation near the reef would probably yield moderate to large quantities of moderately saline water.

Yates Sandstone.—The Yates Sandstone, a prolific oil-producing formation in Ward County, consists of gray and red sandstone, a few thin beds of dolomite, and red and gray shale. The formation ranges in thickness from about 150 to 300 feet in the county.

The Yates yields very saline water and brine in conjunction with oil production.

Tansill Formation.—The Tansill Formation, which is about 200 feet thick in Ward County, is the youngest formation in the Artesia Group. The rocks are predominantly dolomite near the reef but grade to anhydrite and salt away from the reef. The Tansill is not known to yield water to wells in Ward County.

Ochoa Series

In the order of their deposition, the Ochoa Series consists of the Castile, Salado, and Rustler Formations and the Dewey Lake redbeds. Deposition of the Castile was limited to the Delaware basin; the other three formations are coextensive over both the Delaware basin and Central Basin Platform (Figure 25).

Castile Formation.—The Castile Formation consists of calcareous anhydrite, halite (salt), and minor amounts of sandstone. In the Delaware basin, the Castile is as much as 2,300 feet thick. The formation thins on the west flank of the Capitan reef and is absent on the Central Basin Platform to the east (Figure 25).

The Castile Formation is not known to yield water to wells in the county.

Salado Formation.—The Salado Formation overlies the Castile Formation in the Delaware Basin and overlies the Tansill Formation on the Central Basin Platform. It differs from the Castile Formation in that it consists chiefly of halite and has a subordinate amount of anhydrite. Another important difference is that the Salado contains potash minerals such as sylvite and polyhalite instead of calcite as in the Castile. The Salado is thickest (1,700 feet, or more) where it supports a structural high in the overlying Rustler Formation in western Ward County, but it is thinner (300 feet, in places) beneath the two slumpage troughs flanking the high (section A-A', Figure 25). The difference in thickness is attributed mainly to post-depositional solution and removal of salt in the Salado by circulating ground water.

In 1967, six plants in the county engaged in the production of brine from the Salado. The brine is produced by injecting water through wells into the salt beds and jetting the salt solution back to the surface. The brine is used to make drilling fluid for drilling oil and gas wells.

Rustler Formation.—The Rustler Formation, which is 200 to 500 feet thick, consists largely of anhydrite and dolomite but has a basal zone of shale. Locally, the Rustler contains minor amounts of salt and limestone. The sharp lithologic break at the contact of the uppermost anhydrite bed in the Rustler with the overlying Dewey Lake redbeds is readily distinguishable on well logs (Figure 8) and has been used to correlate the top of the Rustler in the subsurface (Figure 7). Depths to the top of the Rustler range from 340 feet in the southeastern corner of the county to as much as 1,900 feet in the Monument Draw trough.

The main producing intervals in the Rustler are porous zones in the dolomite and limestone. Porosity ranges from pinpoint to cavernous and is very irregular in extent. As a result, yields from the Rustler range widely; yields as high as 650 gpm (gallons per minute) have been measured, but most wells yield less than 300 gpm. Water from the Rustler in the eastern third of the county is very saline or brine and is used only for secondary recovery of oil. However, near the south-central edge of the county, five flowing wells yield moderately saline water that has been used successfully for irrigation.

Dewey Lake Redbeds.—The Dewey Lake redbeds, the youngest formation in the Ochoa Series, consists of red siltstone and some gypsum, anhydrite, and red shale. The Dewey Lake is unconformably overlain by the Tecovas Formation of the Triassic Dockum Group. The two formations have similar lithologic and water-bearing characteristics—neither are known to transmit usable quantities of water—and are frequently combined under the general term "Permian-Triassic redbeds." The "redbeds" have not been differentiated on the illustrations in this report.

Triassic System

Dockum Group

The Dockum Group is divided into the Tecovas Formation, the Santa Rosa Sandstone, and the Chinle

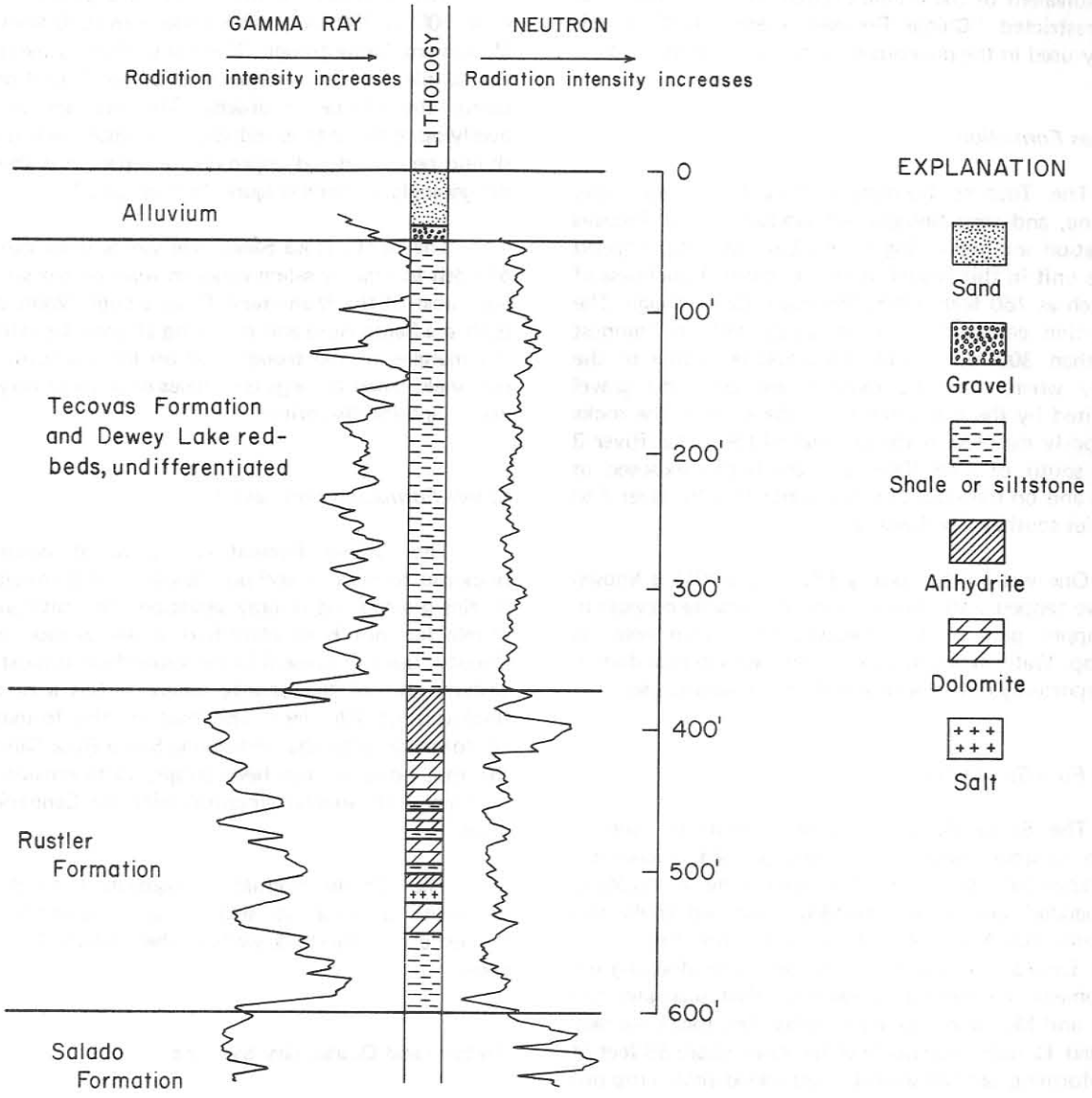


Figure 8

Radioactivity and Driller's Log of the Rustler Formation and Younger Rocks in Southeastern Ward County

Formation equivalent, in ascending order. The Dockum Group is almost the exact equivalent of the Chinle Formation of the Colorado Platform Region (Reeside and others, 1957). Because of local usage, however, Garza and Wesselman (1959) in Winkler County and Armstrong and McMillion (1961) in Pecos County, included only the upper part of the Dockum Group as the equivalent of the Chinle Formation of the type area. The restricted "Chinle Formation equivalent" terminology used in the previous reports is used in this report.

Tecovas Formation

The Tecovas Formation consists of red shale, siltstone, and very fine-grained sandstone. The Tecovas Formation and underlying Dewey Lake redbeds, mapped as one unit in this report, have a combined thickness of as much as 760 feet in the Monument Draw trough. The rocks thin eastward from the trough and are thinnest (less than 300 feet) in the southeastern corner of the county where they are overlain by sand and gravel deposited by the Pecos River. At the surface, the rocks are poorly exposed in the channel of the Pecos River 3 miles south of Grandfalls, but are better exposed in draws and on the sides of benches north of the river 7 to 10 miles southeast of Barstow.

One well in the county (YX-46-39-701) is known to have tapped water-bearing sand or possible crevices in the upper part of the Tecovas Formation near its outcrop. Water from this well, which is now abandoned, was reportedly unfit for livestock and domestic use.

Santa Rosa Sandstone

The Santa Rosa Sandstone consists of reddish-brown to gray, medium- to coarse-grained, micaceous, well-cemented sandstone. The sandstone is typically crossbedded and is interbedded with red shale and siltstone. The Santa Rosa crops out below the rim of Quito Escarpment and is exposed in draws draining the escarpment on the structural high that separates the Pecos and Monument Draw troughs. The rocks are best exposed 12 miles due north of Barstow where 85 feet of ledge-forming sandstone and interbedded shale crop out on the face of Quito Escarpment. A smaller but more accessible outcrop occurs in Rock Quarry Draw, 4½-miles east of Barstow, where 15 to 20 feet of thick-bedded to massive, crossbedded, hard, red sandstone is exposed in an abandoned quarry. Rock from the quarry has been used to construct several buildings in Barstow, including the old County Court House.

In the Pecos trough west of Quito Escarpment, the Santa Rosa is absent except for local slumpage blocks at the base of the alluvial fill (section E-E', Figure 29). The formation is also absent in the southeastern corner of the county where it has been removed by erosion (section G-G', Figure 31). East from Quito Escarpment, the Santa Rosa dips gently toward the Monument Draw trough and underlies the surface at shallow depths; but farther east, the rocks plunge into the trough to depths as great as 1,000 feet. The structure is reversed on the east side of the trough where the rocks rise and again assume a fairly level attitude (section C-C', Figure 27).

The thickness of the Santa Rosa generally ranges from 100 to 350 feet, and is maximum (520 feet) in the Monument Draw trough. The Santa Rosa is overlain by the Chinle Formation equivalent or by alluvial deposits where the Chinle is absent. The contact with the overlying sediments is indistinct on most well logs and should be considered approximate where it is shown on the geologic sections (Figure 25 through 31).

The Santa Rosa Sandstone yields small quantities of fresh to slightly saline water to wells on the structural high west of the Monument Draw trough. Wells tapping both the Santa Rosa and overlying alluvial deposits along the margins of the trough and on the platform to the east yield small to large quantities of fresh to very saline water, and locally, brine.

Chinle Formation Equivalent

The Chinle Formation equivalent consists of brick-red to maroon and purple shale and lenticular beds of fine-grained red or gray sandstone and siltstone. The Chinle has not been identified at the surface in Ward County, but it is present in the subsurface in most of the eastern half of the county where it has a maximum thickness of 220 feet. The base of the formation is conformable with the underlying Santa Rosa Sandstone; the top, however, has been subjected to erosion and is overlain with angular unconformity by Cenozoic alluvium.

The Chinle Formation equivalent yields small quantities of fresh to slightly saline water to a few domestic and livestock wells in the eastern third of the county.

Tertiary and Quaternary Systems

Alluvium

Alluvium of Tertiary and Quaternary ages rests unconformably on rocks of Permian and Triassic ages in Ward County. The alluvium consists of clay, sand, gravel, and caliche—material that has been eroded from the older rocks. The lithology and thickness of the beds differ widely within short distances. Normally, the deposits are unconsolidated or poorly cemented. However, patches of indurated caliche and well-cemented gravel conglomerate locally occur on the uplands in the county. The alluvial deposits are thinnest where they wedge out against outcrops of older rocks on the face of

Quito Escarpment, and are thickest (as much as 1,050 feet) in the Pecos and Monument Draw troughs.

In the Monument Draw trough, wells tapping lenses of sand and gravel and beds of well-sorted "quick sand" yield large quantities of fresh to moderately saline water. Along the southern and western perimeters of the county, the very permeable sand and gravel deposits underlying the Pecos River terraces yield large quantities of moderately to very saline water. Small to large quantities of fresh to very saline water and locally brine are pumped from wells tapping alluvial deposits and underlying Santa Rosa Sandstone along the margins of the Monument Draw trough and on the platform east of the trough.

Quaternary System

Dune Sand

Windblown sand deposited as a belt of dunes covers about 50 square miles of northeastern Ward County (Figure 24). Part of the belt consists of high drifting dunes which support scant or no vegetation. Less promiment but more extensive are the low dunes that are partly vegetated and stabilized. The dunes consist of reddish-brown to buff, fine to very fine quartz sand that is intermixed with only minor amounts of silt and clay. The sand has a maximum thickness of about 100 feet in the area of high dunes, but is normally less than 30 feet thick in the area of low dunes.

The water table occurs at shallow depths beneath the high dunes and nearly intersects the surface in the deeper blowouts. Although small quantities of fresh water are obtained from pits and shallow wells in the sand, the dunes are more important as a site of recharge for the underlying formations.

Aquifers

A formation, group of formations, or a part of a formation that is capable of yielding usable quantities of water is termed an aquifer. All ground water used for municipal, domestic, and livestock supplies; a large part of that used by industry; and nearly all the water pumped for irrigation in the county is from the Allurosa aquifer. As defined in this report, the Allurosa aquifer consists of saturated deposits in the Santa Rosa Sandstone, Chinle Formation equivalent, alluvium, and dune sand. The base of the aquifer is identical to the base of the Santa Rosa, or the base of the alluvium where the Santa Rosa is absent. The top of the aquifer is the water table. The aquifer is more than 1,200 feet thick in the Pecos and Monument Draw troughs, but it is much thinner (50 to 300 feet thick) on the platform east of Monument Draw trough, and is discontinuous on the structural high west of the trough. The approximate depth to and the altitude of the base of the aquifer are shown on Figure 9.

The deeper aquifers, such as the Rustler Formation and the Capitan Limestone, are important primarily as a source of saline water for secondary recovery of oil, or as they pertain to the possible contamination of the overlying Allurosa aquifer.

HYDROLOGY

The general principles of ground-water hydrology as they apply to the study area are discussed in the following sections of this report. For additional technical information, the reader is referred to Meinzer (1923a, 1923b), Meinzer and others (1942), Todd (1959), Tolman (1937), and Wisler and Brater (1959); and for nontechnical discussions to Baldwin and McGuinness (1963) and Leopold and Langbein (1960).

Source and Occurrence of Ground Water

The natural source of ground water in Ward County is precipitation in the county and in areas mainly to the north and west. Most of the precipitation is evaporated at the surface or is transpired by vegetation. In normal years, only a small amount runs off into streams. Water that escapes runoff, evaporation, and transpiration migrates slowly downward by gravity through the zone of aeration until it reaches the zone of saturation. In the zone of saturation, all the voids and pore spaces in the rocks are filled with water. The surface of this zone is called the water table, and the water within it is called ground water.

Ground water in Ward County occurs under two conditions—water table, or unconfined; and artesian, or confined. Under water-table conditions, the water will not rise in wells above the level at which it is found in the formation; under artesian conditions, the water rises under pressure to a level above the top of the formation.

The water in the Allurosa aquifer occurs under both water-table and artesian conditions. Normally, the water in the unconsolidated or partially consolidated eolian and alluvial deposits is stored under water-table conditions. Locally, however, water in the deeper alluvial deposits in the Monument Draw and Pecos troughs is confined under slight artesian pressure by overlying, less permeable beds of silt and clay. Artesian conditions are generally observed in wells tapping the consolidated rocks—the Chinle Formation equivalent and Santa Rosa Sandstone—in the lower part of the Allurosa aquifer.

Both the Rustler Formation and Capitan Limestone store water under artesian pressure. The pressure head in the Rustler is sufficient along the south-central edge of the county to cause wells to flow. Well

YX-46-32-305, the first to be drilled to the Capitan Limestone (Capitan reef), reportedly had a shut-in pressure of 105 psi (pounds per square inch) at the land surface and flowed 778 gpm when it was drilled in 1953. In 1967, seven wells tapping the Rustler Formation and five wells tapping the Capitan Limestone in Ward County were flowing or had sufficient heads to flow.

Recharge, Movement, and Discharge

The Allurosa aquifer is naturally recharged by infiltration of precipitation, by seepage from streams and depression ponds, and by underflow across the Ward-Loving and Ward-Winkler County lines. The aquifer is also recharged by seepage from irrigation canals and infiltration of irrigation water. The sources and estimated amounts of recharge to the Allurosa aquifer are shown on Figure 10.

Recharge from precipitation and streamflow is intermittent and largely contingent on heavy rainfall. The aquifer is substantially recharged only when storms of long duration or of frequent occurrence saturate the soil so that deep percolation takes place.

The surficial materials in Ward County range widely in their ability to absorb precipitation and transmit it downward to the water table. By far the most favorable site for recharge is the belt of sand dunes that covers the northeastern corner of Ward County. The high permeability of the sand, together with the scarcity of vegetation, permits rapid infiltration of rainfall with minimum evapotranspiration loss. Precipitation that infiltrates to the water table beneath the sand dunes moves southwestwardly towards areas of ground-water withdrawals. Based on the ability of the aquifer to transmit water (coefficient of transmissibility) and the hydraulic gradient, about 2,000 acre-feet of water per year is flowing across the southwestern edge of the sand dunes.

Although sandy soils are prevalent over much of the remainder of the county, they are most always underlain by finer materials that retard the downward percolation of water. The rate of recharge from precipitation is not known, but if it is assumed to be on the order of one-eighth of an inch per year, which is comparable to the less than a quarter of an inch of recharge reported by Theis (1964) for the southern high plains of Texas, then about 5,000 acre-feet per year is being recharged over the remainder of the county.

An estimated 5,000 acre-feet per year of underflow enters Ward County from Loving and Winkler Counties; most of the water flows through alluvial deposits in the Monument Draw and Pecos troughs.

The total amount of natural recharge to the Allurosa aquifer from the sources cited above is estimated to be about 12,000 acre-feet per year.

The Allurosa aquifer is also recharged by seepage from irrigation canals and by infiltration of irrigation water applied to the land in excess of the consumptive use of crops. Recharge from these sources occurs mainly within the three irrigation districts in the lowlands bordering the Pecos River and is largely dependent upon the amount of water diverted from the river, which varies widely from year to year. During the water year 1967 (October 1966 through September 1967), the districts diverted 75,510 acre-feet for irrigation of 9,740 acres. According to reports from the districts, 34,739 acre-feet or about 3.6 acre-feet of water per acre was actually applied to the cropland; more than one-half of the total amount of water diverted was lost to seepage from canals. Canal losses ranging from 30 to 72 percent were measured in 1940 during the Pecos River joint investigation (U.S. National Resources Planning Board, 1942) and were summarized as follows:

> ". . . None of the lower [Pecos River] basin ditches is lined to prevent seepage losses. Such losses for all irrigation ditches in Ward County Water Improvement District No. 3 (Cedarvale area) amount to 30 to 32 percent of the water delivered at the headgate. In this area a shallow ditch 8 miles long, constructed almost entirely in caliche, supplies water to irrigate between 100 to 150 acres of land. The ditch has a bottom width of about 10 feet, and the irrigation stream at the headgate is 29 second-feet. In the first 6 miles the loss is 12.5 second-feet, and in the last 2 miles it is 8.5 second-feet, a total loss of 21 second-feet, or 72 percent, in 8 miles of ditch. . . There is so much seepage from this ditch that 24 hours is required to prime it, 24 hours to build up a head, and 60 hours to irrigate an area of 110 acres."
>
> "In Ward County Water Improvement District No. 2 (Grandfalls area) the seepage loss from irrigation canals is about 30 percent of the total quantity delivered at the headgate. In Big Valley there is an old main irrigation canal constructed along the foothills in porous sand and gravelly soil. Water is delivered at the headgate at the rate of 30 cubic feet per second and of this amount 18 second-feet is lost in 15 miles of canal."

In addition to seepage from canals, approximately 20 percent of the water applied to cropland in irrigation projects in Ward County percolates to the water table. This estimate is based on detailed hydrologic studies conducted during the Pecos River joint investigation (U.S. National Resources Planning Board, 1942). Table

118 (p. 224) of that report shows that the normal consumptive use of water, weighted by type and acreage of crops grown, was 2.81 acre-feet per acre in the Imperial-Zimmerman area near the northern border of Pecos County. In view of the similarity in agricultural practices and hydrologic conditions, the results of this study are believed to be applicable to irrigation projects in Ward County. Accordingly, of the 3.6 acre-feet per acre that was applied in the projects, about 0.8 acre-foot per acre or about 7,700 acre-feet of water was added to the Allurosa aquifer through infiltration of irrigation water during 1967.

The available data suggest that at least 60 percent of the flow that is diverted from the Pecos River eventually percolates to the water table. Accordingly, about 45,000 acre-feet of Pecos River water was added to the Allurosa aquifer during 1967.

The Rustler Formation is recharged naturally by infiltration of precipitation and by seepage from streams at its outcrop in eastern Culberson County (west of the report area). Also, some of the water that enters equivalent formations, which crop out in the Glass Mountains (south of the report area in Pecos and Brewster Counties) may eventually percolate into the Rustler. From the outcrops, the water moves toward the north and east through Pecos and Reeves Counties and enters Ward County as underflow. The quantity of water thus recharged is not known.

In addition to underflow into the county, the Rustler is recharged by injection of salt water through disposal wells within the county. All of the disposal wells are in oil fields on the Central Basin Platform in the eastern third of the county where water in the Rustler is highly mineralized (classed as very saline or brine) and is pumped only for secondary recovery of oil. Based on records of the Texas Water Commission and Texas Water Pollution Control Board (1963), about 18 million barrels, or about 2,300 acre-feet, of oil-field brine was injected into the Rustler Formation during 1961. Data collected from oil companies during the present investigation show that approximately 8 million barrels, or about 1,000 acre-feet, was injected in 1967.

The Capitan Limestone (Capitan reef) is recharged where it crops out in the Guadalupe Mountains in New Mexico and Texas, but probably also receives inflow from its equivalent, the Gilliam Limestone which crops out in the Glass Mountains in Brewster and Pecos Counties. The water moves into Ward County along the trend of the reef shown on Figure 6. The available data are insufficient to determine the amount of water entering the county from these sources.

Ground water in Ward County moves slowly, probably 10 to 500 feet per year, through the aquifers from areas of recharge to areas of discharge, gravity being the motivating force. Initially, the movement is downward in the areas of recharge; thereafter, the water moves parallel to the slope of the land surface in the alluvial deposits and in the general direction of dip in the consolidated deposits. Exception to the downslope and downdip movement are in the areas where large quantities of water are withdrawn from the aquifers. In those areas, water moves from all directions toward the center of pumping.

The general direction of movement of water in the Allurosa aquifer is shown by the configuration (shape and slope) of the water table, which is contoured on Figure 11. The movement of water is in the direction of decreasing altitude and is at right angles to the contours. Accordingly, water moves toward the southwest from the belt of sand dunes in the northeastern corner of the county; elsewhere, the water moves southward or southeastward in the direction of the Pecos River.

Water in transient storage in the Allurosa aquifer is discharged both naturally and artificially. Natural discharge is by three processes: (1) evapotranspiration, (2) effluent seepage to the Pecos River, and (3) underflow beneath the river into Reeves and Pecos Counties. Water is discharged artificially by pumping of wells (see section on Use of Ground Water) and by seepage into drainage ditches.

Natural discharge by evaporation and transpiration occurs on the lowlands bordering the Pecos River and on the wetlands in and about Soda Lake where the water table is near the land surface. Salt grass, saltcedar, tule, and other salt-tolerant plants are particularly abundant in those areas. Saltcedar, which chokes the banks of the Pecos River, is known to use as much as 5 acre-feet of water per year and to have roots extending to the water table even where it is as much as 50 feet below the land surface.

A program of saltcedar control on the Pecos River downstream from Red Bluff Reservoir was begun by the U.S. Bureau of Reclamation in 1969. As part of this program, the areas of infestation having a density of 10 percent or more were delineated on the flood plain of the river from Mentone (northwest of the report area) in Loving County to the stream-gaging station near Grandfalls. According to Mr. Leon Hill (written communication, 1968), Director of Region 5 of the Bureau of Reclamation:

> "The Pecos River flood plain within this reach is quite wide and has poorly defined boundaries. Numerous oxbows, loops, and meanders cause the narrow, deeply incised low-flow channel to have a length at least double that of the flood plain. The heaviest growth occurs either just above the numerous diversion dams or as a heavy growth along the channel. The width of the heavy growth along the channel is approximately equal to

the meander breadth of the river. The remaining portions of the flood plain have less dense infestations, which are probably indicative of the existing lower ground water conditions."

"From a field inspection it was determined that in all probability the phreatophytes have reached their maximum growth and density. It was further estimated that about 15 percent of the infested area was mesquite with the remaining 85 percent saltcedar. Of the 28,270 acres of growth, 83 percent, or 23,450 acres, was considered to have light density (10-35 percent); 11 percent, or 3,120 acres, was considered to have medium density (35-65 percent); and 6 percent or 1,700 acres, was considered to be dense growth (65-100 percent)."

"Using the Blaney method of computing consumptive use, it was determined that the present net consumptive use (precipitation excluded) on the 28,270 acres is 83,130 acre-feet. . ."

Based on the results of the above study conducted in 1964, approximately 40,000 acre-feet of water is consumed annually by phreatic vegetation along the Pecos River in Ward County.

Discharge of water into the Pecos River via drainage ditches was small or negligible during the current investigation. The only flowing ditch observed drains irrigated land near Barstow. The flow on March 28, 1968, was 310 gpm (.7 cubic-foot per second) measured at a point 300 feet from its confluence with the river, 3¾ miles southeast of Barstow. The water contained 10,900 mg/l (milligrams per liter) dissolved solids and was therefore classed as very saline.

Pecos River Low-Flow and Water-Delivery Studies

A seepage study conducted by the U.S. Geological Survey on May 28-29, 1918, showed that the flow of the Pecos River increased 47.8 cfs (cubic feet per second) or 34,600 acre-feet per year from the New Mexico-Texas State line to Girvin, Texas, during a period of little or no rainfall (Grover, Gray, and Ellsworth, 1922). Of this amount, about 24 cfs (17,400 acre-feet per year) was gained in the reach of river opposite Ward County. Assuming that all of the inflow was effluent seepage from ground water and that both sides of the river contributed equal amounts, about 12 cfs, or approximately 8,700 acre-feet per year, was discharged to the river from the Allurosa aquifer in Ward County.

During the Pecos River Joint Investigation, hydrologic studies were made from Red Bluff Reservoir near the New Mexico-Texas State line to Girvin, Texas, a distance of 188 river miles, to determine the sources and amounts of inflow to the river. The studies indicated that ground-water inflow averaged 30,000 acre-feet per year during the period 1905-1939, ". . .and that in the long run, ground-water inflow and flood inflow occurred in approximately equal proportions" (U.S. National Resources Planning Board, 1942a). Assuming that at least half of the ground-water inflow was gained within the 98-mile reach of river opposite Ward County, and that aquifers on both sides of the river contributed equal amounts, an average of about 7,500 acre-feet per year was discharged to the river from the Allurosa aquifer in Ward County. It should be noted, however, that this study and the seepage study in 1918 were made during periods in which ground-water pumpage and phreatophyte consumption along or near the river were much smaller than in 1967.

Grozier and others (1966) made a water-delivery study February 15 to March 31, 1964, and conducted a low-flow study May 10 to May 12, 1965, to determine the changes in the quantity and quality of flow in the Pecos River for the reach from Red Bluff Reservoir to Girvin, Texas. Figure 12 shows the results of the water-delivery study during which 4,370 acre-feet of water passed the stream-gaging station near Orla, Texas (14.3 miles downstream from Red Bluff Reservoir); 130 acre-feet was diverted from the river; and 1,760 acre-feet passed the stream-gaging station near Girvin. The loss of 2,480 acre-feet of water between the two stations was 57 percent of the flow measured near Orla. This loss was attributed to evaporation, transpiration, and seepage to ground-water aquifers. According to Grozier and others (1966), ". . .Because the weather was cool and phreatophytes were relatively dormant in February and March, most of the loss was to ground-water aquifers." During this study, about 1,300 acre-feet of water was lost in the reach of river opposite Ward County.

The daily chloride concentration in the Pecos River below Red Bluff Dam near Orla and Pecos River near Girvin for the period February 15 through March 31, 1964, is shown in Figure 12. The figure indicates the chloride content at the sampling station near Orla was markedly uniform during the study, ranging from about 2,900 to 3,000 mg/l. In contrast, the chloride content in the river near Girvin was quite variable, ranging from a high of 7,900 mg/l to a low of 3,780 mg/l. The peak in the chloride content measured on March 7 was likely caused by flushing of salt which had accumulated on the river enbankments during low flow; the peak was followed by a sharp drop in chloride to about 4,100 mg/l when the flushing action was completed. The chloride content gradually increased after most of the released water had passed the sampling station, but it decreased temporarily during a period of refreshment from local runoff.

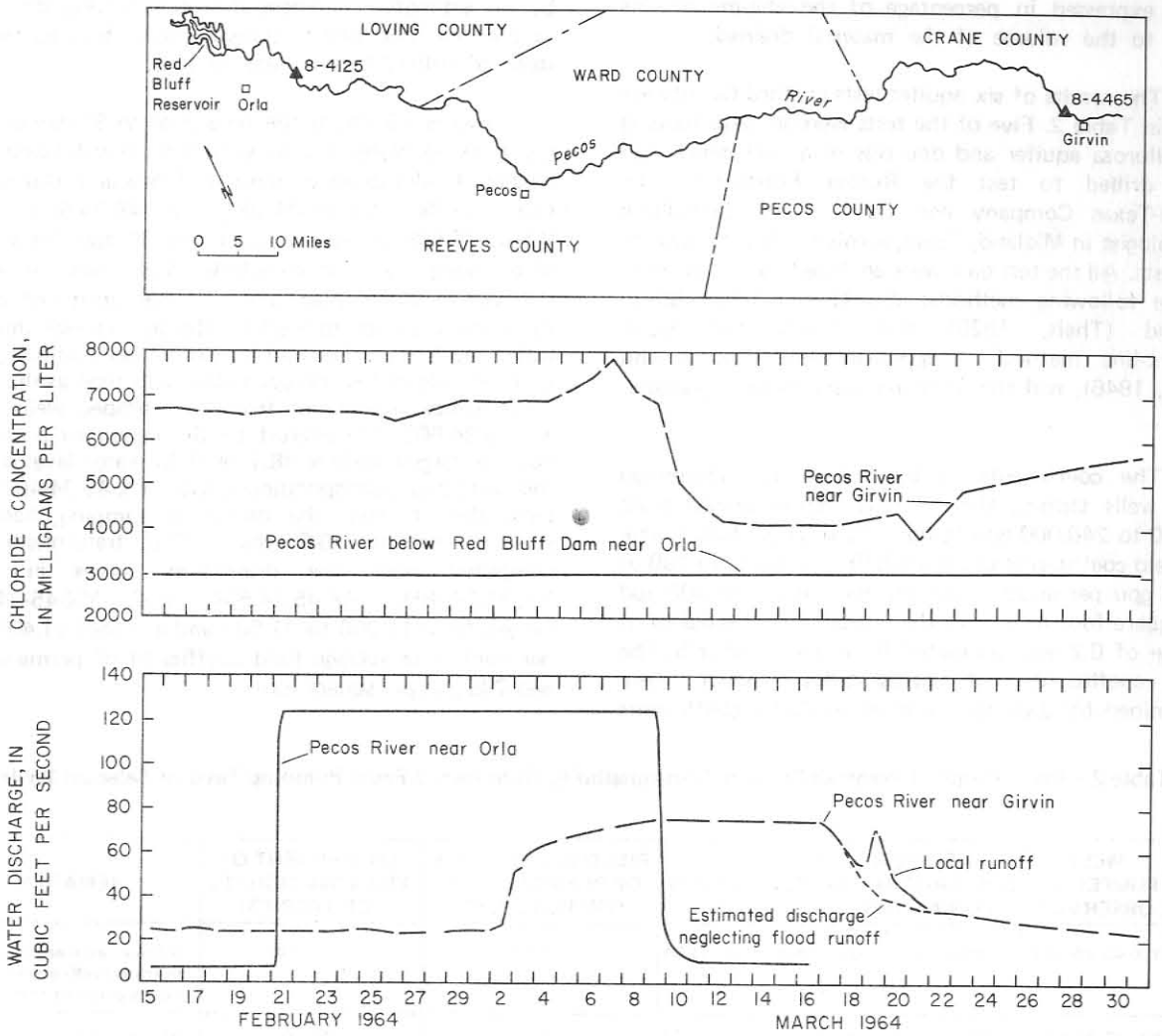


Figure 12.—Hydrograph of Flow and Chloride Concentration in the Pecos River Near Orla and Girvin

During the low-flow study of May 10-12, 1965, the river was dry for about half of its reach along Ward County. Small amounts of flow were measured in reaches of river downstream from Barstow and Grandfalls (Grozier and others, 1966), but most of this water was likely return of flow that had been previously diverted to irrigation projects along the river.

Hydraulic Properties of the Aquifers

Aquifer tests were made in a few wells in Ward County to determine the coefficients of permeability, transmissibility, and storage, which govern the ability of the aquifer to transmit, yield, or store water.

The field coefficient of permeability is the flow of water in gallons per day at the prevailing temperature through a cross section of 1 square foot of the aquifer under a hydraulic gradient of 1 foot per foot.

The coefficient of transmissibility, a similar measure for the entire thickness of the aquifer, is defined as the rate of flow of water in gallons per day at the prevailing water temperature through a vertical strip of the aquifer 1 foot wide extending the full height of the aquifer under a hydraulic gradient of 1 foot per foot. The volume of water that will flow each day through each foot of the aquifer is the product of the coefficient of transmissibility and the hydraulic gradient. The smaller the coefficient of transmissibility, the greater the hydraulic gradient must be for the water to move through the aquifer at a given rate.

The coefficient of storage is the volume of water released from or taken into storage per unit surface area of the aquifer per unit change of the component head normal to that surface. Under water table conditions, the coefficient of storage is practically equal to the specific yield. The specific yield is the quantity of water that a formation will yield under the force of gravity, if it is first saturated and then allowed to drain, the ratio

being expressed in percentage of the volume of this water to the volume of the material drained.

The results of six aquifer tests in Ward County are given in Table 2. Five of the tests were in wells tapping the Allurosa aquifer and one was in a well which had been drilled to test the Rustler Formation. The Layne-Texas Company and Ed L. Reed, Consulting Hydrologist in Midland, Texas, furnished data for two of the tests. All the test data were analyzed by one or more of the following methods: the Theis nonequilibrium method (Theis, 1925), the Cooper and Jacob straight-line method of approximation (Cooper and Jacob, 1946), and the Theis recovery method (Wenzel, 1942).

The coefficients of transmissibility determined from wells tapping the Allurosa aquifer ranged from 11,400 to 240,000 gpd (gallons per day) per foot (Table 2). Field coefficients of permeability ranged from 190 to 2,200 gpd per square foot, but were less than 400 gpd per square foot in four of the five tests. A coefficient of storage of 0.2 was computed from test number 5. The field coefficients of permeability shown were determined by dividing the transmissibility coefficients by the estimated thickness of sand supplying the water to the well. The sand thicknesses were obtained from a study of drillers' logs or electrical logs.

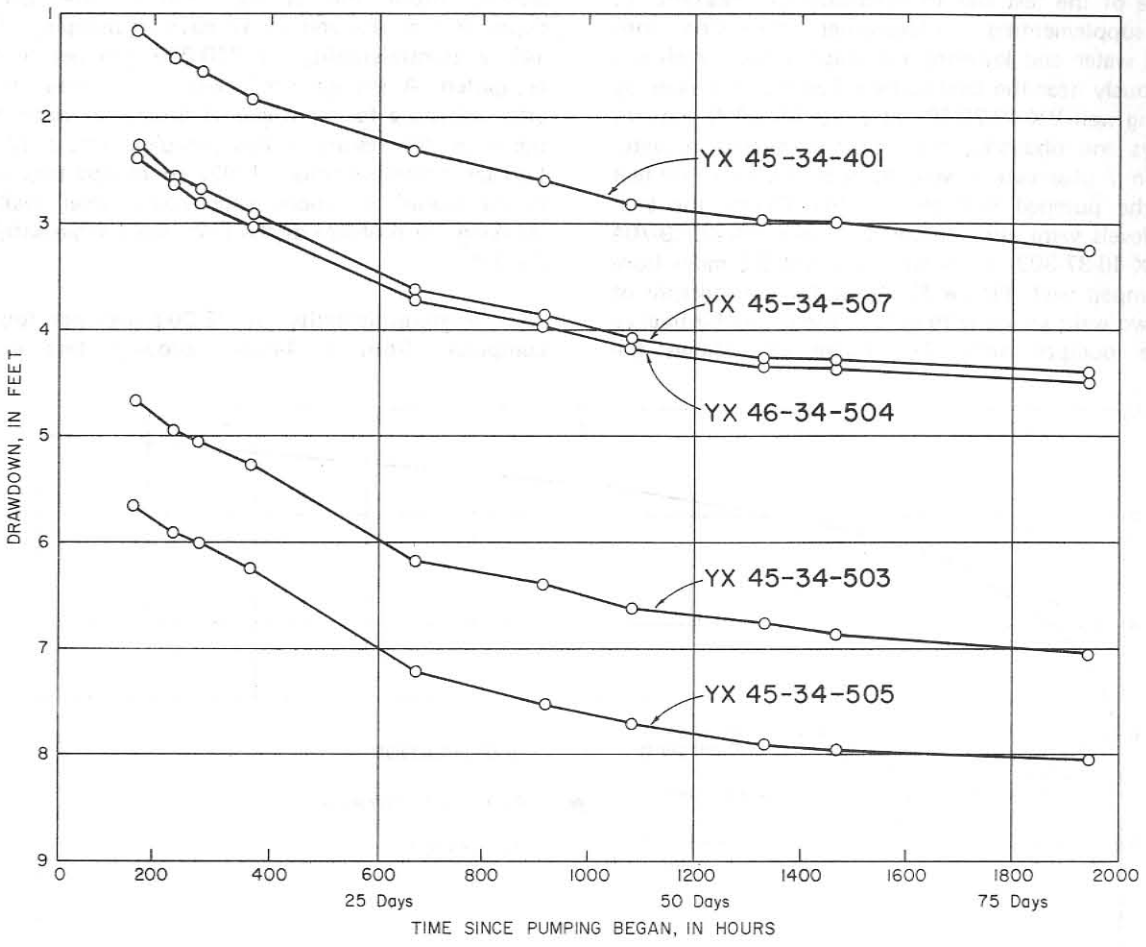
Figure 13 shows the results of an 81-day aquifer test in Ozark-Mahoning Company's fresh-water well field located 9 miles south-southeast of Monahans. During the test, wells YX-45-34-503, YX-45-34-505, and YX-45-34-506 pumped a combined 90 gpm for supply of the company's sodium sulfate plant 2 miles south of the well field. The plant and wells had been shut down for 3 months prior to the test. The graph shows that the water levels were lowered by continued pumping, but that the rate of decline decreased with time as the cone of influence spread out from the pumped wells. Well YX-45-34-505, the nearest to the center of pumping, had the largest decline (8.1 feet) in water level during the test; and correspondingly, well YX-45-34-401, the most distant from the center of pumping, had the smallest decline (3.2 feet). The transmissibilities computed from the drawdown curves in wells YX-45-34-401, YX-45-34-504, and YX-45-34-507 ranged from 11,000 to 11,800 and averaged 11,400 gpd per foot. The average field coefficient of permeability was 285 gpd per square foot.

Table 2.—Coefficients of Permeability and Transmissibility Determined From Pumping Tests of Selected Wells

TEST	WELL PUMPED OR OBSERVED	AQUIFER (WATER-BEARING FORMATION)	TEST COMPLETION DATE	FIELD COEFFICIENT OF PERMEABILITY (GPD PER SQ. FT)	COEFFICIENT OF TRANSMISSIBILITY (GPD PER FT)	REMARKS
1	YX-45-25-317	Rustler Formation	Mar. 20, 1951	670	22,000	4-hour recovery test. Well pumped 600 gpm for 21 hours prior to test.
2	YX-45-33-802	Allurosa aquifer	Aug. 14, 1967	190	34,000	27½-hour recovery test. Well pumped 490 gpm for 44½ hours prior to test.
3	YX-45-34-401 503 504 505 506 507	Allurosa aquifer	Oct. 21, 1967	285	11,400	81-day interference test (Figure 13). Wells YX-45-34-503, 505, and 506 pumped a combined 90 gpm during test. Declines in water levels were measured in wells YX-45-34-401, 503, 504, 505, and 507.
4	YX-46-24-701 703 704	Allurosa aquifer	June 8, 1957	280	56,000	24-hour interference test.1/ Well YX-46-24-703 pumped 500 gpm during test. Declines in water levels were measured in wells YX-46-24-701 and 704.
5	YX-46-29-701 Obs. well 1 Obs. well 2 Obs. well 3 Obs. well 4 Obs. well 5 Obs. well 6 Obs. well 7	Allurosa aquifer	Sept. 24, 1941	2,200	240,000	12-day interference test (Figure 14). Well YX-46-29-701 pumped 1,300 gpm during test. Declines in water levels were measured in pumped well and 7 observation wells. Coefficient of storage = 0.2.
6	YX-46-40-308	Allurosa aquifer	Aug. 12, 1962	390	49,000	3½-hour recovery test. Well pumped 1,050 gpm for 4 hours prior to test.2/

1/ Pumping test conducted by Layne-Texas Co.

2/ Pumping test conducted by Ed L. Reed, Consulting Hydrologist, Midland, Texas.



EXPLANATION

- Pumped well
- 26 Discharge (gallons per minute)
- Observed well
- Pumped and observed well

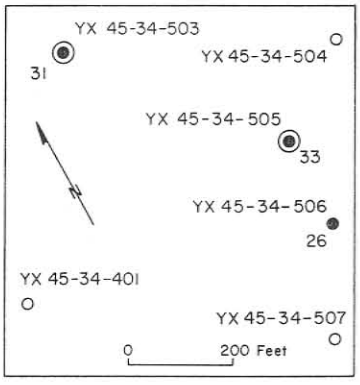


Figure 13

Drawdown of Water Levels in Five Wells Tapping the Allurosa Aquifer During an 81-Day Period of Pumping

The highest transmissibility in Table 2, 240,000 gpd per foot, was computed from a 12-day aquifer test made in Ward County Water Improvement District 3, 6½ miles northwest of Barstow. The test was conducted in the fall of 1941 by U.S. Geological Survey personnel at the request of the District's Board of Directors. The purpose of the test was to determine the feasibility of both supplementing surface-water diversions with ground water and lowering the water table, which was dangerously near the land surface. The test was made by pumping well YX-46-29-701 at a rate of 1,300 gpm for 12 days and observing the resultant decline in water levels in 7 observation wells located 150 to 1,640 feet from the pumped well (Figure 14). During the test, water levels were also measured in wells YX-46-29-704 and YX-46-37-303 which were 1.3 and 5.3 miles from the pumped well. Figure 15 shows the hydrographs of these two wells which were outside the cone of influence of the pumped well. The figure also shows the hydrographs of observation wells 1 and 7, which were 150 and 1,640 feet from the pumped well and within its cone of influence. During the test, the water level in the two wells (YX-46-29-704 and YX-46-37-303) declined 0.6 foot. This decline probably reflected a regional decline in the water table at the end of the irrigation season. From the configuration of the cone of depression at the end of 12 days of pumping (Figure 14), a transmissibility of 240,000 gpd per foot was computed. A storage coefficient of 0.2 was obtained after adjusting for the regional decline in water levels. Based on the results of this pumping test, J. W. Lang (written communication, 1942) concluded that surface drains would be more satisfactory than wells for relieving the problem of the high water table within the district.

A transmissibility of 22,000 gpd per foot was computed from a 4-hour recovery test in well

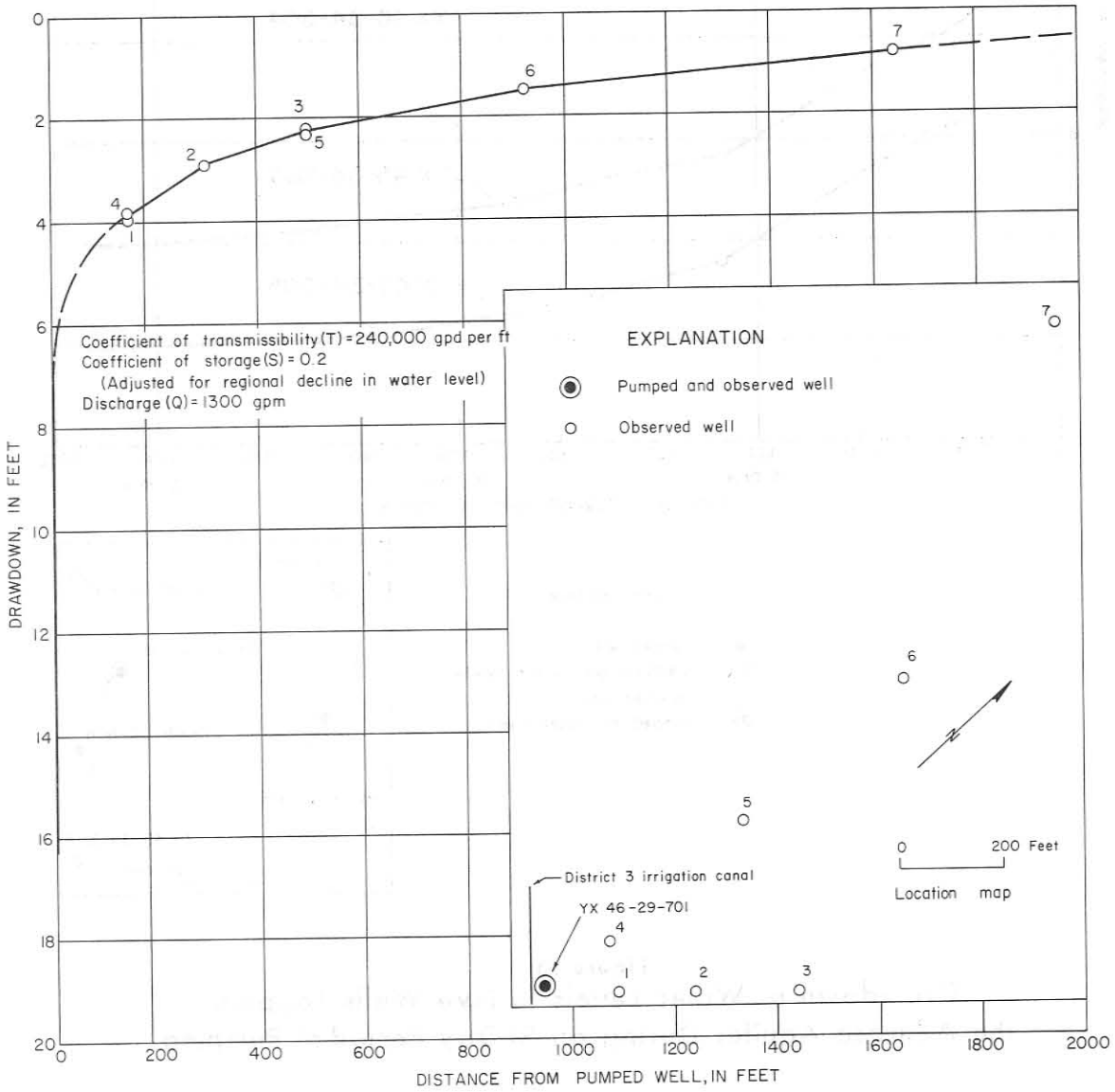
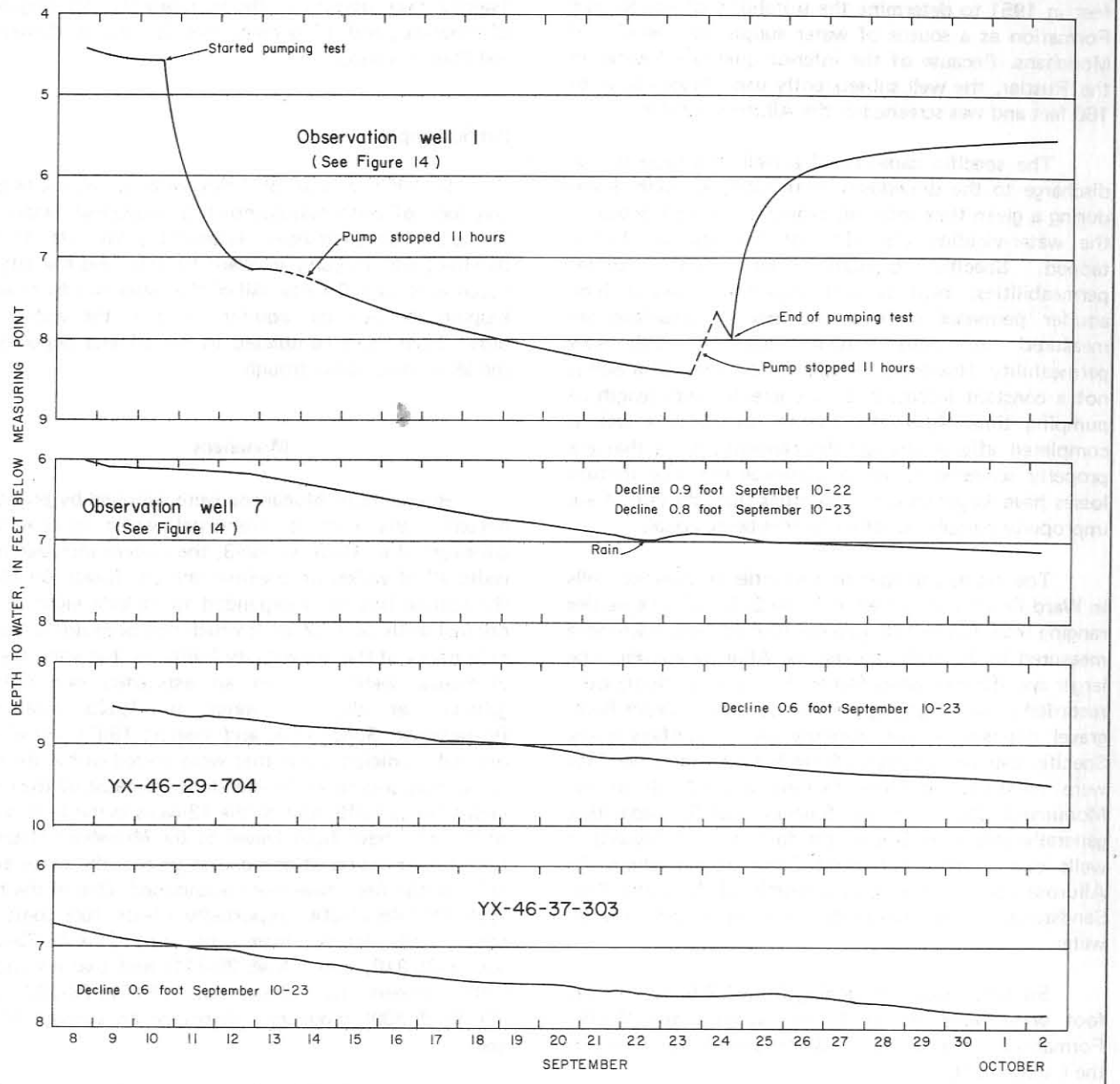


Figure 14.—Relation of Drawdown to Distance From a Well Pumping 1300 gpm for 12 Days



Well number	Distance from pumped well
Observation well 1	150 feet
Observation well 7	1640 feet
YX-46-29-704	1.3 miles
YX-46-37-303	5.3 miles

Figure 15

Fluctuations of Water Levels in Four Wells at Varying Distances From a Pumped Well (YX-46-29-701)

YX-45-25-317. This well was drilled to a depth of 965 feet in 1951 to determine the suitability of the Rustler Formation as a source of water supply for the city of Monahans. Because of the inferior quality of water in the Rustler, the well subsequently was plugged back to 160 feet and was screened in the Allurosa aquifer.

The specific capacity of a well, the ratio of the discharge to the drawdown or recovery of water levels during a given time interval, provides a general index of the water-yielding capability of the aquifer that is tapped. Specific capacities vary with aquifer permeabilities; high specific capacities denote high aquifer permeability, and low specific capacities are measured in wells tapping aquifers with low permeability. However, the specific capacity of a well is not a constant inasmuch as it decreases with length of pumping time. Also, the manner in which a well is completed affects the specific capacity. Wells that are properly screened so as to minimize entrance friction losses have larger specific capacities than those that are improperly completed, other factors being equal.

The yields and specific capacities of selected wells in Ward County are listed in Table 3. Specific capacities ranging from 0.3 to 173 gpm per foot of drawdown were measured in 76 wells tapping the Allurosa aquifer. The larger specific capacities (40 to 173 gpm per foot) were recorded in wells tapping the very permeable Pecos River gravel deposits in the Barstow and Grandfalls areas. Specific capacities ranging from 5 to 43 gpm per foot were measured in wells tapping alluvial fill in the Monument Draw trough. Smaller specific capacities, generally less than 5 gpm per foot, were measured in wells east of the Monument Draw trough where the Allurosa aquifer is composed mostly of the Santa Rosa Sandstone, which transmits only small amounts of water.

Specific capacities ranging from 1.7 to 13 gpm per foot were measured in 4 wells tapping the Rustler Formation and from 2.5 to 13 gpm per foot in 8 wells in the Capitan reef.

Use of Water

All water used for public supply, industry, domestic supply, and nearly all of the livestock supply in Ward County is from wells. Water used for irrigation is furnished both by pumping of wells and by diversion of flow from the Pecos River. Part of the water that is pumped in the county is exported for municipal and industrial supply in adjacent counties.

In 1967, a total of 11,208 million gallons (34,400 acre-feet) of water was pumped from aquifers in Ward County, nearly two-thirds or about 7,364 million gallons (22,600 acre-feet), of which was from the Allurosa aquifer. Of the water pumped in the county, 60 percent was used by industry, the principal use being in the secondary recovery of oil by the waterflood method. Twenty-seven percent of the pumpage was for irrigation of cropland, and 13 percent was for public, domestic, and livestock supply.

Public Supply

In 1967, a total of 1,506 million gallons (4,698 acre-feet) of water was pumped for municipal supply for the cities of Monahans, Grandfalls, Wickett, Pyote, Barstow, and Royalty in Ward County and the city of Pecos in Reeves County. All of the water was from wells tapping the Allurosa aquifer; most of the water was piped from wells completed in the alluvial deposits in the Monument Draw trough.

Monahans

Residents of Monahans were supplied by privately owned wells until a municipal water system was constructed in 1930. In 1943, the system included nine wells, all of which were within the city limits. By 1948, the system had been expanded to include eight of the original wells plus 12 wells which had been drilled half a mile north of the present city limits. In that year, the 20 municipal wells supplied an estimated one million gallons per day of water to 1,825 customers (Broadhurst, Sundstrom, and Weaver, 1951). All of the original municipal wells that were drilled within the city limits were subsequently abandoned because of their low yields. Since 1946, four of the 12 wells in the field north of the city have been leased to the Monahans Country Club for irrigation of golf-course greens; the other eight wells in the field have been abandoned. One of the four wells (YX-45-25-306) reportedly yields 100 gpm; the other wells leased from the city (YX-45-25-307, YX-45-25-310, and YX-45-25-311) and two additional wells owned by the club (YX-45-25-308 and YX-45-25-309) reportedly discharge an average of 70 gpm.

Currently (1967), Monahans obtains its municipal supply from the West Monahans and Hogg Ranch well fields. Six wells (YX-45-25-313, YX-45-25-315, YX-45-25-316, YX-45-25-603, YX-45-25-604, and YX-45-25-605) are in use in the West Monahans field. Pumpage from these wells in 1967 amounted to 309,685,000 gallons (950 acre-feet). The combined discharge of the six wells measured by a master meter at the Maxwell pumping station was 800 gpm, or an average of 133 gpm per well.

The four municipal wells which are in use in the Hogg Ranch addition 1/ pumped a metered 408,275,000 gallons (1,253 acre-feet) of water in 1967. All of the

1/ The Hogg Ranch addition to the city of Monahans includes 18¾ square miles of range land in Ward and Winkler Counties (boundaries of the addition in Ward County are shown on Figure 24).

Table 3.—Specific Capacities of Selected Wells in Ward County and Adjacent Areas

WELL	DEPTH OF WELL (FT)	TEST COMPLETION DATE	LENGTH OF TEST (HOURS)	DISCHARGE (GPM)	DRAWDOWN, D, OR RECOVERY, R (FT)	SPECIFIC CAPACITY (GPM/FT)
		Allurosa aquifer				
YX-45-17-701	403	Apr. 28, 1967	101	53	33 D	1.6
25-304	110	1940	72	75	45 D	1.7*
305	176	Mar. 31, 1965	8	125	55 D	2.3*
321	220	Dec. 16, 1946	8	192	68 D	2.8*
322	221	Nov. 20, 1945	24	160	62 D	2.6*
501	200	May 13, 1967	1	200	88 R	2.3*
507	250	May 24, 1950	24	131	48 D	2.7*
508	275	May 4, 1950	24	147	53 D	2.8*
603	140	Oct. 29, 1953	1	137	50 D	2.7*
707	220	1960	8	34	25 D	1.4*
907	126	May 11, 1967	2	15	54 D	.3
26-701	213	May 16, 1967	14	72	57 D	1.3
33-208	240	Mar. 1967	a/	146	26 D	5.6*
209	352	June 7, 1953	5	800	17 D	47 *
209	352	do	5	1,000	23 D	43 *
214	330	Jan. 6, 1961	4	135	40 D	3.4*
401	250	June 22, 1967	3	555	37 D	15
507	230	June 23, 1967	6	685	34 D	20
515	311	Sept. 1952	24	1,500	40 D	38 *
609	252	1958	—	131	30 D	4.4*
706	300	June 21, 1967	720	275	114 D	2.4
707	210	June 22, 1967	720	710	112 D	6.3
802	220	Aug. 14, 1967	44	490	21 D	23
805	116	1960	½	38	10 D	3.8*
811	220	Feb. 1951	12	400	21 D	19 *
812	140	Aug. 7, 1967	1	295	7.5 D	39
822	135	1960	½	51	6 D	8.5*
903	137	July 1966	3	200	35 D	5.7*
908	135	do	4	200	26 D	7.7*
42-505	62	Apr. 27, 1967	10	1,000	20 D	50
46-21-703	228	Feb. 26, 1963	6	175	96 D	1.8*
ZP-46-23-603	400	1956	12	1,040	69 D	15 *
YX-46-23-902	225	Sept. 13, 1967	1	160	21 D	7.6
904	300	do	17	440	32 D	14
24-702	395	June 18, 1959	11	713	86 D	8.3*
703	385	June 8, 1957	6	500	36 D	14 *

See footnotes at end of table.

Table 3.—Specific Capacities of Selected Wells in Ward County and Adjacent Areas—Continued

WELL	DEPTH OF WELL (FT)	TEST COMPLETION DATE	LENGTH OF TEST (HOURS)	DISCHARGE (GPM)	DRAWDOWN, D, OR RECOVERY, R (FT)	SPECIFIC CAPACITY (GPM/FT)
704	392	Apr. 2, 1959	34	1,220	64 D	19 *
704	392	Apr. 14, 1967	2	830	35 D	24
705	387	Feb. 21, 1965	36	1,000	47 D	21 *
705	387	Apr. 17, 1967	1	920	38 D	24
29-701	115	Sept. 23, 1941	300	1,300	16 D	81
705	152	Apr. 23, 1947	72	1,430	16 D	89
804	153	do	1	960	24 D	40
903	190	Jan. 1966	21	410	44 D	9.3*
31-602	200	Sept. 11, 1967	336	240	13 D	18
603	200	do	2	260	25 D	10
604	225	do	2	445	12 D	37
801	300	Nov. 13, 1967	22	380	16 D	24
32-204	425	Dec. 1957	48	1,000	38 D	26 *
204	425	Sept. 26, 1967	½	810	25 D	32
401	226	Sept. 9, 1967	126	285	17 D	17
403	400	Sept. 12, 1967	9	500	30 D	17
409	185	Nov. 16, 1967	¾	207	36 D	5.8
501	182	Jan. 1945	96	280	12 D	23 *
508	425	Sept. 19, 1967	½	888	37 D	24
509	385	Aug. 6, 1958	24	838	44 D	19 *
509	385	Sept. 19, 1967	½	759	29 D	26
510	259	Sept. 26, 1967	½	197	27 D	7.3
511	235	1942	60	190	36 D	5.3*
512	235	July 1943	60	214	13 D	16 *
514	240	Sept. 24, 1945	8	380	85 D	4.5*
514	240	Nov. 16, 1967	2	328	70 D	4.7
603	306	1963	48	1,500	90 D	17 *
604	284	Apr. 1966	134	310	15 D	21
37-110	125	Oct. 19, 1967	14	940	14 R	67
207	80	Apr. 1940	102	1,400	14 D	100
212	80	Apr. 4, 1940	4	730	14 D	52
213	58	Oct. 7, 1940	168	1,200	16 D	75
223	110	Apr. 26, 1947	1	1,125	29 D	39
305	80	Oct. 25, 1967	4	1,450	20 D	73
313	103	June 8, 1940	3	1,270	11 D	115
314	77	Apr. 18, 1947	24	1,675	14 D	120
321	107	1946	168	1,505	30 D	50 *

See footnotes at end of table.

Table 3.—Specific Capacities of Selected Wells in Ward County and Adjacent Areas—Continued

WELL	DEPTH OF WELL (FT)	TEST COMPLETION DATE	LENGTH OF TEST (HOURS)	DISCHARGE (GPM)	DRAWDOWN, D, OR RECOVERY, R (FT)	SPECIFIC CAPACITY (GPM/FT)
324	105	Nov. 15, 1967	4	740	4.9 D	151
604	95	do	3	1,160	6.7 D	173
38-104	110	May 21, 1940	3	1,000	23 D	43
39-205	142	Nov. 7, 1967	2	100	14 D	7.1
40-305	250	May 29, 1967	b/	884	34 D	26 *
306	240	do	b/	865	40 D	22 *
307	316	do	b/	656	21 D	31 *
308	256	do	b/	766	33 D	23 *
503	210	Aug. 11, 1967	c/	870	39 D	22
		Rustler Formation				
ZP-45-17-802	950	Feb. 15, 1967	1	220	17 D	13 *
YX-45-25-317	d/965	Mar. 30, 1951	21	600	129 D	4.7
317	d/965	do	4	600	112 R	5.4
34-703	656	Jan. 1957	5	346	40 D	8.6
46-40-702	1,080	June 1, 1967	83	250	147 D	1.7
		Capitan Limestone (Capitan reef)				
YX-46-32-305	3,700	June 28, 1957	5	704 Flow	97 R	7.3*
306	3,950	Feb. 20, 1957	24	288 Flow	113 D	2.5
307	4,100	June 28, 1957	5	640 Flow	88 R	7.3*
308	4,500	Feb. 20, 1957	24	655 Flow	74 D	8.9*
309	4,100	June 28, 1957	5	780 Flow	76 R	10 *
610	4,450	Feb. 20, 1957	24	375 Flow	111 D	3.4
611	4,500	June 28, 1957	5	435 Flow	116 R	3.8*
901	4,421	July 11, 1962	4	1,310 Flow	102 D	13

* Reported data.

a/ 3 months.

b/ Pumped 60 percent of the time for 42 days.

c/ 4 months.

d/ Well was subsequently plugged back to 160 feet and completed in the Allurosa aquifer.

water was piped 11 miles southeast to the city proper. Yields of 830 and 920 gpm were measured from wells YX-46-24-704 and YX-46-24-705 in April 1967. Yields from the other two wells, YX-46-24-702 and YX-46-24-703, are reportedly of the same magnitude. The four wells tap alluvial deposits in the Monument Draw trough.

Grandfalls

The city of Grandfalls purchased its water system from the L. C. Harrison Water Company in January 1964. At that time, the system was supplied by wells YX-45-33-901, YX-45-33-902, and YX-45-33-903 in a field 4 miles northwest of the city. City well number 1 (YX-45-33-901) was plugged in 1965 after the water became salty (see water analyses in Table 8). City well number 2 (YX-45-33-902) is abandoned and will be plugged. Wells 3 and 4 (YX-45-33-903 and YX-45-33-908) are used only during the summer months when the water demand is greatest.

Most of the municipal supply for Grandfalls is pumped from well number 5 (YX-45-33-812), 6½ miles northwest of the city. This well was originally drilled for Ward County Improvement District No. 2 in 1946, but was not used until it was turned over to the city in 1965.

Wells YX-45-33-903 and YX-45-33-908 reportedly discharge about 200 gpm. During a 1-hour pumping test in August 1967, well YX-45-33-812 pumped 295 gpm and had a drawdown in water level of 7½ feet. In 1967, the three wells pumped 64,211,700 gallons (197 acre-feet).

Wickett

In 1967, the residents of Wickett used 55,436,000 gallons (170 acre-feet) of water supplied from wells YX-46-32-603 and YX-46-32-604. Well YX-46-32-603 discharges 800 gpm; well YX-40-32-604, which is on standby status, pumped 310 gpm during a development test by the driller.

Pyote

The municipal water system of the city of Pyote is leased from the University of Texas. The well field, 3½ miles east of the city, has six wells, of which only three—YX-46-32-501, YX-46-32-513, and YX-46-32-514—are in use. Wells YX-46-32-511 and YX-46-32-512 have been abandoned, and well YX-46-32-515 may be returned to use. All of the wells were drilled in the 1940's to supply the Pyote Air Force Base during World War II. The base was closed after the war, but part of it is now occupied by the West Texas Children's Home, which is connected to the water system.

Yields of the three wells in use range from 260 to 328 gpm. In 1967, the wells supplied 71,457,586 gallons (219 acre-feet) for use in the city and children's home. All of the wells tap alluvial deposits in the Monument Draw trough.

Royalty

Well YX-45-42-102 serves 12 families in Royalty, or about one-fourth of the population; other residents purchase water from the city of Grandfalls or pump their own supply. The well yields an estimated 15 gpm, and in 1967, supplied about 2,700,000 gallons (8.3 acre-feet).

Barstow

Since July 1966, the residents of Barstow have purchased water piped from the city of Pecos. Previous to that time, wells YX-46-38-201 and YX-46-38-202, located 4 miles east of Barstow, supplied the municipal system. Both wells tapped the Santa Rosa Sandstone and neither yielded more than 75 gpm.

In 1967, Barstow used a metered 25,547,000 gallons (78 acre-feet).

Pecos

The water supply for the city of Pecos is piped from two well fields—one in Reeves County and a second in Ward County. The former has been previously described by Ogilbee, Wesselman, and Irelan (1962). The latter is located 6 miles southeast of Pyote and has 4 wells, YX-46-40-305, YX-46-40-306, YX-46-40-307, and YX-46-40-308, all of which tap alluvial deposits in the Monument Draw trough. Yields of three of the wells measured in the spring of 1967 ranged from 766 to 884 gpm and averaged about 790 gpm. In 1967, pumpage from the wells totaled 593,970,600 gallons (1,823 acre-feet).

Industrial Use

Industry pumped 6,661 million gallons (20,435 acre-feet) of water from wells in Ward County in 1967, two-thirds or 4,760 million gallons (14,600 acre-feet) of which was used to waterflood oil fields in Ward and adjoining counties.

Waterflooding

Waterflooding, a method used in the secondary recovery of oil, involves the injection of water to the oil-bearing strata. In some wells, the water is injected by gravity flow; in others, it is injected under pressure

exerted at the well head. (A maximum surface pressure of one-half pound per square inch per foot of well depth has been recommended by the Railroad Commission of Texas.) Once injected, the water raises the pressure in the oil reservoir and displaces the oil, forcing it to flow toward the producing wells.

Water used for waterflooding consists generally of "production" and "extraneous" water mixed in varying proportions. Production water is that which has been separated from the oil-water pumped from the oil wells. Normally, production water is too saline for purposes other than waterflooding; if not injected for secondary recovery, it is disposed of as waste water. Extraneous water is derived from other sources such as water wells and surface-water diversions. Extraneous water may be fresh (although use of fresh water is discouraged), or it may be brine, and may require treatment to be compatible with the fluids and gases in the oil reservoir.

Secondary recovery of oil by the waterflood method began in Ward County in September 1948, when Forest Oil Corporation started a project on a 600-acre lease in the South Ward Field. The practice steadily developed, and by 1955, 32 units were operating. The most recent survey of secondary recovery and pressure maintenance operation in Texas listed 82 units operating in the county as of January 1, 1966, (Texas Petroleum Research Committee, 1967).

In 1967, about 3,100 million gallons (9,500 acre-feet), or nearly 67 percent of the water pumped for waterflooding was from 14 wells tapping the Capitan Limestone (Capitan reef) in Ward County, Part of the water was exported for waterflooding oil fields in neighboring counties.

Fifteen wells, 12 in Ward County and 3 in Winkler County, that tap the Capitan reef are currently (1967) in use in Gulf Oil Corporation's O'Brien water-supply system. The 15 operating wells and 14 unused wells were drilled on a strip of land 1 mile wide extending north from Highway 80 on the west side of Wickett to 1 mile north of the Ward-Winkler County line. O'Brien water-supply well number 1 (YX-46-32-305) was drilled in 1953. At that time, the well flowed 778 gpm and had an artesian head of 242 feet above land surface. In 1957, seven wells in the field were flowing at rates ranging from 288 to 780 gpm. Based on three 24-hour draw-down tests and four 5-hour recovery tests, the specific capacities of these wells ranged from 2.5 to 10 gpm per foot (Table 3). In 1967, three unused wells (YX-46-32-312, YX-46-32-610, and YX-46-32-615) had artesian heads ranging from 21 to 46 feet above land surface. However, all of the producing wells were equipped with pumps and presumably had static water levels near the land surface.

Wells YX-46-32-602 and YX-46-32-901 supply Humble Oil and Refining Company's Wickett water system number 6. Both wells flow, and neither has been equipped with a pump. Well YX-46-32-901 flowed 1,310 gpm during a 4-hour production test in July 1962 and had a specific capacity of 13 gpm per foot. The well had an artesian head of 186 feet above land surface in July 1962; the head had declined to 70 feet above land surface in June 1967.

In 1967, 46 wells tapping the Allurosa aquifer supplied 1,056 million gallons (3,239 acre-feet) of water for secondary-recovery operations in Ward County. Most of the water was injected in the Ward-South and Ward-Estes North Field.

Twelve wells tapping the Rustler Formation pumped 605 million gallons (1,856 acre-feet) for water-flooding in Ward County during 1967. All of the wells are on the structural high east of the Monument Draw trough.

Permian Basin Generating Plant

Texas Electric Service Company's Permian Basin generating plant used a metered 1,110 million gallons of water in 1967. All of the water was from eight wells tapping the Allurosa aquifer. Three wells, YX-45-25-203, YX-45-25-509, and YX-45-25-511, located 1 to 1½ miles east-southeast of the plant, supplied 125 million gallons, and five wells, YX-46-32-204, YX-46-32-508, YX-46-32-509, YX-46-32-510, and YX-46-32-607, located 4½ to 6½ miles west of the plant, supplied 985 million gallons. Water from both well fields was piped to the plant which is located 2½ miles west of Monahans.

Other Uses

Other industrial uses of ground water in Ward County include supplies for three gasoline plants, seven brine-producing plants, Ozark Mahoning Company's sodium sulfate plant, two sand and gravel plants, one bottling plant, highway construction, and drilling rig and oil-field lease supply. In 1967, approximately 790 million gallons (2,420 acre-feet) of ground water was used for these purposes. All of the water was from the Allurosa aquifer.

Irrigation

Surface Water

Irrigation of cropland in Ward County began in the late 1880's. Between 1888 and 1906, four irrigation projects were organized on the lowlands bordering the Pecos River, and by 1914, there were 16,060 acres irrigated from canals diverting water from the river (U.S. National Resources Planning Board, 1942).

Water for the irrigation projects in Ward County is stored in Red Bluff Reservoir near the New Mexico-Texas State line. The quantity of water diverted from the Pecos and the quality of the water near Orla varies widely from one year to the next. Figure 16 shows the amounts of water diverted from the Pecos River for irrigation in the county during the period 1940-67. Generally the amounts diverted are declining. For the 19 years of complete record within that period, diversions ranged from 745 acre-feet in 1953 to 138,000 acre-feet in 1943, and averaged 57,000 acre-feet. During the water year 1967 (October 1966 through September 1967), the projects diverted 75,510 acre-feet of water for irrigation of 9,740 acres.

The discharge-weighted average concentrations of dissolved solids in tons per acre-foot in water sampled from the Pecos River near Orla, Texas, 15 miles downstream from Red Bluff Reservoir, is also shown on Figure 16. A ton per acre-foot is the equivalent of 736 milligrams per liter of dissolved solids. In 1967, the released water contained 4.59 tons per acre-foot which was the fourth lowest concentration in the 28 years of record. The general trend in dissolved solids has been upward, however.

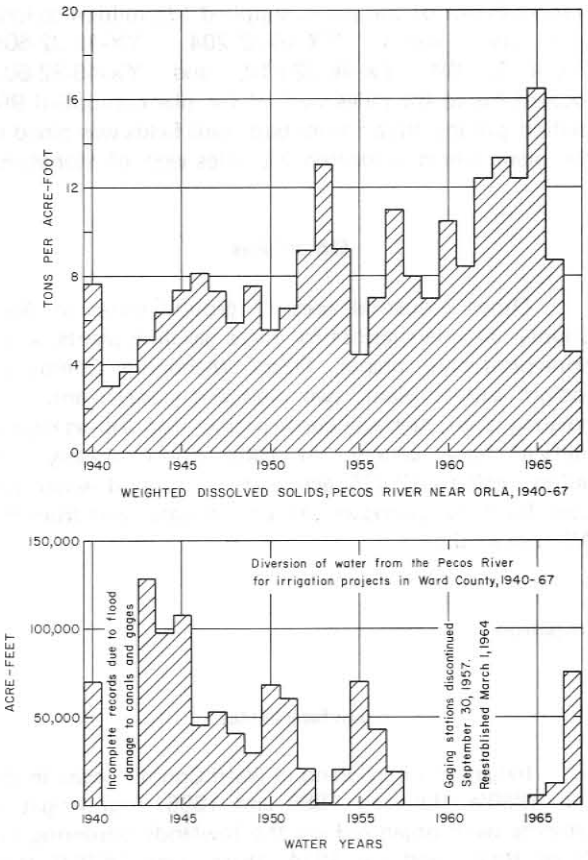


Figure 16.—Weighted Dissolved Solids in the Pecos River Near Orla and Diversion of Water From the Pecos River for Irrigation in Ward County, 1940-67

Ground Water

Irrigation of cropland with water from wells in Ward County began in the vicinity of Barstow shortly after 1900. Wells YX-46-37-102 and YX-46-37-107 are thought to be two of the earliest to be used for irrigation in the county. Both wells are 4½ miles northwest of Barstow; both were drilled in 1908 and were pumped to supplement surface-water supply. Neither of the wells is now in use. Well YX-46-37-305, located three-fourths of a mile east of Barstow, and YX-46-37-207, located 4 miles northwest of Barstow, are two of the oldest wells that remain in use. The former was drilled in 1930 and the latter was drilled before 1930, possibly as early as 1908.

In 1967, 78 wells pumped 9,200 acre-feet of water for irrigation of cropland in Ward County. Of this amount, 8,800 acre-feet was from 76 wells tapping the Allurosa aquifer, and 400 acre-feet was from two wells drilled to the Rustler Formation. Thirty-three of the wells in the Allurosa aquifer are located near Barstow (area A, Figure 17). The two wells in the Rustler Formation are on a farm 10 miles south of Pyote.

Domestic Supply and Livestock Use

Pumping of ground water for domestic supply and livestock use is relatively small, amounting to only 60 million gallons (164,000 gpd) or 184 acre-feet in 1967. All the water was from the Allurosa aquifer. Most of the livestock wells are equipped with windmills, the yields of which are generally less than 5 gpm. Many of the domestic wells and a few of the livestock wells are equipped with small submergible pumps capable of yielding 10 or 15 gpm.

Fluctuations of Water Levels

The fluctuations of water levels in wells depend upon the rate at which water is recharged to an aquifer versus the rate at which it is discharged. When discharge exceeds recharge, the water levels decline; when recharge is greater than discharge, the water levels rise.

Hydrographs showing fluctuations of water levels in 13 wells tapping the Allurosa aquifer are drawn on Figure 18. The locations of wells with hydrographs, the areas and amounts of ground-water withdrawals from the aquifer, and the locations and amounts of surface-water diversions are shown on Figure 17. The ground-water withdrawals are for the calendar year 1967, and the diversions are for the water year 1967 (October 1966 through September 1967).

The hydrographs of wells near canals supplying the irrigation projects in the county show the largest fluctuations in water levels. The hydrograph of well YX-46-29-701, for example, shows a strong relationship

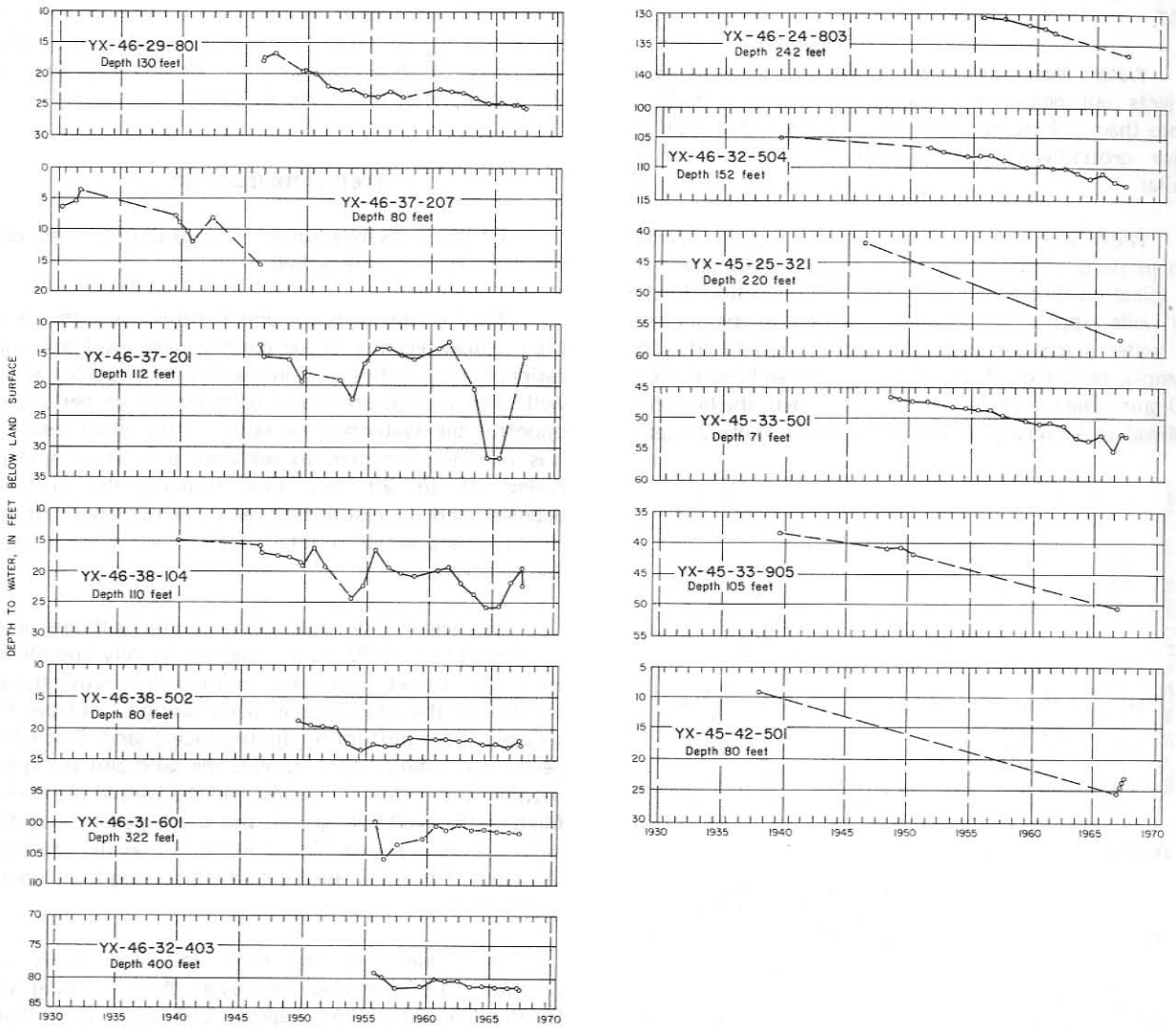


Figure 18

Hydrographs of Wells Tapping the Allurosa Aquifer

to the amount of water diverted by Ward County Water Improvement District No. 3 (Figure 19). The water level in this and other wells within the irrigation projects are generally declining due to reduced recharge resulting from a decrease in surface-water diversions and increased discharge to wells and phreatophytes. However, the water levels partially recover during years in which above-normal amounts of surface water are diverted as in 1967.

Water levels in wells outside of the irrigation projects are generally declining. The larger declines (more than ½ foot per year) are in wells in the areas of major ground-water withdrawals from the Allurosa aquifer.

Water levels in wells tapping the Rustler Formation in parts of the Ward South Field are rising due to the injection of oil-field brine into the formation. In the few wells tapping the Rustler elsewhere in the county, the water levels are declining. Well YX-46-40-701, for example, reportedly had sufficient artesian head to flow 140 gpm when drilled in 1931. Since then, the head has declined to a point at which the well now flows 29 gpm.

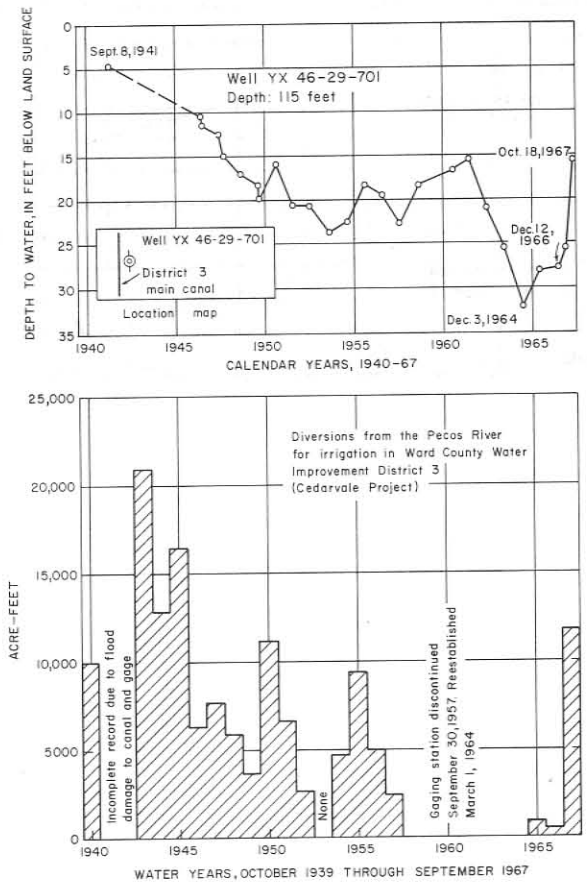


Figure 19.—Hydrograph of Well YX-46-29-701 and Graph Showing Diversion of Water From the Pecos River for Irrigation in Ward County Water Improvement District No. 3

The artesian head in well YX-46-32-305 (Gulf Oil Corporation's O'Brien water-supply well no. 1), which taps the Capitan reef, has declined 253 feet since it was drilled in 1953. This well had a shut-in pressure of 105 psi at the land surface (equivalent to 242 feet of fresh-water head) when drilled. The water level was 11 feet below land surface in June 1967. Well YX-46-32-901 in the Humble Oil and Refining Company's Wickett water system had a shut-in pressure equivalent to 186 feet of fresh-water head in July 1962. The pressure had declined to 29 psi (70 feet of fresh-water head) as of June 8, 1967.

Well Construction

Of the wells inventoried in Ward County, only one was dug; the rest were drilled.

Most of the domestic and livestock wells that have been drilled recently in the county have small diameter casing, 5 to 6 inches, and are cased to the bottom of the well. The casings are either torchslotted or perforated opposite the water-bearing sand. In the older wells, it was common practice to set only a joint of surface casing—10 to 20 feet long—through the surficial deposits, and the rest of the well was completed without casing; this practice resulted in the loss of some wells due to caving.

Municipal, industrial, and irrigation wells are larger in diameter—8 to 20 inches—and are usually completed with large-diameter surface casing which is cemented to the wall of the well. Smaller-sized casing is set from the surface to the bottom of the producing sand. Slotted or perforated casing is set opposite the sand and the space between the perforated casing, and the wall of the well is filled with small-size gravel, pea-sized gravel being the most commonly used. The gravel increases the effective diameter of the well and protects the casing from caving of the sand.

Most wells of the type described above are developed by pumping. However, those tapping the Rustler Formation and Capitan Limestone commonly are acidized to increase the permeability of the limestone.

CHEMICAL QUALITY OF GROUND WATER

Precipitation, in the form of rain or snow, contains only small amounts of mineral matter. Once the water reaches the land surface, however, it dissolves mineral substances from the soil and rocks over and through which it moves. Thus, all ground water naturally contains dissolved minerals, the degree of mineralization determining its suitability for municipal supply, irrigation, and industrial use. The chemical-quality of ground water may be degraded by the activities of man. In some

areas of Ward County, the seepage of oil-field brine and other industrial wastes from unlined surface pits has caused an increase in the mineralization and a change in the chemical character of the ground water.

During this investigation in Ward County, 308 samples of water from wells and earthen pits were collected and analyzed. These analyses and those collected during other investigations are listed in Tables 8 and 9. Table 8 shows 620 analyses of water from wells. Table 9 shows 47 analyses of oil-field brine and other industrial waste water that was placed in pits. The locations of the sampled wells are shown on Figure 24; the sampled pits are shown on Figure 23.

The concentrations of the chemical constituents in the water (Tables 8 and 9) are expressed in milligrams per liter.2/However, it is frequently more convenient for interpretive purposes to compare water in terms of equivalents per liter, which is a measure of the reactive weights of the different constituents. The concentration of an ion in equavalents per liter is determined by multiplying its concentration in milligrams per liter by the reciprocal of the combining weight of the appropriate ions. The chemical character of samples of water from aquifers underlying Ward County is illustrated on Figure 20. Each analysis is represented by a circular diagram subdivided to show the relative proportions of the principal cations and anions present, in terms of percentage of total milliequivalents per liter. The three principal cations—calcium, magnesium, and sodium (including potassium)—are shown in the left half of the circle, being separated from the three principal anions—bicarbonate, sulfate, and chloride (includes nitrate and fluoride) by a vertical line. To make the illustration more easily understood, that part of the diagram showing magnesium and sulfate was made solid.

The specific conductance, sulfate, and chloride concentrations in water from wells tapping the Allurosa aquifer are shown on Figure 21. The depth of the sampled well is also given inasmuch as water from several horizons was analyzed in a few test wells. The figure includes a graph which shows the relation between specific conductance and dissolved solids in water sampled from wells and disposal pits in Ward County. Using this graph, it is possible to estimate the dissolved solids in a sample when only the specific conductance has been determined.

The source and significance of the dissolved-mineral constituents and properties of water in Ward County, summarized in Table 4, was adapted from Doll and others (1963, table 7).

2/Previous to October 1, 1967, laboratories in the U.S. Geological Survey computed dissolved solids as parts per million, which is the unit weight of a substance in a million unit weights of water. Since that date, dissolved solids have been reported as milligrams per liter of water. Except in very saline water or brine, the two can be considered identical.

Chemical requirements for industrial uses of water vary according to the industry, but they are fairly rigid where water is used in food, paper, and some chemical-process industries. The most common industrial uses of water in Ward County are for cooling, boiler feed, and waterflooding of oil reservoirs. Excessive concentration of dissolved solids are a problem in water used for cooling because they tend to accelerate corrosion (California State Water Pollution Control Board, 1963). The use of water for boiler feed is dependent on very strict limits relative to the dissolved-solids content and silica because of the formation of scale in the boilers. High-pressure systems, operating at a pressure of more than 400 psi, require a dissolved-solids content of 50 mg/l or less and a silica content of not more than 1 mg/l; low-pressure systems, less than 150 psi, can use water having as much as 3,000 mg/l dissolved solids and 40 mg/l silica (Moore, 1940).

According to the U.S. Salinity Laboratory Staff (1954), some of the principal factors that determine the quality of water for irrigation are the concentrations of dissolved solids, sodium, and boron. The relative importance of the dissolved constituents in irrigation water is dependent upon the degree to which they accumulate in the soil. Sodium is a significant factor in evaluating irrigation water because a high SAR (sodium-adsorption ratio) may cause the soil structure to break down. The RSC (residual sodium carbonate) is another factor used in assessing the quality of water for irrigation. According to Wilcox (1955), water containing more than 2.5 me/l (milliequivalents per liter) RSC is not suitable for irrigation, 1.25 to 2.5 me/l is marginal, and less than 1.25 me/l probably is safe.

Most state and municipal authorities have adopted the standards set by the U.S. Public Health Service (1962) for drinking water used on common carriers in interstate commerce. The standards are designed to protect the traveling public and are useful in evaluating public water supplies, although they may not be directly applicable in an area such as Ward County where much of the water may exceed the standards for some constituents. According to the standards, in a public water supply, the chemical constituents should not be present in excess of the concentrations shown below except where more suitable supplies are not available.

SUBSTANCE	CONCENTRATION (MG/L)
Chloride (Cl)	250
Fluoride (F)	1.0*
Iron (Fe)	.3
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Dissolved solids	500

* Based on the annual average of maximum daily air temperature of 77° at Midland, Texas, for the period 1931-60.

Table 4.—Source and Significance of Dissolved-Mineral Constituents and Properties of Water

CONSTITUENT OR PROPERTY	SOURCE OR CAUSE	SIGNIFICANCE
Silica (SiO_2)	Dissolved from practically all rocks and soils, commonly less than 30 mg/l. High concentrations, as much as 100 mg/l, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/l of iron in surface waters generally indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and potassium (K)	Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. U.S. Public Health Service (1962) drinking-water standards recommend that the sulfate content should not exceed 250 mg/l.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 mg/l.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptbility of the individual. (Maier, 1950)
Nitrate (NO_3)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. U.S. Public Health Service (1962) drinking-water standards suggest a limit of 45 mg/l. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes some water of crystallization.	U.S. Public Health Service (1962) drinking-water standards recommend that waters containing more than 500 mg/l dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 mg/l dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness as much as 60 mg/l are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard.
Specific conductance (micromhos at 25°C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

Of the samples analyzed, 586 were from the Allurosa aquifer, 21 from the Rustler Formation, and 7 from the Capitan Limestone (Table 8). Table 9 includes 47 analyses of water produced with oil and disposed of in earthen pits. The producing horizons ranged in age from Permian to Ordovician. Five of the samples were classed moderately saline, 5 were very saline, and 37 were brine. Most of the water would be unsuitable for use except in waterflood operations.

Although parts of Ward County now yield ground water that has been contaminated, presumably by the disposal of oil-field brine, it is desirable first to summarize the chemical character of the ground water in the various formations where it has not been contaminated. This affords a basis for comparison of the native waters, those whose chemical character is natural to a particular water-bearing zone and locality.

Allurosa Aquifer

The quality of water from wells tapping the Allurosa aquifer varies widely within the county (Figures 20 and 21). The dissolved solids, which influence or limit the general use of water, ranged from 189 to 223,000 mg/l in samples collected during the current investigation. Forty-eight percent of the samples collected from wells during the present or previous investigations had less than 1,000 mg/l dissolved solids and would be classified as fresh. Twenty-three percent of the samples were slightly saline (1,000-3,000 mg/l); 25 percent were moderately saline (3,000-10,000 mg/l); and 4 percent were very saline or brine, containing more than 10,000 mg/l dissolved solids.

In general, water in the dune deposits in the northeastern corner of the county has the least mineralization. The dissolved solids, mostly calcium bicarbonate, normally total less than 500 mg/l (Figure 20). At the other extreme, brine containing more than 100,000 mg/l dissolved solids is pumped from wells tapping alluvial deposits underlying two playas in the county—Sodium Sulfate Lake, which is 3 miles northeast of Royalty, and Soda Lake, which is 3 miles north of Barstow. The brine that has accumulated in the alluvial deposits beneath and bordering Sodium Sulfate Lake is currently being mined by 70 small-capacity wells owned by the Ozark Mahoning Company. All of the wells discharge into the lake where the brine is concentrated by evaporation. From there it is pumped to the company's plant where the sodium sulfate (Glaubers salt) is extracted.

Dissolved solids in water in the alluvial deposits along the Pecos River in the Barstow and Grandfalls areas are principally sodium plus chloride (Figure 20). The total dissolved solids in 12 samples ranged from 5,610 to 11,300 mg/l and averaged 8,400 mg/l.

The principal reservoir of fresh water in the county is in the alluvial deposits which fill the Monument Draw trough. Most of the fresh water is stored east of a line drawn south along Monument Draw from the Ward-Winkler County line to a point 2 miles southeast of Pyote, where a low escarpment intersects the draw. From there the interface of the fresh water with saline water to the west generally follows this escarpment to a point where deposits containing fresh water wedge out 3 to 4 miles northwest of Royalty.

The quality of water stored in the alluvial deposits in the trough normally deteriorates with depth. Well YX-46-32-206, located 4 miles west of Wickett and 1 mile east of Monument Draw, was drilled to test the quality of water at depths from 324 to 920 feet. An electrical log of this well indicates the base of fresh water to be approximately 500 feet deep and the base of slightly saline water to be about 740 feet deep at that location. Well YX-46-40-203, which was originally drilled to 547 feet, was used to test the quality of water in the alluvium at a location 3 miles southeast of Pyote and 1 mile east of Monument Draw. Partial analyses of water sampled at depths of 424 and 547 feet showed chloride contents of 828 and 1,130 mg/l, respectively.

Fluoride is a problem in water from the Allurosa aquifer. Eighty-nine percent of the samples contained more than 1 mg/l; the average concentration was 2.2 mg/l, which is more than twice the recommended limit.

The hardness of water is commonly recognized by its effect upon soap consumption. Calcium and magnesium—primarily as salts of sulfate and bicarbonate—cause nearly all of the hardness in water from the Allurosa aquifer. Of the samples tested, only 33 contained less than 180 mg/l hardness, which is the lower limit of water classified as very hard.

Much of the water from the Allurosa aquifer that is used for public and domestic supply does not meet the chemical standards established by the U.S. Public Health Service for carriers engaged in interstate commerce. Inasmuch as no other sources of water of suitable quality are readily available, the use of water not fully meeting the standards will likely continue.

Water from the Allurosa aquifer is used extensively for industrial purposes; however, the water is usually treated to reduce the hardness. Nearly all of the compressor stations and gasoline plants use zeolite exchange columns for this purpose. The columns are recharged periodically by flushing with sodium chloride brine. The silica content of the water from the Allurosa aquifer generally is not a problem except when used in boilers. The present trend is toward closed cooling systems in which the water is chemically treated to prevent corrosion and formation of scale. In the closed systems, the water is recycled, which results in considerable reduction in water consumption and pumping costs.

The quality of water for irrigation is commonly judged by a classification proposed by the U.S. Salinity Laboratory Staff (1954). The classification is based on the salinity hazard as measured by the electrical

conductivity of the water and the sodium hazard as measured by the SAR. The relative importance of the dissolved constituents in irrigation water is dependent upon the degree to which they accumulate in the soil—more of the mineral content of the water will accumulate in tight soils than in more permeable soils under similar conditions. Sodium is a significant factor in evaluating the quality of irrigation water because water with a high SAR will cause the soil structure to break down by deflocculating the colloidal soil particles. Consequently, the soil can become plastic, thereby causing poor aeration and low water availability. This possibility is especially true in fine-textured soils.

The SAR value and the conductivity (specific conductance) of samples from 33 irrigation wells tapping the Allurosa aquifer and one well tapping the Rustler Formation are shown on Figure 22. Fifteen of the samples taken from wells in the Barstow and Grandfalls areas were classed as having very high salinity and sodium hazards. Water of this quality has been used successfully in those areas because of the permeable soils and of the practice of applying quantities of water considerably in excess of the consumptive use of crops in order to maintain a favorable salt balance.

Rustler Formation

The dissolved minerals in water from the Rustler Formation consist mostly of sodium and chloride. Wells tapping the Rustler in the eastern third of the county

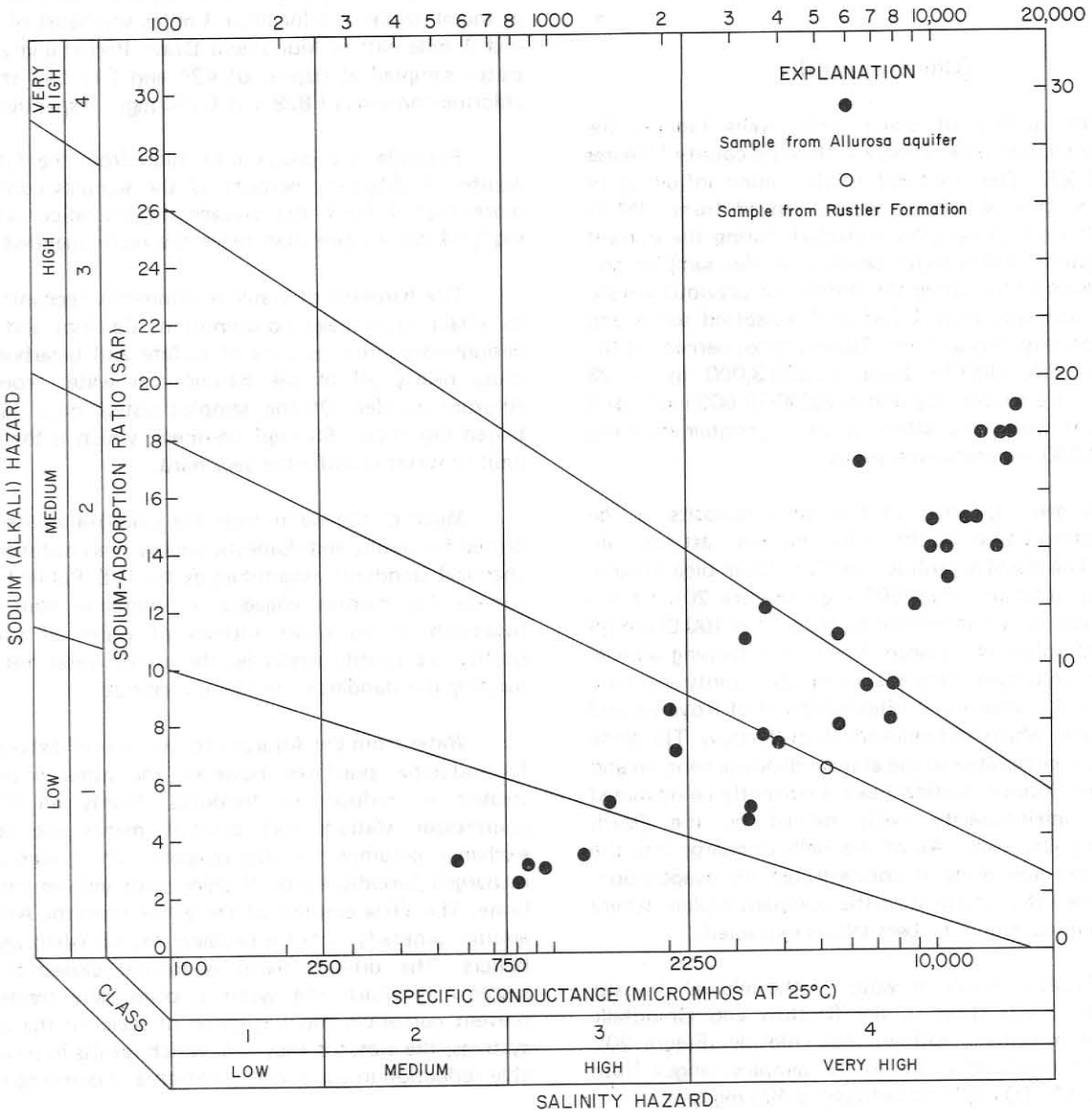


Figure 22.—Sodium-Adsorption Ratio and Specific Conductance of Water From Irrigation Wells

pump very saline water or brine which is used only for secondary recovery of oil. Three wells, located 10 miles south of Pyote, discharge moderately saline water which has been used successfully for irrigation. Elsewhere in the county this aquifer has not been tapped. Consequently, information about the quality of water in the Rustler is lacking over much of the report area.

Capitan Limestone

Fifteen wells tapping the Capitan Limestone in Ward County yield moderately to very saline water, which is used only for secondary recovery of oil. The dissolved solids consist largely of sodium chloride. The main problem in use of this water is the corrosiveness, which requires that the water be treated prior to injection.

GROUND-WATER PROBLEMS

Contamination From Disposal of Oil-Field Brine

The public and domestic water supplies in Ward County are dependent entirely on the ground-water resources of the county. The practice of disposing of oil-field brine through unlined surface pits is a present and potential hazard to the chemical quality of the ground-water supplies in the county.

Brine placed in unlined surface pits either evaporates or seeps into the ground, eventually percolating downward to the water table in a manner similar to that of precipitation on the land surface. Although the average yearly potential evaporation rate from a free water surface in Ward County is about 7 feet, it cannot be depended upon to dispose of the large quantities of brine continuously being produced. Actually, the evaporation rate of the brine is considerably less than that of fresh water because of the presence of oil film on the brine in most of the pits. Furthermore, the evaporation disposes of the water but leaves the salt in the pits as a potential contaminant.

The records of the Texas Water Commission and Texas Water Pollution Control Board (1963) show that 56,586,592 barrels (2,377 million gallons or 7,291 acre-feet) of brine reportedly was produced in Ward County in 1961. Of this amount, 12,053,147 barrels (506 million gallons or 1,553 acre-feet) or about 21 percent of the total was disposed of through unlined surface pits. The rest of the brine was disposed of through injection wells (44,470,254 barrels or 79 percent of the total) or by unknown methods.

A second survey of oil-field brine production and disposal was made by the Texas Water Development Board and Texas Railroad Commission for 1967. The results of the survey, which are not yet published, show that 87,786,967 barrels (3,687 million gallons or 11,312 acre-feet) of brine was produced in the county in that year. Of this amount, 5,113,244 barrels (215 million gallons or 659 acre-feet) or slightly less than 6 percent of the total amount was disposed of in pits. Most of the brine (82,655,792 barrels) or about 94 percent of the total was injected into wells. The remainder (17,931 barrels) was disposed of by unknown methods. The reported amounts of brine production by oil fields and areas and the amounts and methods of brine disposal in 1961 and 1967 are listed in Table 5. The areas are shown on Figure 23.

The chemical analyses of water sampled from 47 disposal pits are listed in Table 9. The table also shows the rate of discharge into the pits when sampled and the producing horizons. Many of the sampled pits are in oil fields that are being repressurized by waterflooding. Therefore, the analyses of water that is pitted in these fields do not represent the true quality of water in the producing horizons, but rather a mixture of native water which has been diluted by better-quality, extraneous water.

The quality of water that is disposed of in oil fields in Ward County is quite variable as is shown by the chemical analyses in Table 9. Five of the 47 analyses in this table would be classed as moderately saline, five as very saline, and 37 as brine.

The five samples of moderately saline water were from oil- and water-bearing formations that are in hydrologic connection with the Capitan reef. Oil wells which tap these formations near the reef produce relatively small amounts of oil and large quantities of water. Although this water is relatively low in salinity compared to water produced in other oil fields in the county, its disposal in unlined pits is a present and potential source of contamination of fresh water in alluvial deposits beneath the pits.

The analyses of water sampled from well YX-46-32-903 in 1940 and 1967 show the chloride has increased from 370 to 840 mg/l, and the specific conductance has increased from 1,900 to 5,380 (Table 8). The composition and concentrations of the dissolved minerals in the sample that was collected in 1967 are very similar to those in samples taken from pits YX-46-32-6A and 6B (Table 9), which are 0.2 mile north and 0.6 mile northeast of the well. A substantial part of the moderately saline water that has been discharged into these and other pits in this area and into adjacent drainages has presumably infiltrated to the water table. Some of the pitted water likely has spread laterally to enter this and possibly other wells near the pits. Of principal concern is the fact that those oil fields in which the moderately saline water is being pitted generally overlie alluvial deposits in the Monument Draw trough where most of the fresh water in the county is stored.

Table 5.—Reported Brine Production and Disposal in 1961 and 1967

(Quantities Reported in Barrels)

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	SURFACE PITS	DISPOSAL INJECTION WELLS	OTHER METHODS	TOTAL BRINE PRODUCTION
1	Twofreds/Delaware/	1961	151,300	0	33,945	185,245
		1967	0	345,219	0	345,219
		Total 1961	151,300	0	33,945	185,245
		Total 1967	0	345,219	0	345,219
2	G-M/Penn./	1961	0	0	0	0
		1967	0	0	2,320	2,320
		Total 1961	0	0	0	0
		Total 1967	0	0	2,320	2,320
3	Pruitt, E. /5270 Delaware/	1961	0	0	0	0
		1967	33,910	0	0	33,910
		Total 1961	0	0	0	0
		Total 1967	33,910	0	0	33,910
4	Monroe	1961	30,641	0	0	30,641
		1967	30,720	0	0	30,720
		Total 1961	30,641	0	0	30,641
		Total 1967	30,720	0	0	30,720
5	Quito/Delaware Sand/	1961	203,025	17,750	9,000	229,775
		1967	595,713	0	0	595,713
	Quito, south/Delaware/	1961	0	0	0	0
		1967	3,650	0	0	3,650
	Quito, west/Delaware/	1961	85,366	0	0	85,366
		1967	208,688	0	0	208,688
	Regan-Edwards/Delaware, upper/	1961	5,657	0	0	5,657
		1967	26,645	0	0	26,645
		Total 1961	294,048	17,750	9,000	320,798
		Total 1967	834,686	0	0	834,686
6	Scott/Delaware Sand/	1961	93,313	0	0	93,313
		1967	78,407	0	0	78,407
		Total 1961	93,313	0	0	93,313
		Total 1967	78,407	0	0	78,407
7	War-Wink/Cherry Canyon/	1961	0	0	0	0
		1967	117,213	0	0	117,213
		Total 1961	0	0	0	0
		Total 1967	117,213	0	0	117,213

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	DISPOSAL SURFACE PITS	DISPOSAL INJECTION WELLS	DISPOSAL OTHER METHODS	TOTAL BRINE PRODUCTION
8	Quito, East/Delaware/	1961	28,445	0	0	28,445
		1967	32,079	0	0	32,079
		Total 1961	28,445	0	0	28,445
		Total 1967	32,079	0	0	32,079
9	Block 17/Lamar Lime/	1961	0	0	0	0
		1967	22,078	0	0	22,078
	Block 17, SE/Delaware/	1961	25,125	0	730	25,855
		1967	204,681	25,550	0	230,231
	Lion	1961	900	0	0	900
		1967	0	4,860	0	4,860
	Poquito/Delaware/	1961	0	0	0	0
		1967	8,323	0	0	8,323
		Total 1961	26,025	0	730	26,755
		Total 1967	235,082	30,410	0	265,492
10	Wil-John/Delaware Sand/	1961	11,160	0	0	11,160
		1967	—	—	—	—
	Wil-John, NW/Delaware Sand	1961	6,825	0	0	1,825
		1967	—	—	—	—
		Total 1961	12,985	0	0	12,985
		1967	—	—	—	—
11	Rhoda Walker	1961	0	0	0	0
		1967	2,745	0	0	2,745
	Rhoda Walker/5900 Canyon/	1961	0	0	0	0
		1967	2,027	0	0	2,027
		Total 1961	0	0	0	0
		Total 1967	4,772	0	0	4,772
12	Lockridge/Ellenburger/	1961	0	0	0	0
		1967	0	2,200	0	2,200
	Lockridge/Wolfcamp/	1961	0	0	0	0
		1967	0	0	0	0
	Love Lady/6200/	1961	0	0	0	0
		1967	7,000	0	0	7,000
	Love Lady/6400/	1961	0	0	0	0
		1967	16,000	0	0	16,000
	Pitzer/Delaware/	1961	0	0	0	0
		1967	3,470	0	0	3,470

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	DISPOSAL SURFACE PITS	DISPOSAL INJECTION WELLS	OTHER METHODS	TOTAL BRINE PRODUCTION
	Pitzer/Ramsey/	1961	0	0	0	0
		1967	18,000	0	0	18,000
	Pitzer, N/Cherry Canyon/	1961	0	0	0	0
		1967	11,000	0	0	11,000
	Pitzer, S/Delaware/	1961	0	0	0	0
		1967	24,662	2,900	0	27,562
		Total 1961	0	0	0	0
		Total 1967	80,132	5,100	0	85,232
13	Pyote, S/4950 Sand/	1961	808	0	7,471	8,279
		1967	0	0	0	0
	Pyote, S/6100 Sand/	1961	9,872	0	0	9,872
		1967	44,072	0	0	44,072
	Pyote, S/6200 Sand/	1961	9,540	0	0	9,540
		1967	—	—	—	—
	Pyote, S/6450 Sand/	1961	150	0	0	150
		1967	—	—	—	—
		Total 1961	20,370	0	7,471	27,841
		Total 1967	44,072	0	0	44,072
14	Delstrat/Brushy Canyon/	1961	0	45,260	0	45,260
		1967	0	4,334	0	4,334
		Total 1961	0	45,260	0	45,260
		Total 1967	0	4,334	0	4,334
15	Magnolia Sealy, W/Brushy Canyon/	1961	0	365	0	365
		1967	0	1,297	0	1,297
	Magnolia Sealy, W/Yates Dolomite/	1961	0	0	0	0
		1967	0	90,128	0	90,128
		Total 1961	0	365	0	365
		Total 1967	0	91,425	—	91,425
16	Pyote, SW/Devonian/	1961	0	0	0	0
		1967	630	0	0	630
		Total 1961	0	0	0	0
		Total 1967	630	0	0	630
17	Spencer	1961	46,075	438,200	0	484,275
		1967	32,120	134,275	0	166,395
		Total 1961	46,075	438,200	0	484,275
		Total 1967	32,120	134,275	0	166,395

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	DISPOSAL SURFACE PITS	DISPOSAL INJECTION WELLS	DISPOSAL OTHER METHODS	TOTAL BRINE PRODUCTION
18	Byrd	1961	37,304	0	0	37,304
		1967	39,420	0	173	39,593
		Total 1961	37,304	0	0	37,304
		Total 1967	39,420	0	173	39,593
19	Miller Block B-29/Penn./	1961	3,436	0	0	3,436
		1967	5,554	5,127	0	10,681
	Ward, South	1961	5,888,246	11,467,751	0	17,355,997
		1967	0	8,434,401	12,153	8,446,554
	Ward, S./Glorieta/	1961	0	0	0	0
		1967	0	5,216	0	5,216
	Ward, S./Line/	1961	365,000	0	0	365,000
		1967	–	–	–	–
	Ward, S./Penn./	1961	0	0	0	0
		1967	0	13,271	0	13,271
	Ward, S./8430 Penn./	1961	0	0	0	0
		1967	496	0	0	496
	Ward, S./Upper Penn. detrital/	1961	0	0	0	0
		1967	16,696	0	365	17,061
	Ward, S./4130 San Andres/	1961	0	0	0	0
		1967	0	3,154	0	3,154
		Total 1961	6,256,682	11,467,751	0	17,724,433
		Total 1967	22,746	8,461,169	12,518	8,496,433
20	Estes, Block 34/Penn./	1961	56,873	0	0	56,873
		1967	0	6,022	0	6,022
	H.S.A./Canyon/	1961	0	0	0	0
		1967	10	0	0	10
	H.S.A./O'Brien Sand, lower/ (Trans. to Ward-Estes, North)	1961	16,875	0	0	16,875
		1967	0	0	0	0
	H.S.A./Penn./	1961	0	0	0	0
		1967	2,397	0	0	2,397
	H.S.A./3050 Queen/	1961	0	0	0	0
		1967	0	5,468	0	5,468
	Hendrick	1961	442,000	0	0	442,000
		1967	–	–	–	–

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	DISPOSAL SURFACE PITS	DISPOSAL INJECTION WELLS	DISPOSAL OTHER METHODS	TOTAL BRINE PRODUCTION
	Magnolia Sealy	1961	158,278	575,445	0	733,723
		1967	0	1,095,449	0	1,095,449
	Magnolia Sealy, S.	1961	327,853	543,485	0	871,338
		1967	769,150	2,303,575	0	3,072,725
	Pyote	1961	0	53,500	0	53,500
		1967	0	40,150	0	40,150
	Sealy, South/Yates/	1961	36,260	0	0	36,260
		1967	5,140	36,932	0	42,072
	Ward-Estes, north	1961	2,978,080	23,898,838	0	26,896,918
		1967	757,636	64,300,257	0	65,057,893
	Wickett, S./Yates/	1961	23,521	0	0	23,521
		1967	18,250	209,015	0	227,265
		Total 1961	4,059,740	25,071,268	0	29,131,008
		Total 1967	1,552,583	67,996,868	0	69,549,451
21	Monahans/Clearfork/	1961	—	—	—	—
		1967	0	249,854	0	249,854
	Monahans/Devonian/	1961	—	—	—	—
		1967	0	8,574	0	8,574
	Monahans/Ellenburger/	1961	—	—	—	—
		1967	0	185,901	0	185,901
	Monahans/Fusselman/	1961	0	765,000	0	765,000
		1967	0	101,146	0	101,146
	Monahans/Queen Sand/	1961	241	0	0	241
		1967	5,250	306,620	0	311,870
	Monahans/Permian TUBB I/	1961	—	—	—	—
		1967	0	705	0	705
	Monahans/Permian TUBB II/	1961	—	—	—	—
		1967	0	838	0	838
	Monahans/Permian TUBB III/	1961	—	—	—	—
		1967	0	24,248	0	24,248
	Monahans/Waddell/	1961	0	0	0	0
		1967	0	8,510	0	8,510
	Monahans, N./Penn./	1961	0	0	0	0
		1967	80,300	0	0	80,300

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	SURFACE PITS	DISPOSAL INJECTION WELLS	OTHER METHODS	TOTAL BRINE PRODUCTION
	Triple -S/8725 Penn./	1961	0	0	0	0
		1967	19,400	0	0	19,400
		Total 1961	241	765,000	0	765,241
		Total 1967	104,950	886,396	0	991,346
22	Wickett/Wolfcamp/	1961	0	0	0	0
		1967	15,314	0	0	15,314
		Total 1961	0	0	0	0
		Total 1967	15,314	0	0	15,314
23	C & M/Queen/	1961	0	0	0	0
		1967	0	8,395	0	8,395
		Total 1961	0	0	0	0
		Total 1967	0	8,395	0	8,395
24	Monahans, W/Devonian/	1961	0	0	0	0
		1967	2,920	0	0	2,920
	Monahans, W/3075 Queen/	1961	0	0	0	0
		1967	7,018	6,406	0	13,424
		Total 1961	0	0	0	0
		Total 1967	9,938	6,406	0	16,344
25	Monahans, S./Queen/	1961	4,372	0	0	4,372
		1967	0	156,541	0	156,541
		Total 1961	4,372	0	0	4,372
		Total 1967	0	156,541	0	156,541
26	Janelle/Devonian/	1961	1,824	0	0	1,824
		1967	—	—	—	—
	Janelle/Wichita Albany/	1961	20,988	0	0	20,988
		1967	7,209	636	0	7,845
	Janelle, SE/Ellenburger/	1961	0	0	0	0
		1967	0	15,501	0	15,501
	Janelle, SE/TUBB/	1961	0	0	0	0
		1967	34,437	37,667	0	72,104
26	Janelle, SE/Waddell/	1961	0	0	0	0
		1967	600	9,413	0	10,013
		Total 1961	22,812	0	0	22,812
		Total 1967	42,246	63,217	0	105,463

Table 5.—Reported Brine Production and Disposal in 1961 and 1967—Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	SURFACE PITS	DISPOSAL INJECTION WELLS	OTHER METHODS	TOTAL BRINE PRODUCTION
27	Crawar/TUBB/	1961	76	0	0	76
		1967	3,650	0	0	3,650
	Crawar/Devonian, north/	1961	8,092	0	0	8,092
		1967	59,392	0	0	59,392
	Crawar/Ellenburger/	1961	84,140	0	0	84,140
		1967	5,475	0	0	5,475
	Crawar/Fusselman/	1961	0	0	0	0
		1967	74,233	20,724	0	94,957
	Crawar/Waddell/	1961	2,523	0	0	2,523
		1967	0	0	0	0
	Crawar, W./Devonian/	1961	0	0	0	0
		1967	27,375	0	0	27,375
		Total 1961	94,831	0	0	94,831
		Total 1967	170,125	20,724	0	190,849
28	Sand Hills, W./Devonian/	1961	394	0	0	394
		1967	0	24,365	0	24,365
		Total 1961	394	0	0	394
		Total 1967	0	24,365	0	24,365
29	Shipley/3900 Clear Fork/	1961	0	0	0	0
		1967	49,275	45,220	0	94,495
	Shipley/Glorieta/	1961	0	0	0	0
		1967	6,242	12,109	0	18,351
	Shipley/Queen Sand/	1961	249,555	3,262,860	12,045	3,524,460
		1967	1,204,302	4,258,083	0	5,462,385
	Shipley/Silurian/	1961	—	—	—	—
		1967	0	6,000	0	6,000
		Total 1961	249,555	3,262,860	12,045	3,524,460
		Total 1967	1,259,819	4,321,412	0	5,581,231
30	Dorr/Queen Sand/	1961	20,680	0	0	20,680
		1967	7,350	0	0	7,350
		Total 1961	20,680	0	0	20,680
		Total 1967	7,350	0	0	7,350
31	Pecos Valley High Gravity	1961	434,504	0	0	434,504
		1967	231,846	95,920	0	327,766
		Total 1961	434,504	0	0	434,504
		Total 1967	231,846	95,920	0	327,766

Table 5.--Reported Brine Production and Disposal in 1961 and 1967--Continued

AREA SHOWN ON FIGURE 23	FIELD	YEAR BRINE WAS PRODUCED	DISPOSAL SURFACE PITS	DISPOSAL INJECTION WELLS	DISPOSAL OTHER METHODS	TOTAL BRINE PRODUCTION
32	Payton	1961	168,830	3,401,800	0	3,570,630
		1967	132,720	0	2,920	135,640
	Payton/Devonian/	1961	0	0	0	0
		1967	364	3,614	0	3,978
	Payton/Mississippian/	1961	0	0	0	0
		1967	0	0	0	0
		Total 1961	168,830	3,401,800	0	3,570,630
		Total 1967	133,084	3,614	2,920	139,618
	County totals	1961	12,053,147	44,470,254	63,191	56,586,592
		1967	5,113,244	82,655,792	17,931	87,786,967

Water that is produced in oil fields other than those overlying the Capitan reef normally had a very high mineral content and a high chloride-sulfate ratio. Examination of the specific conductance and chloride-sulfate ratio in water sampled from wells tapping the Allurosa aquifer during the present or previous investigations (Figure 21 and Table 8) indicated that, in addition to YX-46-32-903, 11 other wells have been contaminated, presumably from oil-field brine. The chloride-sulfate ratios exceeded 10 in 6 of the samples indicating those wells are highly contaminated. Six of the contaminated wells are in area 19 on Figure 23. The volume of brine that was pitted in oil fields in that area during 1961 and 1967 totaled 6,256,682 and 22,746 barrels, respectively.

A marked degradation in the chemical quality of ground water apparently has not occurred except locally. It is possible that contamination may be more extensive than is indicated by Figure 23 because of the low velocity of movement of the ground water. Brine that is placed in a pit may not affect the chemical quality of the water in wells nearby for many years. Moreover, in some areas of surface-disposal pits, wells either were not available or were not sampled.

A statewide "no pit" order was issued by the Railroad Commission of Texas effective January 1,1969. As a result of this order, nearly all of the brine is now being injected into disposal or repressurizing wells. However, contamination will continue for some time because of the large amounts of brine already placed in surface pits.

Contamination From Improperly Cased Wells

Improperly or inadequately cased oil and gas wells are potential sources of contamination of the ground-water supplies. The Oil and Gas Division of the Railroad Commission of Texas is responsible for seeing that oil and gas wells are properly constructed, and the Texas Water Development Board furnishes ground-water data to oil operators and to the Railroad Commission in order that all fresh water may be protected. The term "fresh water" is considered by the surface-casing program of the Texas Water Development Board to include water of usable quality. The term "usable" is rather indefinite in that the qualitative limits differ from place to place in the State. In Ward County, the term "water of usable quality" denotes water that may be of satisfactory quality for domestic, livestock, irrigation, or public-supply purposes or for some restricted industrial purposes. Thus, water of usable quality in Ward County may contain as much as 10,000 mg/l dissolved solids.

The Railroad Commission requires that strata containing usable water be protected by surface casing or new or reconditioned pipe and cement, or by other protective devices. The amount of protection required in the county differs from place to place, but generally casing and cement is required to a depth of a few tens of feet below the base of the Allurosa aquifer, which is the base of the Santa Rosa Sandstone or base of the alluvium where the Santa Rosa is absent.

One of the larger oil fields in the county, the South Ward Field (in area 19, Figure 23), has field rules requiring a minimum of 450 feet of surface casing. Inasmuch as the base of the Allurosa aquifer is 920 feet below the surface in parts of the field, the minimum surface-casing requirement is deficient by as much as 470 feet. Of principal concern is the fact that many of the oil wells in that area have been converted to injection wells for secondary recovery of oil. Injection of oil-field brines into wells for purposes of either secondary recovery or brine disposal is a potential source of contamination of ground water in other fields in the county in which some of the wells may be inadequately cased.

The locations of four oil tests that were abandoned without being plugged are shown in Figure 23. One of the tests, YX-46-38-601, has been flowing very saline water since 1923 when it was drilled. Another test, located 5 miles northwest of Grandfalls, has flowed oil and salt water for several years. Of principal concern is the fact that this test is about half a mile southwest of well YX-45-33-812, which is the major source of water for residents in Grandfalls. The problem of plugging abandoned oil tests will become more acute with time as many of the older fields in the county are in the late stage of production.

Water in the Allurosa aquifer in the vicinity of the Montex Chemical Plant, 3 miles south of Monahans, has been contaminated, presumably by brine that is produced at the plant. Nine small-capacity wells which tap the Allurosa supply the plant. Three of the wells, YX-45-25-909, 910, and 911, were inventoried during the current investigation. Chemical analyses of water sampled from wells YX-45-25-909 and 911 in 1967 (Table 8 and Figure 21), showed chloride concentrations of 31,500 and 41,000 mg/l, respectively.

The brine well (YX-45-25-912) at the plant, is believed to be the source of the contamination that is evident in the analyses. When inventoried in December 1967, the brine well reportedly had 8 5/8-inch casing from the surface to 92 feet. The surface casing was cemented to the wall of the well. The well had 5½-inch casing from the surface to 1,008 feet, and had open-hole completion from 1,008 feet to 1,750 feet in the Salado Formation. The brine was produced by injecting water through the 5½-inch casing and jetting the salt back to the surface through tubing inside the 5½-inch casing. Inasmuch as the base of the Allurosa aquifer is about 270 feet below the land surface at the brine plant, the length of surface casing in the brine well was inadequate to prevent leakage of salt water into the fresh-water sands.

The owner of the plant was subsequently notified of the contamination problem. On December 12, 1967, he reported that the 5½-inch casing had been cemented from 356 feet to the surface with 140 sacks of cement. It was agreed that water samples should be taken periodically from the supply wells to determine if the source of contamination had been successfully eliminated.

Salt-Water Encroachment

The well fields supplying the cities of Pyote and Pecos are both about 1 mile east of the western boundary of fresh water in the Monument Draw trough. Encroachment of saline water into these well fields could occur in the future, depending upon the rate at which the wells are pumped or additional development that could cause the cone of influence of pumping to intersect the fresh water-saline water boundary. The vertical movement of water of inferior quality that underlies the fresh water body may also be a potential problem.

AVAILABILITY OF GROUND WATER

An estimated 10 million acre-feet of water is stored in the Allurosa aquifer in Ward County. However, much of the water in storage, particularly in the alluvial deposits along the Pecos River, is too highly mineralized for drinking and can be used only to irrigate the more salt-tolerant crops. In addition to the water in storage, the Allurosa aquifer received about 12,000 acre-feet of natural recharge per year, or slightly more than one-half of the total amount pumped from the aquifer in 1967.

The principal supply of fresh water, about 4 million acre-feet, is stored in the alluvial fill in the Monument Draw trough. During 1967, approximately 8,000 acre-feet of water was pumped from these deposits. Additional development is anticipated, most of which will likely be in the area south of Highway 80 and east of Monument Draw on land owned by the University of Texas.

Data are not available to determine the water-supply potential of the other water-bearing formations such as the Rustler Formation and Capitan Limestone. These aquifers are important primarily as a source of saline water for secondary recovery of oil.

SUMMARY AND CONCLUSIONS

Three major aquifers underlie Ward County—the Allurosa aquifer, the Rustler Formation, and the Capitan reef. The Allurosa, the principal aquifer, supplied 22,600 acre-feet of water to wells during 1967. Pumpage from the Capitan reef and Rustler Formation was 9,500 acre-feet and 2,300 acre-feet, respectively.

Yields from wells in the Allurosa aquifer range from less than 10 gpm to more than 1,500 gpm. The highest yields are obtained from wells tapping alluvial deposits along the Pecos River. Wells tapping the Santa Rosa Sandstone on the structural high that separates the Pecos and Monument Draw troughs are the least productive. Large yields are obtained from wells tapping the Capitan Limestone, and moderate to large yields are pumped from the Rustler Formation.

The quality of water in the Allurosa aquifer varies widely. Water stored in the dune deposits in the northeastern corner of the county has the least mineralization, generally containing less than 500 mg/l dissolved solids. Water in the alluvial deposits along the Pecos River is moderately to very saline. The water is highly mineralized in deposits beneath and bordering Soda Lake and Sodium Sulfate Lake, and in areas where it has been contaminated by oil-field brine. Fresh to slightly saline water can be obtained in most of the remainder of the county.

The water in the Rustler Formation along the south-central edge of the county is suitable for irrigation. Wells tapping the Rustler in the eastern third of the county yield very saline water and brine suitable only for secondary recovery of oil.

The Capitan reef yields moderately to very saline water which is highly corrosive. For this reason and because of the great depth to the top of the reef (about 3,000 feet), additional development of this aquifer is not anticipated.

The ground-water resources of Ward County are adequate to supply the present rate of demand and support a two or three-fold increase in withdrawals.

The agricultural economy of the county is largely dependent upon surface water diverted from the Pecos River. The supply is undependable, is generally declining, and is practically nonexistent during periods of drought. A program of saltcedar control begun in 1969 may regain as much as 40,000 acre-feet of water per year which was being consumed along the river embankments and flood plain in Ward County.

Lining of irrigation canals would prevent seepage losses which average more than half the flow diverted from the river, but would also greatly reduce recharge of the Allurosa aquifer.

In order to keep abreast of changes in water levels and possible salt-water encroachment into the aquifers, a continuing program of water-level measurement and ground-water sampling for chemical analysis is recommended.

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Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas

All wells drilled unless otherwise noted in Remarks column.
Water level : Reported water levels given in feet; measured water levels given to tenth of a foot and hundreths of a foot in observation well; R, reported.
Method of lift and type of power: C, cylinder; Cf, centrifugal; E, electric; G, gasoline, butane or Diesel engine; H, hand; J, jet; N, none; Ng, natural gas; S, submergible; T, turbine; W, windmill. Number indicates horsepower.
Use of water : D, domestic; Ind, industrial; Irr, irrigation; N, none; P, public supply; S, livestock.
Water-bearing unit : A, Allurosa aquifer; Pr, Rustler Formation; Ps, Salado Formation; Pc, Capitan Limestone (reef complex and associated limestone); Psr, Seven Rivers Formation.

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
Ward County												
*YX-45-17-701	Cactus Cattle Co.	W. E. (Bud) Tone	1962	403	8	A	2,646	66.7	Apr. 14, 1967	S,E, 5	Irr S	Irrigated 3 acres of grass and watered 28 head of hogs in 1967. Pumped 53 gpm for 101 hours and had 32.5 feet of drawdown Apr. 24-28, 1967.
* 702	H. A. Clements	Layne-Texas Co.	1947	284	4	A	2,650	--	--	C,W	S	Drilled as test hole 3-A. Cased to 180 ft, open hole 180 to 284 ft. Base of alluvium at 119 ft. 1/
703	do	do	1947	322	10	A	2,650	78.0	Apr. 7, 1967	N	N	Drilled as test hole 3-AB for Texas Electric Service Co. Set and cemented 137 ft of 10 3/4-in. casing. Open hole 137 to 322 ft. Reported pumped 50 gpm and had 54 ft of drawdown.
* 801	Sealy-Smith Foundation	--	old	64	7	A	2,634	40.34 41.62	Mar. 6, 1956 Dec. 30, 1967	C,W	S	Well W-66 in Pecos River Joint Investigation (P. R. J. Inv.) called "Honky Tonk" well. 60 ft of 2-in. column pipe. Measured discharge 3.4 gpm 4-28-67. Current Texas Water Development Board Observation Well. 2/

See footnotes at end of table

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-17-902	El Paso Nat. Gas. Co.	A. T. Wilhite	1949	129	8	A	2,669	45 R	Mar. 15, 1967	T,E, 5	Ind	Wells YX-45-17-902, 903, 904, 905, and 906 supply Sealy-Smith Gasoline Plant. Plant well No. 6. Driller's log: sand, surface to 47 ft; red sand, shale and gravel (Triassic) 47-129 ft. Casing perforated 49-129 ft. Reported discharge 15 gpm. Water has gassy taste and odor. Plant employees haul drinking water from Monahans. 1/
* 903	do	--	1954	120	12	A	--	47 R	Mar. 15, 1967	T,E, 7 1/2	Ind	Plant well No. 8. Driller's log: sand and sandy clay, surface to 52 ft; redbeds (Triassic) 52-120 ft. Casing perforated 80-115 ft. Reported discharge 10 gpm 3-15-67. Water has gassy taste and odor. 1/
* 904	do	J. D. Cole	--	126	10	A	--	53 R	Mar. 15, 1967	T,E, 7 1/2	Ind	Plant well No. 9. Casing perforated 74-113 ft. Gravel packed. Reported drawdown of 27 ft pumping 40 gpm for 1 hour 3-15-67. 1/
* 905	do	Dixon Pump and Equipment Co.	1962	123	8	A	--	51 R	Mar. 15, 1967	T,E, 5	Ind	Plant well No. 10. Casing perforated 64-81 and 116-120 ft. Gravel packed. Reported drawdown of 44 ft pumping 39 gpm for 1 hour 3-15-67. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-17-906	El Paso Nat. Gas. Co.	Pete Hill	1949	442	16	A	--	40 R 80 R	June 2, 1949 Mar. 15, 1967	T,E, 5	Ind	Plant well No. 2. Casing perforated 50-56 ft. Open hole 67-442 ft. Driller reported no water below 110 ft. Reported drawdown of 70 ft pumping 43 gpm for 1 hour 6-2-49. Drawdown of 34 ft pumping 14 gpm for 1 hour 3-15-67. 1/
907	Sealy-Smith Foundation	Shell Oil Co.	1947	10	--	A	2,716	9.9 9.6	July 4, 1957 May 17, 1967	N	S	Pit bulldozed 10 foot deep in dune sand. Well No. H-70 in Winkler County report.
909	do		old	90	7	A	2,659	30.4	Apr. 7, 1967	C,W	S	Called "Bull Well." 60 ft of 2 1/2-in. column pipe.
910	Shell Oil Co.	Sharp Drlg. Co.	1959	850	8	Pr	2,705	180 R	Dec. 17, 1959	S,E, 50	Ind	Sealy-Smith water well No. 1. Open hole 776-850 ft. Supplies water for secondary recovery of oil in the Monahans field.
* 18-701	Sealy-Smith Foundation	Shell Oil Co.	1948	10		A	2,736	13.0 13.0	July 4, 1957 Apr. 8, 1967	N	S	Pit bulldozed in dune sand. Well H-68 in Winkler Co. report.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-18-801	Monahans Sand Hills State Park	R. C. (Dick) Murray	1957	75	8	A	--	28.0	Apr. 7, 1967	C,W	P	Cased to 44 ft. Casing cemented to wall of well. Open hole 44-75 ft. Driller reported white (eolian) sand, surface to 40 ft; red clay 40-45 ft; red sand 45-50 ft; red clay 50-55 ft; red sand and gravel 55-73 ft; and red clay 73-75 ft. Reported tested at 35 gpm when drilled. Water from shallow sands reported to be gyppy. Water from deeper sands has a very low content of dissolved minerals. 1/
802	do	Shell Oil Co.	1956	63	6	A	2,745	22.3	Sept. 2, 1967	N	N	Supplied water for drilling Shell Oil Co. Sealy-Smith well A-1. Reported supplied plenty of water for drilling the well. Has not been used since.
* 901	F. L. Williams	--	1930±	81	6	A	2,760	60.3 60.1	Mar. 22, 1940 Mar. 16, 1967	C,W	S	Called "Polk Bagley" well. Well W-87 in P.R.J. Inv. 3-inch column pipe. Estimated discharge 36 gpm 3-16-67.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-101	H. A. Clements	W. E. (Bud) Tone	1962	485	8	A	2,640	97.1	Apr. 7, 1967	S,E, 7 1/2	D,S	Drilled to replace a well 250 ft deep at this location when the water became salty. Casing cemented from the surface to 135 ft. Open hole 135-485 ft.
102	Gulf Oil Corp.	J. R. Marshall	1934	350	8	A	2,672	134.1	June 23, 1967	N	N	Well W-58 in P. R. J. Inv. Casing perforated 171-195, 265-288, and 312-326 ft. Supplied water for drilling oil tests. 1/
* 103	G. W. O'Brien Est.	--	1937	157	6	A	2,665	118.2 122.6	May 3, 1940 June 23, 1967	N	N	Well W-58 in P. R. J. Inv. Originally drilled for oil-field supply. Was used for livestock supply until 1965, when column pipe stuck in casing. Reported to have been a strong well.
104	do	Layne-Texas Co.	1947	334	4	A	2,676	121.0	Sept. 27, 1967	N	N	Drilled as test well for Texas Electric Service Co. Cased to 224 ft; open hole 224-334 ft.
105	do	do	do	320	10	A	2,658	93.7	Sept. 27, 1967	N	N	Drilled as test well for Texas Electric Co. Set and cemented 188 ft of 10 3/4-in. casing. Open hole 188-320 feet. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-201	Byron Jackson Co.	--	1937	95	6	A	2,602	61.6	Apr. 12, 1967	S,E, 2	Ind	Well W-69 in P. R. J. Inv. formerly supplied Texas-New Mexico pipeline camp. Cased to 59 ft; open hole 59-95 feet.
* 202	Texas-New Mexico Pipeline Co.	--	1937	86	6	A	--	36 R	Apr. 1937	S,E, 2	Ind	Well W-67 in P. R. J. Inv.
203	Texas Electric Service Co.	Layne-Texas Co.	1947	294	8	A	2,603	62.0	Aug. 30, 1967	T,E, 15	Ind	Company well 29-A. Casing: 10 3/4 in. to 101 ft, cemented; 8 5/8-in. surface to 294 ft; slotted 175-285 ft. Gravel packed. Reported pumped 71 gpm and had 11 ft of drawdown in Aug., 1967. 1/
* 301	L. G. Brine and Water Sales Co.	Harry McMahen	1962	134	6	A	--	40 R	Oct. 1962	T,E, 10	Ind	Cased to 90 ft, open hole 90-134 ft. Reported discharge 100 gpm. Water has salty taste.
* 302	R. C. (Dick) Murray	Owner	1958	123	8	A	2,610	52.0	Apr. 13, 1967	S,E, 1	D	Open hole 100-123 ft. Estimated yield 15 gpm.
303	W. S. Roberts	E. T. (Gene) Watkins	1948	93	6	A	2,610	21 R 1948 52.2 Apr. 13, 1967		N	N	Replaced well W-26 in P. R. J. Inv. Cased to 86 ft; open hole 86-93 ft. Reported well was abandoned in 1953 because of the large decline in water level and a deterioration in water quality.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-304	Lena Brown (Bronies Grocery Store)	J. J. Harrell	1939	110	8	A	--	45.4	Apr. 13, 1967	S,E, 1	D	Well W-70 in P. R. J. Inv. Formerly owned by city of Monahans. Open hole 72-110 ft. Reported pumped 75 gpm for 72 hours and had a drawdown of 45 ft in 1940. 1/
* 305	Monahans Brine Co.	W. E. (Bud) Tone	1965	176	6	A	2,617	46.6	Apr. 12, 1967	S,E	Ind	Casing: 10 3/4-in. surface to 72 ft, cemented; 6-in. to 176 ft; perforated 85-103, and 130-176 ft. Reported pumped 125 gpm for 8 hours and had 55 ft drawdown. 1/
* 306	City of Monahans (Monahans Country Club)	R. C. (Dick) Murray	1954	160	10	A	2,632	43.5	Apr. 12, 1967	T,E, 10	Irr	Casing: 20-in. surface to 65 ft, cemented; 10-in to 160 ft; perforated 65-160 ft. Leased to Monahans Country Club for irrigating golf course. Reported discharge 100 gpm.
307	do	--	1946	150	8	A	--	--	--	T,E, 7 1/2	Irr	4-in. column pipe. Reported discharges 70 gpm.
* 308	Monahans Country Club	--	1944	150	8	A	--	--	--	T,E, 7 1/2	Irr	Do.
309	do	--	1946	150	8	A	--	--	--	T,E 5	Irr	
310	City of Monahans (Monahans Country Club)	--	1946	170	8	A	2,630	45.0	Apr. 12, 1967	T,E, 5	Irr	

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-311	City of Monahans (Monahans Country Club)	--	1945	150	8	A	--	--	--	T,E, 7 1/2	Irr	
* 312	City of Monahans	Frank Gaylon	1948	149	8	A	2,609	49 R 62.4	Mar. 1948 Apr. 10, 1967	N	N	Abandoned municipal well No. 3-5. Casing perforated 79-149 ft. Reported discharged 100 gpm in 1964. Decline of 13 feet in water level since 1948 reflects municipal pumping.
* 313	do	do	1948	160	8	A	--	--	--	T,E, 40	P	City well 3-6. Combined discharge of wells YX-45-25-313, 315, 316, 603, 604, 605 in use in city's west Monahans field was 800 gpm (133 gpm/well) in Apr. 67.
* 314	do	do	1948	160	16	A	2,610	63.8	Apr. 10, 1967	N	N	Abandoned city well 3-7.
* 315	City of Monahans	R. C. (Dick) Murray	1952	221	14	A	2,607	--	--	T,E, 15	P	City well 3-8. Casing perforated 121-221 ft. Chemical analyses show the quality of water in the west Monahans well-field has progressively deteriorated.
* 316	do	do	1955	165	10	A	2,603	72 R	Oct. 20, 1959	T,E, 20	P	City well 3-10. Casing: 20-in. to 65 ft, cemented; 10-3/4 in. surface to 165 ft; slotted 65 to 165 ft. Reported tested at 450 gpm when drilled.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-317	City of Monahans	J. C. Lewis	1951	160	20	A	2,610	61.2	May 17, 1967	T,E, 10	Irr	Cemetary well. Originally drilled to 965 feet to test the Rustler Formation. Because the water in the Rustler was unsuitable for public supply, the well was subsequently plugged back to 160 ft. 1/
* 318	Texas & Pacific Railroad	L. F. Buchanan	1937	222	8	A	--	50 R	Nov. 1937	N	N	Well W-71 in P. R. J. Inv. Formerly supplied locomotives. Casing perforated 142-222 ft. 1/
319	do	T. E. Shutt	1928	200	8	A	--	--	--	N	N	Abandoned railroad well. Well W-72 in P. R. J. Inv. 1/
320	Paul De Cleva	J. L. Pettit	1967	1,002	7	--	--	--	--	N	--	Salt water disposal well. Cased to 810 ft. Casing cemented with 350 sacks. Open hole 810 to 1002 ft in Rustler Formation. Top of Triassic at 120 ft. Top of anhydrite (top of Rustler) at 770 ft. Limestone (main water-bearing zone in Rustler) 810 to 855 ft. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-25-321	City of Monahans	Layne-Texas Co.	1946	220	10	A	--	42 R 57.6	Dec. 16, 1946 May 17, 1967	N	N	Old T & P R. R. well No. 7. Casing: 18-in., surface to 80 ft; 10 3/4-in. liner, slotted 97-137 and 170-210 ft. Base of alluvium (top of Triassic) at 84 ft on driller's log. Pumping test by driller 12-16-46: drawdown of 68 ft pumping 192 gpm for 8 hours. 1/
* 322	do	do	1945	221	10	A	2,613	55.7	May 17, 1967	T,E, 10	P	Old T & P R. R. well No. 6. Casing: 20-in. surface to 81 ft; 10 3/4-in. to 221 ft; screened 107-117, 127-149, 163-178, and 187-211 ft. Base of alluvium at 113 ft. Development test by driller 11-20-45: drawdown of 62 ft. pumping 160 gpm for 24 hours. Current (1967) status: stand-by well for municipal supply. 1/
* 323	John Fitch	John Woodfin	1963	100	9	A	--	--	--	T,E, 3	Irr	9 5/8-in. casing to 86 ft, cemented; open hole 86-100 ft. 80 ft of 2 1/2-in. column pipe. Reported discharges 25 gpm. Irrigated 3 acres of pasture in 1967.
* 324	City of Monahans	--	1930	450	--	A	--	47.3	Aug. 13, 1967	N	N	Well W-82 in P. R. J. Inv. Old city well No. 3 at Monahans High School. Reported discharged 80 gpm in 1941.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-325	Coca Cola Bottling Co.	Holt Drlg. Co.	1955	126	10	A	2,616	--	--	T,E, 15	Ind	Cased to 90 ft; open hole 90-126 ft. Casing cemented to wall of well to shut out shallow water which is reported to be gyppy. 1/
326	do	--	--	130	6	A	2,615	47.0	Aug. 17, 1967	S,E	Ind	
401	Gulf Oil Corp.	S. C. Ingham	1937	407	8	A	2,668	136.1	July 25, 1967	N	N	Well W-105 in P. R. J. Inv. Casing perforated 323-376 ft. Open hole 376-407 ft. 1/
* 402	Richardson Oils	W. E. (Bud) Tone	1962	763	10	A	--	118 R	Aug. 1962	T,E, 10	Ind	University Lands water well No. 3. Casing slotted 180-205 and 220-752 ft. Reported discharge 167 gpm.
* 403	Gulf Oil Corp.	J. D. Cole	1952	325	8	A	--	131 R	Jan. 1952	S,E, 40	Ind	O'Brien W. W. No. 22. Casing: 16-in. to 143 ft, cemented with 75 sacks; 8 5/8-in. to 325 ft; perforated 174-185 and 220-322 ft. Gravel-packed with 15 1/2 yards. Metered discharge 8-18-67 was 134 gpm. This well and wells YX-46-32-302 and YX-45-33-106 pumped a reported 4,285,008 gallons in 1966. The water supplies Gulf Oil Corp's Ward-Estes fresh water system. It is used for drilling oil tests; it supplies the Warren-Monahans Gasoline Plant, Gulf's Wickett Field Office, several ranch houses and 22 livestock tanks.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-404	Gulf Oil Corp.	S. C. Ingham	1937	346	10	A	2,668	137.3	Aug. 30, 1967	N	N	Well W-55 in P. R. J. Inv. formerly supplied city of Wickett. Casing: 10 3/4-in. to 326 ft; 8 5/8-in. 306-346 ft; perforated 326-346 ft. Log shows slight amount of water at 140 ft and in interval 145 to 200 ft. Large show of water in interval 222-234 ft. 1/
* 405	Humble Oil and Refining Co.	Owner	1955	650	8	A	2,646	--	--	S,E	Ind	University water well F-3. Casing: 13 3/8-in. to 519 ft; 8 5/8-in. 10-640 ft; perforated 519-640 ft. Open hole 640-650 ft. Reported pumped 200 gpm during a 16 hour development test. Water is used to wash filters at water-flood plant.
406	do	do	1955	624	8	A	2,648	111.1	Sept. 8, 1967	N	N	University water well F-2. Casing: 13-in. to 520 ft; 8 5/8-in. to 624 ft; perforated 499-624 ft. Reported pumped 133 gpm for 6 hours in 1955.
407	do	do	1955	643	8	A	2,650	113.4	Sept. 8, 1967	N	N	University W. W. No. F-1 formerly supplied water for secondary recovery of oil. Casing perforated 495-643 ft.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-25-408	Humble Oil and Refining Co.	Owner	1945	2,753	6	--	1,945	--	--	--	--	University F-14 water injection well. Drilled as oil test. Plugged back to 1,630 ft in Nov. 1953. Gun-perforated 6 5/8-in. casing 1,375-1,381, 1,420-1,479, 1,490-1,540 and 1,570-1,585 ft in Rustler Formation. Acidized with 14,000 gallons HCl. Swabbed 15 barrels water per hour for 5 hours. Temporarily abandoned in Nov. 1953. Cut and pulled 662 ft of casing. Set plug at 677 ft. Gun-perforated casing 560 to 640 ft in Santa Rosa. Pumped 112 gpm. Converted to injection well for secondary recovery of oil from Yates Sandstone in 1963. 1/
409	Ward County Parks Dept.	R. C. (Dick) Murray	1957	240	8	A	--	--	--	T,E, 15	Irr	Casing: 16-in. to 160 ft, cemented; 8 5/8-in. to 240 ft; perforated 60 ft in interval 160-240 ft. Set 190 ft of 4-in. column pipe. Reported discharge 100 gpm. Irrigates park lawns and fills swimming pool.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-501	C. W. Freeman	W. E. (Bud) Tone	1964	200	16	A	--	53 R	Sept. 1964	T,E, 30	Irr	Set and cemented 86 ft of 16-in. casing. Open hole 86-200 ft. 200 ft of 5-in. column pipe. Discharged 200 gpm 5-13-67. Pumping level 181 ft; 1 hour recovery level, 93 ft. Irrigated 110 acres of grain and alfalfa from this well and YX-45-25-502 in 1966.
* 502	do	do	1964	210	12	A	--	53 R	Dec. 1964	T,E, 30	Irr	Open hole 85-210 ft. Water level was 201 ft below the surface pumping 112 gpm 5-13-67. Had been pumping continuously since fall of 1965.
* 503	do	do	--	168	6	A	2,596	60.6	May 13, 1967	T,G	Irr	Open hole 85-168 ft. 160 ft of 4-in. column pipe. 6-in. bowls. Not in use in 1967.
504	C. D. Estes	L. B. Russell	1967	212	6	A	--	50.6 51.9	May 12, 1967 Sept. 26, 1967	S,E, 10	Irr	Set and cemented 70 ft of 8-in. casing set 6 in. to 212 ft; perforated 88-98 and 145-195 ft opposite sand and gravel. Reported will irrigate 20 acres of nursery stock in 1968.
* 505	F. I. Dyer	--	1938	120	6	A	2,589	43.1 52.7 52.3	May 15, 1941 July 25, 1967 Mar. 29, 1968	C,W	S	Called "Division Well." Open hole 10-120 ft. 60 ft of 3-in. column pipe.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-506	F. I. Dyer	--	old	90	6	A	2,580	45.4	July 25, 1967	C,W	S	Called "Middle Well." Open hole 10-90 ft. 60 ft of 2 1/2-in. column pipe.
* 507	City of Monahans	Dixon Pump & Equipment Co.	1949	250	8	A	--	75.3	Aug. 14, 1967	T,E, 25	P	Gulf Oil Corp., Hutching Camp well No. 3. Casing: 10 3/4-in. to 60 ft, cemented with 60 sacks; 8 5/8-in. to 250 ft; perforated 50-250 ft. Pump test by Gulf Oil 5-24-50: drawdown of 48 ft pumping 131 gpm for 48 hours. 222 ft of column pipe. 12 stage, 8-in. bowls.
* 508	do	Flack & Felton	1948	275	8	A	--	81 R	May, 1950	T,E, 15	P	Gulf Oil Corp., Hutching Camp well No. 1. Casing: 10 3/4-in. to 71 ft, cemented with 85 sacks; 8 5/8-in. to 275 ft; perforated 72-275 ft. Pump test by Gulf Oil 5-4-50: drawdown of 53 ft pumping 147 gpm for 24 hours.
* 509	Texas Electric Service Co.	Layne-Texas Co.	1947	300	10	A	2,607	74.8	Sept. 26, 1967	T,E, 30	Ind	Owners well No. 10. Casing: 18-in. to 193 ft, cemented; 10 3/4-in. to 300 ft; perforated 219-300 ft. Gravel packed. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-510	Texas Electric Service Co.	Layne-Texas Co.	1947	150	7	A	2,607	45.8 57.0	Mar. 31, 1947 Sept. 26, 1967	N	N	Owner's well No. 10-A drilled and logged to 444 ft. Pump tested open hole to 286 ft. Drawdowns of 64, 82, and 89 ft, pumping 307, 304 and 306 gpm respectively. Plugged back to 150 ft and shot casing from 66 to 82 ft. ft. Tested at 40 gpm with pump set near bottom. Not used since. 1/
* 511	do	do	1947	266	10	A	2,592	42 R 58.0	May 1947 Aug. 30, 1967	T,E, 20	Ind	Owner's well No. 18 drilled and logged to 324 ft. Plugged back to 266 ft. Set and cemented 18-in. casing to 32 ft. Set 10 3/4-in. to 263 ft. Perforated 51-159, and 178-263 ft. Gravel packed. Pumping 98 gpm with pumping level at 166 ft 8-30-67. Recovery level 58 ft after shut down 1/2 hour. 1/
512	do	do	1947	100	10	A	2,590	53.3	Sept. 26, 1967	N	N	Test well No. 28 drilled and logged to 100 ft. Set 46 ft of 10 3/4-in. casing. Open hole 46-100 ft. Bailed 60 gpm when drilled. 1/
601	City of Monahans	Frank Gaylon	1948	117	14	A	2,605	46.4	Apr. 10, 1967	N	N	Abandoned city well No. 3-2. Casing slotted 79-160 ft.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-25-602	City of Monahans	Frank Gaylon	1948	160	14	A	--	--	--	N	N	Abandoned city well No. 3-3. Pump pulled and well capped 4-21-64.
* 603	do	R. C. (Dick) Murray	1953	140	10	A	2,606	53 R	Oct. 29, 1953	T,E, 7 1/2	P	City well No. 3-9. Top of perforations at 76 ft. Pumping test by Smith Machinery Co., Pecos, Texas: drawdown of 50 ft pumping 137 gpm for 1 hour. 1/
* 604	do	do	1954	156	10	A	2,602	--	--	T,E, 20	P	City well No. 3-11.
* 605	do	do	1954	154	10	A	2,599	--	--	T,E, 15	P	City well No. 3-12. Reported tested at 400 gpm for 72 hours when drilled.
* 606	Texas Highway Dept.	J. D. Cole	1959	171	6	A	2,606	72.2	May 15, 1967	S,E, 3	Ind	Base of alluvium (top of Triassic) at 89 ft. Driller reported water-bearing sands at 50, 63, 80, and 140 ft. Set and cemented 93 ft of 7-in. casing. Open hole 93-171 ft. Reported discharge 30 gpm. Water used to irrigate lawns and to supply office and motor pool. 1/
* 607	O. R. White	L. W. Pulley	1940	102	6	A	2,607	45.1	May 18, 1967	C,W	N	Well W-81 in P. R. J. Inv. Open hole 85-102 ft. Not used for more than 3 years, but may be used in future. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-25-608	P. & N. Trucking Co.	W. E. (Bud) Tone	1964	176	5	A	--	47.6	June 21, 1967	S,E, 2	Ind	Open hole 160-176 ft. 132 ft of 1-in. column pipe. Water used to wash trucks.
* 701	F. I. Dyer	--	old	190	5	A	2,630	112.1	July 25, 1967	C,W	S	Owner's "South Well." Open hole 10-190 ft. 180 ft of 3-in. column pipe.
* 702	Bluford Thornton	--	old	79	6	A	2,595	64.0	Aug. 30, 1967	C,W	S	Well W-99 in P. R. J. Inv. Water level was 65.7 ft in 1940 with the pump shut down 5 minutes.
703	Cabot Corp. Estes Gasoline Plt.	O. C. Reynolds	1937	265	12	A	--	--	--	T,E, 10	Ind	Owner's No. 1 well. Well W-101 in P. R. J. Inv. Casing: 12 1/2-in. to 228 ft; 10 3/4-in. 160-265 ft; perforated 222-265 ft. 1/
* 704	do	do	1937	260	12	A	--	--	--	T,E, 10	Ind	Owner's No. 2 well. Well W-100 in P. R. J. Inv. Casing: 12 1/2-in. to 225 ft; 10 3/4-in. 177 to 260 ft; perforated 219-260 ft. 1/
705	do	J. D. Cole	1955	205	8	A	2,638	99.2	Aug. 30, 1967	T,E, 10	Ind	Owner's No. 3 well. Casing perforated 149-205 ft. 170 ft of 4-in. column pipe. Well is on stand-by status--seldom used.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-706	Cabot Corp. Estes Gasoline Plt.	J. C. Cole	1966	280	10	A	2,640	112.2	Aug. 30, 1967	T,E, 20	Ind.	Owner's No. 4 well. Casing perforated 230-280 ft. Gravel packed. 240 ft of 6-in. column pipe. 8-in. bowls. Reported tested at 525 gpm and had 34 ft of drawdown after 24 hours.
* 707	Transwestern Pipeline Co. Estes Compressor Sta.	Layne-Texas Co.	1960	220	6	A	2,634	104.8	Aug. 30, 1967	T,E, 5	Ind	Gravel packed. 6 5/8-in. casing to 220 ft, screened 195-215 ft. Development test by driller: 25 ft of drawdown pumping 34 gpm for 8 hours.
* 801	W. A. Estes	Nathe Fielding	1908	186	6	A	2,590	80 R	1908	N	N	Well W-93 in P. R. J. Inv. Called "Bledsoe Well." Abandoned in 1953. Reported water had sulfur taste. 1/
* 802	do	Kerr McGee Co.	1950	180	6	A	2,604	84.7	July 24, 1967	C,W	S	Drilled for rig supply. 2-in. column pipe.
* 803	F. I. Dyer		old	90	10	A	2,580	36.7	July 25, 1967	C,W	S	Called "Bitter Well." Water is gyppy.
901	W. B. Morris	E. T. (Gene) Watkins	1944	68	10	A	2,583	39.49 40.66	Feb. 9, 1955 Dec. 30, 1967	N	N	Unused irrigation well. Not pumped since 1959. Current observations well. Reported top of redbeds (Triassic) at 65 ft. Casing perforated 40-68 ft. 2/
902	do	--	1943	100	--	A	--	37.3	Dec. 5, 1959	N	N	Used for irrigation until 1954. Historical observation well. Destroyed.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-903	D. L. Varnnum	Bishop Smith	1965	100	8	A	--	40.8	Apr. 27, 1967	T,E, 10	Irr	Casing perforated 80-100 ft. Gravel packed. 95 ft of 4-in. column pipe. Pump was sucking air discharging an estimated 75 gpm 5-11-67.
* 904	Hutchings Joint Stock Assoc. (Frank Anthony)	--	old	76	5	A	--	60.6	May 11, 1967	C,W	S	Well W-334 in P. R. J. Inv. 3-in. column pipe.
* 904	M. McWorter	Nathe Fielding	1903	167	6	A	2,575	76.6	May 11, 1967	N	N	Well W-90 in P. R. J. Inv. Called "Kethley Well." Formerly used for domestic and livestock supply. 1/
* 906	E. E. Cox	Buster Reed	1956	220	6	A	2,575	83.5	May 11, 1967	S,E, 1	D	Casing perforated 105-220 ft. Pump set at 140 ft.
* 907	A. D. Freeman	John Woodfin	1965	126	6	A	2,573	51.2	May 12, 1967	S,E, 2	Irr	Reported hard red shale at 116 ft (top of Triassic). First water sand at 60 ft (in alluvium). Second water sand at 120 ft (Triassic). Set and cemented 6-in. casing to 70 ft. Open hole 70-126 ft. 108 ft of 2-in. column pipe. Drawdown of 54 ft pumping 15 gpm for 2 hours 5-12-67. Irrigated 2 acres of barley in 1967.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-25-908	C. G. Myers	Buster Reed	1963	250	6	A	2,582	--	--	S,E	D,S	Water level was 73.9 ft below the surface 6-21-67 with well shut down 1/2 hour. Water reported not suitable for drinking--has high sulfate content.
* 909	Montex Chemical Co.	do	1963	100	6	A	--	44.4	June 21, 1967	S,E, 3/4	Ind	Cased to 20 ft, open hole 20-100 ft. Discharged 11 gpm 6-21-67. Water has salty taste.
910	do	do	1962	300	6	A	2,582	56.3	June 21, 1967	S,E, 1 1/2	Ind	Cased to 115 ft, open hole 115-300 ft. Discharged 15 gpm 6-21-67. Specific conductance of water was 23,300.
* 911	do	do	1963	100	6	A	2,582	44.6	June 21, 1967	S,E, 3/4	Ind	Cased to 20 ft, open hole 20-100 ft. Discharged 15 gpm 6-21-67. Water is salty.
* 912	do	Gulf Oil Corp.	1957	1,750	5	Ps	2,582	--	--	--	--	Reported drilled as formation test in 1957. Set and cemented 8 5/8-in. casing to 92 ft, open hole 1,008-1,750 ft. Converted to injection well for recovering salt from the Salado Formation in 1963.
* 913	George Brown	Buster Reed	1961	200	8	A	--	44.8	Dec. 9, 1967	S,E, 1	D	Cased to 70 ft, open hole 70-200 ft.
26-101	Troy Hanson (Hanson Motel)	Frank Gaylon	1950	180	16	A	2,645	40.6	Apr. 8, 1967	T,E, 1	N	Casing perforated 90-130 ft. Intends to irrigate pecan trees. Not used in 1967.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-26-102	Sealy-Smith Foundation (Vest Ranch)	--	old	90	10	A	2,663	36.4	Apr. 6, 1967	C,W	S	Called "Demster Well." 80 ft of 2 1/2-in. column pipe.
* 103	J. H. Edwards and Sons	Gulf Oil Corp.	1945	150	10	A	2,665	47.3	May 15, 1967	S,E, 1	D,S	Headquarters well. Open hole 125-150 ft. Supplied water for drilling Gulf Oil Corp's. Edwards No. 1-E. oil test. 60 ft of 2-in. column pipe.
* 201	Monahans Sand Hills State Park	--	1900±	72	--	A	2,707	44.6	May 16, 1940	N	N	Formerly supplied railroad section house. The section house was moved (now headquarters at Sand Hills Park) and the well was destroyed in 1957.
* 202	Sealy-Smith Foundation	--	old	80	10	A	2,682	44.2	May 18, 1967	C,W	S	Called "Railroad Well." Reported water is good quality.
* 401	Frank Anthony	John Woodfin	1965	130	6	A	2,622	51.7	May 15, 1967	S,E, 1	D	Ranch headquarters well. Cased to 80 ft, open hole 80-130 ft. Reported tested at 18 gpm (maximum capacity) for 1 1/2 hours when drilled.
* 501	do		old	80	6	A	2,616	48.7	do	C,W	S	Section 18 well.
* 502	J. H. Edwards and Sons	Robinson Drlg. Co.	1954	124	6	A	2,643	56.4	do	C,W	S	Called "4-Section Well." Open hole 109-124 ft.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-26-701	Lewis Rochester & J. E. Perkins	--	1955	213	18	A	2,560	44.22 57.90	Feb. 9, 1955 May 16, 1967	T,G	Irr	Current observation well. Casing perforated 140-213 ft. Irrigated 415 pecan trees in 1967. Drawdown of 57 ft pumping 75 gpm for 14 hours, May 15-16, 1967. 2/
702	C. J. Middleton	Frank Gaylon	--	933	16	Pr	2,561	45.2	May 12, 1967	N	N	Drilled to test Rustler Formation for irrigation. Bailed sample 5-12-67. Water contained 8,400 mg/l chlorides. Not suitable for irrigation and most other purposes.
* 703	M. E. Bingham	--	1963	150	5	A	2,563	46.5	May 11, 1967	S,E, 1	D	Well had been pumping recently when water level was measured.
* 801	W. I. Winter	--	old	95	8	A	--	42.9	do	C,W	S	Wooden tower.
* 901	J. H. Edwards and Sons	Shell Oil Co.	1950	165	6	A	2,589	40.8	do	C,W	S	Supplied water for drilling Shell Oil Co. Janelle Edwards, et. al. No. 1 oil test. Converted to livestock well. Equipped with 50 ft of 2 1/2-in. column pipe. Discharging 2 gpm 5-11-67.
33-101	Standard Oil Co. of Texas	Prince Bros. Drlg. Co.	1936	157	10	A	2,579	79.16 84.99	June 23, 1948 Dec. 30, 1967	N	N	Casing perforated 116-157 ft. Formerly used for drilling rig supply. Current observation well. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-102	Gulf Oil Corp.	S. C. Ingham	1937	175	8	A	2,609	95.8 100.8	May 17, 1940 June 26, 1967	N	N	Well W-97 in P. R. J. Inv. Casing perforated 113-175 ft. Formerly supplied drilling rigs. Reportedly jetted 36 gpm from well in 1940.
* 103	Standard Oil Co. of Texas	--	1936	157	8	A	2,584	90.8	July 24, 1967	T,E, 20	Ind	McFarland water well No. 1. Casing perforated 116-157 ft. Water used to wash filters, engines, and for secondary recovery of oil.
* 104	Petr. Corp. of Texas	Moore & Russell Drlg. Co.	1955	360	10	A	--	101.2	Aug. 9, 1967	T,E, 15	Ind	Trebol Univ. "C" water well No. 1.
* 105	Sinclair Oil & Gas	Eastland Oil Co.	Before 1955	250		A	--	--	--	T,E, 7 1/2	Ind	Hathaway water well No. 1. Discharged 72 gpm 7-27-67.
* 106	Gulf Oil Corp.	W. E. (Bud) Tone	1963	303	8	A	--	95.8	July 25, 1967	S,E, 40	Ind	E. W. Estes water well No. 8. Casing perforated 254-259, and 265-291 ft. Gravel packed. Reported yield 260 gpm. Pumped for oilfield lease supply and livestock water.
* 107	Texaco Inc.	--	1957	250	8	A	--	102 R	Sept. 1957	T,E, 15	Ind	State of Texas "C & E" water well No. 3. Casing perforated 175-250 ft. Water used for secondary recovery of oil.
* 108	Bluford Thornton	--	1941	125	7	A	--	105.0	Dec. 12, 1967	S,E, 1 1/2	D,S	Ranch headquarters well. Estimated yield 15 gpm.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-201	Humble Oil and Refg. Co.	--	1959	409	7	A	2,567	75.1	July 18, 1967	N	N	American National Bank water well No. 1. Formerly supplied water for secondary recovery of oil.
* 202	do	W. E. (Bud) Tone	1961	300		A	--	--	--	T,E, 25	Ind	Louis Richter water well No. 8. Reported tested at 248 gpm when drilled. 1/
* 203	do	do	1964	319	10	A	--	--	--	T,E, 25	Ind	Louis Richter water well No. 12. Casing perforated 224-319 ft. Gravel packed with 132 yards.
204	do	--	1964	308	10	A	2,583	--	--	T,E, 25	Ind	Louis Richter water well No. 13. Casing perforated 208-308 ft. Reported tested at 575 gpm when drilled. Water level in abandoned well (Richter No. 7) 150 ft north was 91.4 ft below land surface 7-18-67.
* 205	Walsh & Watts Inc.	--	--	300	--	A	2,600	105.4	July 18, 1967	T,E, 7 1/2	Ind	Louis Richter "C" water well.
* 206	Skelly Oil Co.	J. D. Cole	--	340	8	A	--	--	--	T,E, 7 1/2	Ind	Hathaway water well No. 3. Reported tested at 88 gpm when drilled. 1/
* 207	Standard Oil Co. of Texas	Atwood-Clark Drlg. Co.	1954	295	13	A	2,610	104 R 108.6	Feb. 1954 July 24, 1967	N	N	Lucy Adams water well No. 3. Casing perforated 81-144, and 207-281 ft. Reported drawdowns of 30 and 66 ft. Pumping 170 and 248 gpm in 1954.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-208	Standard Oil Co. of Texas	W. E. (Bud) Tone	1955	240	13	A	2,612	96 R	Mar. 1967	T,Ng	Ind	Lucy Adams water well No. 4 reported drawdown of 26 ft. Pumping 5000 barrels per day (146 gpm) for 3 months.
* 209	Richardson Oils	Owner	1953	352	10	A	--	90 R	June 1953	T,E, 30	Ind	Hathaway water well No. 6. Drilled 20-in. hole to 352 ft; Set 13 3/8-in. casing to 352 ft, slotted 224-352 ft; set 10 3/4-in. casing to 352 ft, slotted 226-351 ft. Placed 840 yds. of gravel between the wall of the well and 10 3/4-in. casing. Reported pumped 800 gpm for 5 hours and had 17 ft of drawdown; pumped 1,000 gpm for 5 hours and had 23 ft drawdown in June 1953. Reported pumped 70 million gallons for secondary recovery operations on the lease in 1966.
210	Harlan Prod. Co.	J. D. Cole	1957	210	8	A	2,575	79.6	Aug. 28, 1967	S,E, 3	Ind	W. H. Martin water well No. 1. Casing perforated 140-170 ft. Packed with 10 yards of gravel. Set 175 ft of 2-in. column pipe. Used to supply secondary recovery operations through Mar. 1965. Not used since.
211	do	--	1953	127	--	A	--	77 R 80.0	Sept. 18, 1961 Aug. 28, 1967	S,E	Ind	Hathaway water well No. 1. Not used since Nov. 1961.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-212	Sinclair Oil & Gas	J. D. Cole	1959	300	8	A	2,583	100.1	Aug. 28, 1967	S,E, 7 1/2	Ind	W. H. Martin water well No. 2. Casing: 10 3/4-in. to 185 ft, cemented; 8 5/8-in. to 300 ft; perforated 190-300 ft. Reported bailed 60 gpm for 3 hours and had 40 ft drawdown when drilled. 1/
213	do	do	1959	320	10	A	2,585	95.2	do	N	N	W. H. Martin water well No. 1. Set and cemented 10 3/4-in. Cased to 160 ft open hole 160-320 ft. (Pulled 8-in. production casing).
* 214	do	W. E. (Bud) Tone	1960	330	8	A	2,565	74.1	do	S,E, 10	Ind	W. D. Johnson water well No. 1. Casing: 10 3/4-in. to 194 ft, cemented; 8 5/8-in. to 330 ft; perforated 194-223, and 256-298 ft. Tested by Dixon Pump & Equipment Co., 1-6-61. Drawdown of 40 ft pumping 135 gpm for 4 hours.
* 301	Henry Yates	do	1961	259	8	A	--	46.0	July 5, 1967	C,E, 1/3	D	8-in. casing to 112 ft, cemented; open hole 112-259 ft. Set 100 ft of 2 1/2-in. column pipe. Reported discharged 3 gpm. 1/
* 302	W. A. Estes	--	old	117	6	A	2,560	54.6	July 18, 1967	N	N	Unused livestock well. Well W-94 in P. R. J. Inv.
* 303	Humble Oil & Refining Co.	--	1961	411	7	A	--	--	--	T,E, 10	Ind	American National water well No. 3. Reported discharge 21 gpm. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-304	Humble Oil & Refining Co.	--	1961	405	7	A	--	--	--	T,E, 20	Ind	American National water well No. 4. Reported discharge 97 gpm. 1/
* 305	do	--	1961	400	7	A	--	--	--	T,E, 15	Ind	American National water well No. 5. Reported discharged 107 gpm in Feb. 1967. 1/
* 401	J. C. Cunningham	Clyde Wood	1963	250	12	A	2,586	99.3	June 23, 1967	T,Ng	Irr	Casing perforated 100-250 ft. Set 220 ft of 8-in. column pipe. Drawdown of 37.4 ft discharging 555 gpm for 3 hours June 22, 1967.
* 402	Pan American Petr. Co.	Noll Drlg. Co.	1961	168	8	A	--	--	--	T,E	Ind	Byrd water well No. 1. 40 ft of perforated casing, interval not known. Gravel packed. Set 146 ft of column pipe. Discharged 25 gpm Aug. 22, 1967. 1/
* 501	D. B. Durgin (Bluford Thornton)	--	1910	71	6	A	2,541	46.88 52.94	Jan. 3, 1949 Dec. 30, 1967	C,W	S	Called "Shetland Well." Current observation well. 2/
502	Richardson Oils	--	1934	116	8	A	2,562	68.27 75.74	Jan. 3, 1949 Dec. 30, 1967	C,W	N	Current observation well. 2/
503	Prince Bros. Drlg. Co.	--	old	170	5	A	2,540	51.38	Jan. 24, 1954	N	N	Historical observation well. Obstruction in casing at 50 ft in 1967. Formerly supplied oilfield camp.
* 504	Standard Oil Co. of Texas	--	1948	157	9	A	2,556	60.95 68.85	June 23, 1948 July 21, 1967	N	N	Durgin water well No. 1. Historical observation well. Casing perforated 120-150 ft. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-505	Standard Oil Co. of Texas	--	1948	157	9	A	2,558	61.95 70.10	June 23, 1948 July 21, 1967	T,E, 7 1/2	Ind	Durgin Water well No. 2. Historical observation well. Casing perforated 120-151 ft. Reported discharged 120 gpm in 1942. 2/
506	do	--	1948	157	9	A	--	58.83 67.67	June 23, 1948 July 31, 1967	N	N	Durgin water well No. 3. Historical observation well. Casing perforated 119-150 ft. 2/
* 507	Jack Moore	Bishop Smith	1963	230	12	A	2,584	98.0	June 23, 1967	T,G	Irr	Casing perforated 100-230 ft. Drawdown of 34.3 ft pumping 685 gpm for 6 hours 6-23-67. Reported irrigated 228 acres of maize and grass from this well and well YX-45-33-401 in 1967.
508	Humble Oil & Refining Co.	--	1939	277	6	A	2,576	86.0	July 18, 1967	C,E	D	Louis Richter water well No. 5. Casing perforated 245-276 ft. Supplies lease house and shop. 1/
* 509	Prince Bros. Drlg. Co.	Owner	--	155	8	A	2,552	--	--	T,E, 7 1/2	Ind	Owner's No. 2 well. Casing: 12-in. to 73 ft, cemented; 8-in. to 155 ft; perforated 75-155 ft. Reported yield 70 gpm.
510	do	do	1935	155	8	A	2,552	70.8	July 21, 1967	N	N	Owner's No. 1 well. Casing perforated 75-155 ft.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-511	Standard Oil Co. of Texas	Jap Harrell	--	190	10	A	2,550	73 R	Nov. 2, 1950	T,E, 25	Ind	Durgin water well No. 4. Casing perforated 90-184 ft. Gravel packed with 77 yards. Set 160 ft of 6-in. column pipe. Reported discharge 225 gpm. 1/
512	do	Moore & Russell	1951	220	13	A	2,560	71.8	July 21, 1967	T,E, 25	Ind	Durgin water well No. 5. 1/
* 513	Richardson Oils	M. Z. Zimlock Co.	1937	275	8	A	--	--	--	T,Ng	Ind	Johnson "A" water well No. 2. Casing 8-in. to 208 ft; 6-in. 208-275 ft; perforated. 1/
* 514	do	R. C. (Dick) Murray	1951	223	13	A	--	70 R	1951	T,E, 30	Ind	W. D. Johnson "B" water well No. 4. Casing perforated 161-223 ft. Packed with 45 yards of gravel. Set 217 ft of 4-in. column pipe. Reported discharged 240 gpm when drilled.
* 515	Tidewater Oil Co.	W. E. (Bud) Tone	1952	311	16	A	2,587	90 R	1952	T,E, 10	Ind	W. D. Johnson "B" water well No. 4. Casing perforated 185-305 ft. Packed with 18 yards of gravel. Set 277 ft of 4-in. column pipe. Reported pumped 1,500 gpm for 24 hours and had 40 ft drawdown in 1952.
601	Humble Oil & Refg. Co.	--	1961	440	7	A	2,568	85.1	July 18, 1967	N	N	American National water well No. 6. Unused water-flood supply well.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-602	George R. Bentley	--	--	79	6	A	2,504	32.6	Aug. 4, 1967	C,W	S	4-in. column pipe. Discharging 5 gpm when sampled 7-19-67.
* 603	Standard Oil Co. of Texas	R. C. (Dick) Murray	1952	203	16	A	--	55 R	Feb. 1952	T,E, 20	Ind	Hardage and Wilson water well No. 1. Casing perforated 70-90, 107-114, 117-130, 140-166, and 173-196 ft. Reported discharged 150 gpm in 1952.
* 604	Atlantic Pipeline Co. Brillhart Sta.	E. T. (Gene) Watkins	1950	135	6	A	--	--	--	J,E	Ind	Company No. 2 well. Casing perforated 117-120 and 132-135 ft. Reported discharge 18 gpm.
* 605	C. F. Kolp Oil Co.	--	old	94	6	A	2,550	67.0 69.5	May 1, 1940 July 19, 1967	C,E	Ind	Well W-284 in P. R. J. Inv. Discharged 1/4 gpm 7-19-67.
* 606	Harlan Prod. Co.	--	--	82	6	A	2,537	49.2	July 19, 1967	N	N	Replaced well W-285 in P. R. J. Inv. Bailed water sample 7-19-67.
* 607	K. S. Green	--	1932	75	6	A	2,535	58.2	Aug. 28, 1967	N	N	Well W-278 in P. R. J. Inv. Reported "red clay" (redbeds) at 80 ft.
608	Maxwell Oil Co.	Dixon Pump & Equip. Co.	1960	100	6	A	2,564	75 R	1965	T,E, 5	Ind	F. G. Smith water well No. 1. Set 85 ft of 4-in. column pipe. Reported water is brackish but drinkable.
* 609	Cities Serv. Co.	C. & H. Drlg. Co.	1956	252	8	A	2,545	48 R	1948	T,E, 10	Ind	Grimes water well No. 1. Reported pumped 131 gpm and had 30 ft of drawdown in 1958. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-33-701	Clayton Hughes	Clyde Word	1964	156	12	A	2,534	71.3	June 2, 1967	T,G	Irr	Casing perforated 60-166 ft. Set 146 ft of 6-in. column pipe. Irrigated 150 acres of feed from 2 wells in 1967.
702	do	Chas. Miller	1965	153	14	A	--	53.6	do	T,G	Irr	
703	Paragon Corp.	--	1958	100	8	A	--	65 R	1967	T,E, 5	Ind	W. L. Moody water well No. 1. Set 75 ft of 3-in. column pipe.
* 704	Bolin Oil Co.	Owner	1959	200	8	A	--	--	--	T,E, 10	Ind	Wallace water well No. 1. Reported discharges 90 gpm. Water has salty taste.
705	Troy Eiland	K. Kimble Oil Co.	1960	127	16	A	--	50.8	June 22, 1967	N	Ind	Drilled to 300 ft in 1960. Well was cleaned out to 127 ft in June 1967. Will supply water for drilling oil tests.
* 706	do	--	1962	300	16	A	2,484	37.4	Aug. 8, 1967	T,E, 25	Irr	Owner's No. 2 well. Casing perforated 50-300 ft. Gravel packed. Set 230 ft of 8-in. column pipe. Drawdown of 114 ft pumping 275 gpm for about 30 days in 1967.
* 707	do	--	1958	210	16	A	2,490	41.8	June 8, 1967	T,G	Irr	Owner's No. 1 well. Drilled to 400 ft. Plugged back to 210 ft. Perforated casing 50-210 ft. Gravel packed. Drawdown of 112 feet pumping 710 gpm for about 30 days in 1967. Irrigated 160 acres from 2 wells in 1967.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-708	J. W. Andrews	--	1965	110	8	A	--	21.2	June 22, 1967	T,G	Irr	Set and cemented 8 5/8-in. casing to 90 ft. Open hole 90-110 ft. Owner reports first water sand was at 18 ft. Water was brackish and had H_2S odor. Irrigated 10 acres of garden in 1967.
* 709	Monroe Est.	Sid Richardson	old	62	6	A	2,500	25.3	Aug. 9, 1967	C,W	S	Well W-252 in P. R. J. Inv. Discharged 2 gpm 8-9-67.
710	Bob Randolph	Clyde Word	1962	230	16	A	--	28 R 32.5	1962 Aug. 9, 1967	T,G	Irr	Casing perforated 35-350 ft. Gravel packed. Reported discharge 550 gpm. Irrigated 33 acres of sweet sue and coastal bermuda in 1967.
* 711	Bluford Thornton		--	93	6	A	--	55.4	Aug. 9, 1967	C,W	S	Discharged 2.4 gpm 8-9-67.
* 712	Sunset Internat. Petr. Corp.	Ed Henderson	1957	127	9	A	2,490	38.2	Aug. 8, 1967	T,E, 5	Ind	G. Combs water well No. 1. Casing: 20-in. to 17 ft, cemented; 9 5/8-in. to 126 ft; perforated 21-63, and 105-114 ft.
* 713	do	--	--	2,583	--	Psr	--	Flows	--	N	N	John Miller No. 2 oil well. Flowing an estimated 20 gpm of sulfur water and oil 12-11-67. Oil is skimmed off and water is pitted.
* 801	Standard Oil Co. of Texas	Ingram Bros.	1934	130	8	A	--	--	--	C,E, 7	Ind	J. E. York water well No. 3. Water used for camp and lease supply. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-802	W. E. Anderson	Kennedy & Ham	1952	220	16	A	--	35 R 42.5	1952 Aug. 6, 1967	T,E, 30	Ind	Owner's No. 4 well. Casing perforated 40-220 ft. Gravel packed. Set 90 ft of 10-in. column pipe, and 1 stage 13-in. bowl. Drawdown of 21 ft pumping 460 gpm for 44.5 hours in Aug. 1967.
803	Standard Oil Co. of Texas	Ingram Bros.	1953	95	6	A	2,548	58.69 67.33	Mar. 2, 1949 July 21, 1967	N	N	York water well No. 2. Formerly supplied gasoline plant. Current observation well. 2/
804	do	W. L. Theriac	1934	130	10	A	2,547	67.25 68.90	Feb. 7, 1958 July 21, 1967	N	N	York water well No. 5. Formerly supplied gasoline plant. Historical observation well. 1/
* 805	Atlantic Refining Co.	Frank Gaylon	1950	116	8	A	2,548	71 R	1960	S,E	Ind	W. D. Johnson water well No. 2. Drilled to 130 ft. Set 8 5/8-in. casing to 93 ft; open hole completion. Cleaned out to 116 ft in June 1951. Pumping test by owner in 1960: drawdown of 10 ft pumping 38 gpm for 30 minutes. Pumping level was 80.3 ft discharging 60 gpm 12-11-67. 1/
806	W. D. Johnson	--	--	115	7	A	--	64.45 69.99	Dec. 3, 1948 Jan. 10, 1955	N	N	Historical observation well. Formerly used for domestic supply. Destroyed in 1956.
807	John Bennett	Blacky Caprito	1932	120	7	A	2,555	61.31 67.20	Sept. 2, 1950 Jan. 4, 1956	N	N	Historical observation well. Has obstruction at 20 ft.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-33-808	John Bennett	Blacky Caprito	1932	103	7	A	--	61.60 61.70	Dec. 3, 1948 Mar. 2, 1949	N	N	Historical observation well. Formerly used for oilfield camp supply. Destroyed.
809	do	Farrell Oil Co.	1930's	116	6	A	--	58.86 69.65	Dec. 3, 1948 Aug. 6, 1967	N	U	Historical observation well. Not pumped since 1953.
810	Aaron Wilcox	--	1924	29	6	A	--	20.04 14.82	Mar. 29, 1940 Dec. 24, 1940	N	N	Well W-255 in P. R. J. Inv. Historical observation well. Formerly used to water livestock and irrigate garden. Destroyed.
* 811	Standard Oil Co. of Texas	Moore & Russell	1951	220	13	A	--	61.2	July 21, 1967	T,E, 30	Ind	J. E. York water well No. 6. Set 180 ft of 6-in. column pipe. Reported drawdown of 21 feet pumping 400 gpm for 12 hours in Feb. 1951. Water tastes salty.
* 812	City of Grandfalls	Bradford Drlg. Co.	1946	140	15	A	2,503	28.7 25.9 41.3	Nov. 26, 1946 Nov. 30, 1947 Aug. 7, 1967	T,E, 25	P	City well No. 5. Casing perforated 68-140 ft. Set 114 ft of 6-in. column pipe. Drawdown of 7.5 ft pumping 295 gpm for 1 hour 8-7-67.
813	W. E. Anderson	Moore & Russell	1947	169	20	A	2,510	33.2 38.9 46.0	Apr. 30, 1947 July 2, 1949 Aug. 6, 1967	N	U	Owner's No. 1 well. Formerly used for irrigation. Casing perforated 99-159 ft. Reportedly pumped 500 gpm in 1947.
* 814	do	Bradford Drlg. Co.	1948	107	16	A	2,510	33.5 42.0	July 1, 1949 Aug. 6, 1967	T,E, 30	Irr	Owner's No. 2 well. Casing perforated 40-107 ft. Set 80 ft of column pipe. Two stage 12-in. bowls.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-815	W. E. Anderson	--	1950	240	16	A	2,510	44.8	Aug. 6, 1967	T,E, 3	D	Owner's No. 3 well. Casing: 16-in. to 240 ft; 12-in. liner to 240 ft. Top of perforations at 40 ft. Discharged 46 gpm 8-13-67.
* 816	Sam Patterson	J. L. Gillette	1936	123	6	A	2,516	40 R	1940	S,E	D	Well W-260 in P. R. J. Inv. Formerly supplied Rio Bravo oilfield camp (Olcott water well No. 2). Casing perforated 99-123 ft. 1/
* 817	Aaron Wilcox	--	1922	25	48	A	2,487	19.3 22.7	Mar. 29, 1940 Aug. 8, 1967	N	U	Well W-254 in P. R. J. Inv. Dug to 35 ft. Curbed to 2 ft. Filled to 28 ft in 1940; 25 ft in 1967. Formerly used for domestic and livestock supply.
818	Forest Oil Corp.	--	1930's	106	7	A	2,546	61.4 73.4	May 1, 1940 Aug. 8, 1967	N	U	Well W-277 in P. R. J. Inv. Formerly used for oilfield supply.
819	do	Sidwell & Imler	1949	614	10	A	2,534	52.6 64.0	July 5, 1950 Aug. 2, 1967	N	U	A. B. Gordon water well No. 2. Casing perforated 579-614 ft. Reported Gordon water wells 1 and 2 supplied the first secondary recovery operation in Ward County. Well No. 2 has not been used since 1950. 1/
820	do	Wilhite	1950	215	10	A	--	53 R	Aug. 1950	T,E, 50	Ind	A. B. Gordon water well No. 3. Replaced well No. 2. Casing perforated 50-70, 80-105, 125-140 and 155-215 ft. Reported discharge 350 gpm in 1967. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-821	Forest Oil Corp.	Frank Gaylon	1958	208	12	A	2,534	70 R	Mar. 1950	T,E, 40	Ind	A. B. Gordon water well No. 4. Casing: 20-in. to 45 ft, cemented; 18-in. to 87 ft; 12 3/4-in. to 208 ft; perforated 53 to 208 ft. Reported pumps 11,500 barrels per day (335 gpm). Has pumped continuously since 1958. 1/
* 822	Atlantic Refining Co.	do	1951	135	8	A	--	--	--	S,E	Ind	W. D. Johnson water well No. 1. Open hole, interval not known. Pumping 70 gpm 12-11-67.
* 901	City of Grandfalls	Boyd Hopkins	1940	95	8	A	--	43.81	Jan. 2, 1951	N	N	City well No. 1 Well W-263 in P. R. J. Inv. Historical observation well. Casing was perforated 55-95 ft. Well was abandoned and plugged in 1965 when water became salty.
* 902	do	--	1943	95	8	A	--	49.5	Apr. 26, 1967	N	N	City well No. 2. Abandoned, due to be plugged.
* 903	do	Tipton Drlg. Co.	1943	137	12	A	--	--	--	T,E, 7 1/2	P	City well No. 3. Reported drawdown of 35 ft pumping 200 gpm for 3 hours in July 1966.
904	Standard Oil Co. of Texas	Prince Bros. Drlg. Co.	1937	112	8	A	--	40.59 41.43	June 3, 1948 Jan. 2, 1951	N	N	Formerly supplied drilling rigs. Historical observation well. Filled to above water level in 1952.
905	Cities Service, et al.	--	1930's	105	7	A	2,521	38.06 50.33	Apr. 29, 1940 Apr. 22, 1967	N	N	Well W-265 in P. R. J. Inv. Historical observation well. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-906	Buckles & Hostetler	--	--	982	7	Pr	2,535	111.2	July 19, 1967	T,E, 20	Ind	Armstrong-Green water well No. 2. Cased to 787 ft, open hole 787-982 ft in Rustler Formation. Reported discharged 160 gpm in 1962.
* 907	Handel Hall	John Woodfin	1964	90	5	A	2,522	51.1	Apr. 26, 1967	S,E, 3/4	D	Casing perforated 65-90 ft.
* 908	City of Grandfalls	Tipton Drlg. Co.	1949	135	8	A	--	--	--	T,E, 7 1/2	P	City well No. 4. Casing perforated 40-95 ft. Reported drawdown of 26 ft, pumping 200 gpm for 4 1/3 hours in July 1966.
* 909	Cities Service, et al.	--	old	31	6	A	--	9.2 11.8	June 6, 1940 Nov. 2, 1950	N	N	Well W-267 in P. R. J. Inv. Filled to 10 ft from surface in 1967. Residents in Grandfalls report that a spring flowed at this location during the early 1900's. The quality of water was reportedly much better than water pumped from wells in the town.
910	Texas & Pacific Oil Co.	Ed Henderson	1955	910	10	Pr	2,543	79.8	Dec. 11, 1967	N	N	James water well No. 1. Cased to 860 ft. Open hole 860-910 ft in Rustler Formation. Reported tested at 390 gpm in 1955.
911	do	--	--	128	7	A	2,526	47.2 54.5	May 1, 1940 Apr. 26, 1969	N	N	Well W-274 in P. R. J. Inv. Bailed sample of water 12-11-67.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-33-912	Forest Oil Corp.	Frank Robinson	1958	1,033	7	Pr	2,530	200 R 130 R	Feb. 1958 Feb. 1967	N	N	A. B. Gordon salt water disposal well No. 1. Cased to 833 ft, open hole 833-1,033 ft in Rustler Formation 5 1/2-in. tubing. Packer set at 821 ft. Reported 44 million barrels (1,856 million gallons) of salt water was injected between Apr. 1958 and Dec. 31, 1967. Well-head injection pressures ranged from 40 to 95 psi. Well is acidized once or twice a year with 1,500 gallons of 15 percent HCl.
* 34-101	Chapman Rch.	--	old	79	5	A	2,511	49.4 55.6	Apr. 23, 1941 June 25, 1967	C,W	S	Well W-335 in P. R. J. Inv. Decline of 6.2 ft in water level since 1941 reflects pumping from Ozark-Mahoning well field 1 mile southeast.
* 102	do	--	--	122	6	A	2,517	59.8	June 25, 1967	C,W	D,S	Supplies ranch headquarters.
301	W. I. Winter	--	old	98	5	A	2,556	41.2	May 11, 1967	C,W	S	Wooden tower; 2 1/2-in. column pipe. Discharged 4 1/2 gpm 5-11-67.
* 302	do	--	--	75	6	A	2,564	47.5	June 28, 1967	C,W	S	Formerly supplied ranch house which has been abandoned.
* 401	Jack Richardson	W. E. (Bud) Tone	1950	100	16	A	2,500	44.68 48.66	Feb. 9, 1955 Oct. 21, 1967	N	N	Unused irrigation well. Historical observation well. Casing perforated 60-100 ft. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-34-402	Texas State Highway Dept.	Henderson	--	155	8	A	2,532	55.13 58.63	Dec. 4, 1955 Dec. 8, 1966	C,W	P	Supplies roadside park. Current observation well. Set 147 ft of 3-in. column pipe. 2/
403	Ozark-Mahoning Co.	S. C. Ingham	1937	86	8	A	--	--	--	N	N	Well W-339 in P. R. J. Inv. Owner's well No. 216 casing perforated 69-86 ft. 1/
404	Jack Richardson	--	1950	94	10	A	--	45.8	Dec. 5, 1959	N	N	Formerly used for irrigation. Not used since 1955. Casing perforated 60-94 ft.
405	Geo. R. Bentley	--	--	150	--	A	2,539	70.49 71.34	Mar. 5, 1956 Dec. 30, 1967	C,W	S	Current observation well. 2/
* 406	Ozark-Mahoning Co.	S. C. Ingham	1937	85	--	A	2,450	5.8	June 27, 1967	N	N	Owner's well No. 209. Well W-340 in P. R. J. Inv. Cribbing to 35 ft. Perforated casing 35-58 ft. Well is at eastern edge of Sodium Sulfate Lake. 1/
* 407	do	W. E. (Bud) Tone	1964	110	6	A	2,453	--	--	C,E 2	Ind	Owner's well No. 580. Casing: 10-in. to 10 ft; 6 5/8-in. to 110 ft; perforated 20 to 110 ft. Well is on dike crossing Sodium Sulfate Lake and is about 3 ft higher than lake level. Pumping 3.6 gpm 10-1-67. Pumping level was 35.6 ft below top of casing. 1/
* 501	T. C. Barnsley	Delhi-Taylor Oil Corp.	1955	70	12	A	2,491	42.2	June 25, 1967	C,W	S	Drilled for rig supply. Converted to livestock well in 1964. Replaced well YX-45-34-502 located 500 ft northwest.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-34-502	T. C. Barnsley	--	1940	86	6	A	2,492	39.1 41.8	Apr. 23, 1941 June 25, 1967	N	N	Well W-297 in P. R. J. Inv. Abandoned in 1964.
503	Ozark Mahoning Co.	R. C. (Dick) Murray	1954	98	8	A	--	45.2	June 20, 1967	S,E	Ind	Owner's well No. 387. Pumping 31 gpm 9-8-67. 1/
504	do	L. W. Pulley	1946	91	8	A	--	43 R 45.7	May 1946 June 26, 1967	T,E	Ind	Owner's well No. 357. On stand-by status in 1967. Casing perforated 30-91 ft. 1/
* 505	do	R. C. (Dick) Murray	1956	400	10	A	--	46.5	June 26, 1967	S,E	Ind	Owner's well No. 442. Cased to 83 ft; perforated 53-83 ft; open hole 83-400 ft. Driller reported only small seeps (1 quart per minute) from interval 83-400 ft. 1/
506	do	F. C. Ingham	1942	120	8	A	--	--	--	T,E, 5	Ind	Owner's well No. 312. Casing perforated 41-95 ft; open hole 95-120 ft. Driller reported water-bearing sands at intervals 57-72 and 79-86 ft. Discharging 27 gpm 9-8-67. 1/
507	do	--	1949	94	8	A	--	45.1	June 26, 1967	N	N	Owner's well No. 366. Casing perforated 36-94 ft. Gravel packed (4 yards). 1/
601	T. C. Barnsley	--	old	100	8	A	2,520	53.5	June 25, 1967	C,W	D,S	

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-34-602	T. C. Barnsley	--	1902	100	8	A	--	--	--	S,E 5	S	Well D-18 in Crane County report. Discharging 53 gpm 6-25-67. Reported pumped an estimated 55 gpm in June 1961. Water level recovered 10.5 ft with pump shut down for 15 minutes.
* 604	J. H. King	R. C. (Dick) Murray	--	102	6	A	--	--	--	C,W	D	Supplies ranch headquarters. Open hole 20-102 ft.
* 701	Jess M. Wristen	Dugan	1945	102	6	A	2,500	65.2	July 20, 1967	C,W	S	Replaced well W-292 in P. R. J. Inv. at this location. Casing perforated 62-102 ft.
* 702	Geo. Brandenberg	Texas-Mexico Petr. Co.	1932	136	6	A	2,529	85 R 86.6	Apr. 1940 Aug. 7, 1967	C,E	Ind	Water pumped for lease supply and household use. Reported dependable supply but water is hard. Discharging 4.8 gpm 7-20-67.
703	Sinclair Oil & Gas Co.	J. D. Cole	1957	656	10	Pr	2,530	140 R	Jan. 1957	T,E, 40	Ind	Shipley-Queen water well No. 1. Casing: 13 3/8-in. to 200 ft, cemented; 10 3/4-in. 196-640 ft; open hole 640-656 ft in Rustler Formation. Acidized with 2,000 barrels 15 percent HCl. Reported drawdown of 40 ft pumping 346 gpm for 5 hours in Jan. 1957. Reported pumps 270 gpm in 1967.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-34-801	Jess M. Wristen	Miles & Beatty	1944	100	5	A	2,497	57.4 56.6	June 21, 1961 June 28, 1967	S,E	S	Headquarters well. Casing perforated 60-100 ft. Pump set at 70 ft. Reported discharge 30 gpm.
* 802	do	--	old	89	6	A	2,525	80.5 80.8	Mar. 20, 1940 June 28, 1967	C,W	S	Well W-289 in P. R. J. Inv. Pumping 2.6 gpm 6-28-67.
803	do	--	1945	70	6	A	2,487	44.8	June 28, 1967	C,W	U	Replaced well W-291 in P. R. J. Inv. Casing perforated 40-70 ft. Reported well has not been used for several years.
* 41-101	Ida M. Carr Well No. 1	Ben Glast	--	2,566	7	Psr	--	+	1967	N	!!	Oil well. Cased to 2,525 ft. Open hole 2,525-2,566 ft in Seven Rivers Formation. Flowing 24 gpm of oil and moderately saline water through 2-in. tubing 3-31-68. Oil is skimmed and water is pitted.
* 202	Consolidated P Prod. Co.	Burkholder Drlg. Co.	1960	301	8	A	2,443	20 R	1967	T,E	Ind	Viola Myers water well No. 1. Casing: 18-in. to 34 ft, cemented; 8 5/8-in to 301 ft; perforated 90-150 and 280-290 ft. Gravel packed. Set 275 ft of 3-in. column pipe. Reported discharge 50 gpm. Water is brackish.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-41-203	Porter & Sons Gravel Co.	--	1960	55	12	A	--	15.2	Aug. 8, 1967	T,E, 20	Ind	Supplies gravel plant. Driller reported soil and caliche to 5 ft; sand, gravel, and clay 5-65 ft; red beds below 65 ft. Pumping level was 26 ft discharging an estimated 250 gpm for 6 hours 8-7-67. Water level rose to 15.2 ft after well was shut down for 15 hours.
* 301	A. H. Adams, et al.	--	--	62	8	A	2,434	20.4	July 20, 1967	S,E	Ind	Pump disconnected when visited 7-20-67. Bailed sample of water.
302	Harlan Prod. Co.	Ambassador Oil Co.	--	700	8	Pr	2,458	27.6	Aug. 16, 1967	N	N	Fort Worth National Bank water well No. 1. Drilled to 2,263 ft as oil test. Plugged back to 700 ft. Set 8 5/8-in. casing to 124 ft; open hole 124-700 ft. Log of oil test #8 located 100 ft north. Shows top of red beds (Permian-Triassic) at 40 ft; top of anhydrite (Rustler) at 680 ft; water-bearing oölitic limestone 680-690 ft (Rustler); and top of salt (Salado?) at 825 ft.
* 42-101	Texas Electric Serv. Co.	--	1937	58	8	A	--	13.00 20.40	June 12, 1940 May 9, 1967	T,E, 2	N	Well W-301 in P. R. J. Inv. Supplied cooling water for Grandfalls generating plant until it was shut down in 1947.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-42-102	R. R. Browning and J. T. Cox	--	1934	125	8	A	2,497	63.8	Apr. 26, 1967	S,E, 3/4	P	Well W-271 in P. R. J. Inv. Pumps an estimated 15 gpm. Supplied 12 families in Royalty in 1967.
* 103	W. H. Sloan	E. D. Eaton	1940	146	8	A	--	--	--	N	N	Well W-295 in P. R. J. Inv. Test hole drilled for city of Grandfalls. Driller's log shows surface soil to 2 ft; caliche 2-30 ft; dry sand 30-85 ft; red rock (Permian-Triassic) 85-113 ft; water sand 113-142 ft; and red rock 142-146 ft. Set 146 ft of 8 1/4-in. casing; perforated 117-146 ft. Reported pumping 60 gpm "would exhaust well." Water quality deteriorated with time. Well was abandoned and plugged. 1/
* 104	Raymond Hill	--	1930's	50	6	A	--	27.9 26.9	Mar. 27, 1940 May 10, 1967	N	N	Well W-299 in P. R. J. Inv. Drilled to 78 ft; perforated casing 30-78 ft. Sanded in to 50 ft in 1967.
* 105	J. J. Kenedy Prod. Co.	Seismograph Crew	1964	70	7	A	2,430	20.3	July 20, 1967	S,E, 5	Ind	Casing perforated 15-70 ft. Water is injected into well tapping the Salado Formation for production of brine. Reported tops of Rustler and Salado Formations were at 630 and 850 ft respectively in the brine well (not inventoried).

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-42-106	J. D. Witcher	Lewis	1954	50	7	A	--	22.5	Aug. 16, 1967	C,W	D	Casing perforated 22-50 ft.
* 401	R. M. Ott, et al.	--	1936	14	--	A	--	9.9	Mar. 5, 1940	N	N	Well W-360 in P. R. J. Inv. formerly used for livestock supply. Destroyed.
402	Geo. Brandenberg	Owner	1966	52	16	A	2,429	22.4	Aug. 29, 1967	T	Irr	Not used in 1967. Owner reports sand, soil, and caliche to 14 ft; hard pan 14-16 ft; gravel and sand 16-50 ft; red beds (Triassic) 50-52 ft. Casing perforated 20-52 ft. Reported pumped 850 gpm for 25 days in 1966. 1/
501	Chas. W. Potts	Marvin Russell	1938	80	6	A	2,426	9 R 1938 22.54	Nov. 6, 1967	N	N	Unused domestic and livestock well. Casing perforated 50-80 ft. Located 100 ft south of irrigation canal. 2/
502	Raymond Lindsey	--	old	14	--	A	--	10.70 9.60	Feb. 2, 1940 Dec. 29, 1942	N	N	Well W-309 in P. R. J. Inv. Dug to 14 ft at a location 50 ft north of irrigation canal. Destroyed. 2/
503	Mrs. E. J. Dorr	--	old	14	--	A	--	12.0	May 15, 1941	N	N	Well W-310 in P. R. J. Inv. Dug to 14 ft. Destroyed.
504	R. D. Morris	--	1946	65	16	A	2,418	21.60 18.31	Apr. 26, 1967 Nov. 6, 1967	N	N	Unused irrigation well. Casing perforated 22-65 ft. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-45-42-505	R. D. Morris	--	1946	62	16	A	2,418	18.5 18.5	Oct. 1, 1967 Nov. 6, 1967	T,E, 25	Irr	Casing perforated 22-62 ft. Set 56 ft of 8-in. column pipe. Pumped a metered 1,000 gpm for 9 1/2 hours and had 20 ft of drawdown in Apr. 1967. Irrigated 33 acres of bermuda grass in 1967.
* 506	J. D. Witcher	Clyde Word	1966	63	16	A	--	21.42 17.83	Apr. 27, 1967 Nov. 6, 1967	T,E, 30	Irr	Casing perforated 24-63 ft. Set 65 ft of 8-in. column pipe. Discharged 1,100 gpm 4-29-67. Owner reports: Pecos River sand and gravel to about 60 ft with redbeds (Permian-Triassic) below. No water-bearing strata between the base of alluvium and top of Rustler (Permian) in this area. The water from the alluvial deposits is moderately saline. However, because of the sandy nature of the soils it can be used successfully for irrigation if sufficient water and fertilizer are applied. 2/
* 507	Eddie Mosley	do	1966	67	12	A	--	19.28 16.14	Apr. 27, 1967 Nov. 6, 1967	T,E, 15	Irr	Casing perforated 20-67 ft. Discharged 700 gpm 4-29-67. Irrigates 5 acres of oats and barley with well and canal water in 1967. 1/ 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL: ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	WATER LEVEL: DATE OF MEASUREMENT	METHOD OF LIFT	USE OF WATER	REMARKS
YX-45-42-508	John R. Williams	Owner	1966	65	16	A	--	18.56 15.57	Apr. 27, 1967 Nov. 6, 1967	N	N	Drilled for irrigation. Casing perforated 24-65 ft. Not used in 1967. 2/
* 509	L. E. Wilcox	Clyde Word	1966	64	16	A	2,422	20.13 19.08	July 19, 1967 Nov. 6, 1967	T,E, 15	Irr	Casing perforated 23-63 ft. Reported surface soil to 14 ft; and sand and gravel 14-62 ft. Top of redbeds at 62 ft. Set 55 ft of 8-in. column pipe. Irrigated 60 acres of oats and wheat with well and canal water in 1967. 2/
* 510	W. R. Puckett	John H. Tipton	1965	60	15	A	--	15.1	Oct. 1, 1967	T,E, 15	Irr	Casing perforated 30-60 ft. Set 57 ft of 8-in. column pipe. Pumping 450 gpm 4-27-67. Irrigates 34 acres of grass.
* 511	Chas. W. Potts	A. Bradford	1940	57	6	A	--	12 R 22.0	1940 May 9, 1967	J,E, 1	D	Drilled to 80 ft. Cased to 55 ft. Filled to 57 ft in 1967.
512	Carpenter Farms	--	1950	56	16	A	--	19.35 17.69	May 6, 1967 Nov. 6, 1967	N	N	Unused irrigation well. Casing perforated to total depth. 2/
513	A. H. Dunlap	--	1938	13	--	A	--	8.6	Dec. 6, 1940	N	N	Well W-314 in P. R. J. Inv. Dug well. Destroyed.
601	Hal Eudaly, Jr.	John H. Tipton	1949	64	16	A	2,408	19.18 18.65	May 9, 1967 Nov. 6, 1967	T	N	Unused irrigation well. Casing perforated from surface to total depth. Reported top of redbeds (base of alluvium) at 62 ft. 1/ 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-45-42-602	Hal Eudaly, Jr.	John H. Tipton	1950	64	16	A	--	19.8	May 9, 1967	T,G	N	Unused irrigation well. Casing perforated 20-64 ft. Reported discharged 1,650 gpm in 1966. 1/
603	do	Great Basin Petr. Co.	--	1,695	5	Pr?	2,412	+1	May 15, 1940	N	N	Well W-312 in P. R. J. Inv. Drilled as oil test "Eudaley No. 1." Flowing 1/4 gpm over top of casing 3-15-40. Destroyed.
702	Atlantic-Dorr Well No. 3	Sahara-Crandal Oil Co.	--	2,087	--	?	2,417	18.5	May 9, 1967	N	N	Abandoned oil test. 4 ft of 22-in. casing. Open hole below 4 ft.
801	F. M. White Well No. 4	Jameson, et al.	1943	4,000	--	Pc?	2,423	--	--	N	N	Oil test. Reported flowing 50-60 gpm when drilled. Water had H_2S odor. Was used to irrigate small garden. Destroyed.
* 802	Signal Oil & Gas Co.	--	1963	491	8	Pr	2,410	38.8	May 9, 1967	T,E, 7 1/2	Ind	Casing perforated 440-454 ft in Rustler Formation. Acidized with 1,000 barrels 15 percent HCl. Water used for secondary recovery of oil. Has salty taste.
803	L. E. Wilcox	--	1938	10	--	A	2,422	8.9	May 15, 1941	N	N	Well W-316 in P. R. J. Inv. Destroyed.
* 46-21-701	Mobil Oil Co.	Lang Buchanan	1939	105	6	A	2,715	91.3	Dec. 28, 1942	N	N	Well W-1 in P. R. J. Inv. Formerly used for livestock supply. Filled to above water level in 1967. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-21-702	Mobil Oil Co.	Buffalo Drlg. Co.	1965	286	10	A	--	--	--	T,E, 30	Ind	Twofreds unit, Tr. 4. Water well No. 1.
* 703	do	do	1963	228	10	A	2,720	100 R	Feb. 1963	T,E, 20	Ind	Twofreds unit, Tr. 8. Water well No. 1. Set 200 ft of 4-in column pipe and 18 stages of 8-in. bowls. Development test, by Dixon Pump and Equipment Co. 2-26-63: drawdown of 96 ft pumping 175 gpm for 6 hours.
* 801	J. C. Dunagan Est.	Clyde Simmonds	1941	137	7	A	2,695	81.9 86.2	Mar. 26, 1941 Oct. 4, 1967	C,W	S	Well W-224 in P. R. J. Inv. Open hole 4-137 ft. Top of redbeds at 18 ft on driller's log. 1/
* 802	do	do	1939	97	5	A	2,702	74.1 77.4	Oct. 25, 1939 Oct. 4, 1967	C,W	S	Well W-4 in P. R. J. Inv. Casing perforated 91-97 ft.
23-802	L. W. Anderson Rch.	--	1939	176	6	A	2,704	79.4	Sept. 28, 1967	C,W	S	North "Harville Well." Reported seldom used--weak supply.
* 803	do	Lang Buchanan	1939	176	6	A	2,705	59.7	do	C,W	S	South "Harville Well." Open hole 20-176 ft. Wells are in playa (or sink) on upland surface.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-23-902	R. B. Leck	J. D. Cole	1956	225	16	A	2,692	108.25 108.92	Dec. 5, 1959 Dec. 30, 1967	S,E	Irr	Current observation well. Casing perforated 145-225 ft. Set 185 ft of 4-in. column pipe. Drawdown of 21 ft pump-160 gpm for 1 hour 9-13-67. Supplies house, waters stock, and irrigates 4 acres of orchard and 3 acres of pasture in 1967. 2/
* 904	do	do	1956	300	16	A	2,687	107.24 109.30	Oct. 7, 1956 Sept. 12, 1967	T,Ng	Irr	Well G-166 in Winkler County report. Historical observation well. Set 185 ft of 8-in. column pipe. Drawdown of 32 ft pumping 440 gpm for 17 hours in Sept. 1967. Reported irrigated 33 acres of feed, 10 acres vegetables, 12 acres alfalfa, and 92 acres of cotton in 1967. 2/
* 905	Fay and Lula Hogg	--	1938	125	6	A	2,690	108.4 109.1 109.2	Aug. 23, 1940 Oct. 16, 1956 Sept. 12, 1967	C,W	S	Well W-41 in P. R. J. Inv. Well G-167 in Winkler County report.
24-701	City of Monahans	Layne-Texas Co.	1957	386	4	A	2,697	117.43 123.89	June 7, 1957 Dec. 14, 1967	N	N	Test hole 2-A. Not completed as water well. Historical observation well. Casing perforated 183-188, 256-261, 280-285, 302-307, 327-332, 352-357, and 376-381 ft. 1/ 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-24-702	City of Monahans	Layne-Texas Co.	1959	395	12	A	--	119 R	July 1969	T,E, 100	P	City well No. 4-3. Drilled and logged to 404 ft. Plugged back to 395 ft. Set and cemented 20-in. casing to 185 ft. Underreamed to 30-in. hole from 185 to 395 ft. Set 12 3/4-in. casing to 395 ft. Perforated 185-280, 290-340, 350-375 and 378-383 ft. Packed 60 yards of gravel outside 12-in. casing. Pumping tests by driller 6-18-59: drawdown of 125 ft pumping 1,000 gpm for 12 hours. Drawdown of 86 ft pumping 713 gpm for 11 hours. 1/
* 703	do	do	1957	385	12	A	2,697	118 R	June 1957	T,E, 40	P	City well No. 4-1. Dri Drilled and logged to 386 ft. Set 12 3/4-in. casing to 385 ft. Perforated 182-385 ft. Pumping test by driller June 7-8, 1957: drawdown of 35.8 ft pumping 500 gpm for 24 hours. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-24-704	City of Monahans	Layne-Texas Co.	1957	392	12	A	2,694	116 R 121.7	May 1957 Dec. 14, 1967	T,E, 100	P	City well No. 4-2. Drilled and logged to 519 ft. Plugged back to 392 ft. Set and cemented 20-in. casing to 191 ft. Underreamed to 30-in. hole from 191-392 ft; Set 12 3/4-in. casing to 392 ft with shutter screens 200-290, 294-314 and 324-384 ft. Packed 65 yards of gravel outside 12-in. casing. Pumping test by driller 4-14-67: drawdown of 64 ft pumping 1,220 gpm for 34 hours. Well was pumping 830 gpm 4-14-67. Water level rose 35 ft with well shut down 55 minutes. 1/
* 705	do	Dixon Pump and Equip. Co.	1965	387	14	A	--	118.3	Apr. 14, 1967	T,E, 100	P	City well No. 4-4. Drilled and logged to 399 ft. Plugged back to 387 ft. Set and cemented 20-in. casing to 177 ft. Set 14-in. casing to 387 ft with shutter, screens 232-382 ft. Gravel packed. Set 238 ft of 8-in. column pipe and 6 stage 8-in. bowls. Pumping test by driller Feb. 21-22, 1965; drawdown of 47 ft pumping 1,000 gpm for 36 hours. Pumped 920 gpm for 1 hour and had 38.2 ft of drawdown 4-14-67. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-24-706	Fay & Lula Hogg	--	old	142	6	A	--	112.4	Aug. 31, 1967	C,W	S	Well W-43 in P. R. J. Inv.
* 801	Gulf Oil Corp.	J. R. Marshall	1938	216	8	A	2,722	144.90 152.85	Mar. 28, 1957 Aug. 31, 1967	N	N	O'Brien water well No. 18. Well W-44 in P. R. J. Inv. Well G-173 in Winkler County report. Casing perforated 164-216 ft. Driller reported water sand 162-211 ft--unable to bail water level down. Pumped 440 barrels in 2 hours (115 gpm) when drilled. Decline in water level of 7.95 ft since 1957 reflects pumping from city of Monahans Hogg Ranch well field. 1/
* 802	G. W. O'Brien Est. (Jack O'Brien)	--	1938	149	6	A	2,707	135.95 137.87	Mar. 6, 1956 Dec. 30, 1967	C,W	S	Well W-45 in P. R. J. Inv. Current observation well. 2/
803	Texas Elec. Serv. Co.	--	1955	242	16	A	2,706	130.49 136.70	Mar. 6, 1956 Aug. 31, 1967	N	N	Unused irrigation well. Historical observation well. Decline in water level of 6.33 ft since 1956 reflects pumping from city of Monahans well field. 2/
* 804	Al & Sam Ares	--	1957	225	8	A	2,721	145.3	Aug. 31, 1967	N	N	Magnolia-Sealy water well No. 1. Formerly supplied water for secondary recovery operations. Bailed sample of water from well 12-14-67.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-46-24-805	Geo. Sealy Est.	--	1937	180	7	A	2,721	142.2	Aug. 31, 1967	C,W	S	Well G-171 in Winkler County report. Well was formerly used for lease supply by the McQueen and Stout Drlg. Co.
806	Texas Elec. Serv. Co.	Layne-Texas Co.	1955	469	--	A	2,696	--	--	N	N	Drilled and logged to 469 ft as test hole B-3. Not completed as water well. Destroyed. 1/
807	Gulf Oil Corp.	--	--	4,500	13	Pc	2,710	66.1	June 7, 1967	N	N	O'Brien water supply well No. A-2.
808	do	--	--	4,141	13	Pc	2,708	--	--	T,E, 100	Ind	O'Brien water supply well No. A-3.
809	do	--	1960	4,500	13	Pc	--	70.1	June 7, 1967	N	N	O'Brien water supply well No. A-5. Casing: 20-in. to 526 ft, cemented with 625 sacks; 13 3/8-in. to 1,013 ft; and 9 5/8-in. 1,013 to 3,441 ft, cemented with 1,900 sacks. Open hole 3,441 to 4,500 ft in Capitan reef.
810	do	--	1961	4,500	13	Pc	2,715	--	--	Cf,E, 7 1/2	Ind	O'Brien water supply well No. A-6. Casing: 20-in. to 519 ft, cemented with 500 sacks; 13 3/8-in. to 1,000 ft; and 9 5/8-in. 1,000-3,445 ft, cemented with 2,100 sacks. Open hole 3,445-4,500 ft in Capitan reef.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-46-24-811	Gulf Oil Corp.	--	1961	4,500	13	Pc	2,700	--	--	T,E, 100	Ind	O'Brien water supply well No. A-7. Casing: 20-in. to 517 ft, cemented with 500 sacks; 13 3/8-in. to 1,000 ft; and 9 5/8-in. 1,000-3,485 ft, cemented with 1,500 sacks. Open hole 3,485-4,500 ft.
812	do	--	1961	4,300	13	Pc	2,713	60.0	June 7, 1967	N	N	O'Brien water supply well A-9. Drilled to 4,470 ft; plugged back to 4,300 ft. Casing: 20-in. to 516 ft, cemented with 400 sacks; 13 3/8-in. to 1,000 ft; and 9 5/8-in. 1,000 to 3,425 ft, cemented with 2,100 sacks. Open hole 3,425-4,300 ft.
813	do	--	--	4,500	13	Pc	2,718	66.7	do	N	N	O'Brien water supply well No. A-9.
814	do	--	1962	4,400	13	Pc	2,725	--	--	T,E, 100	Ind	O'Brien water supply well No. A-10. Casing: 20-in. to 577 ft, cemented with 450 sacks; 13 3/8-in. to 980 ft; and 9 5/8-in. 980 to 3,531 ft, cemented with 1,805 sacks. Open hole 3,531-4,400 ft.
* 901	do	--	1936	300	8	A	2,663	85.2	Aug. 31, 1967	N	N	O'Brien water well No. 13. Cased to 121 ft; open hole 121-300 ft. Reported pumped 935 barrels in 24 hours (27 gpm) in Apr. 1936. 1/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-46-24-902	G. W. O'Brien Est. (Jack O'Brien)	--	1939	127	5	A	2,700	112.57 111.71	Mar. 6, 1956 Dec. 30, 1967	N	N	Current observation well. Well G-176 in Winkler County report. 2/
* 903	Richardson Oils	--	1930's	180	7	A	--	--	--	C,E, 3	D	Supplies oilfield lease house. Set 160 ft of 2 1/2-in. column pipe. Discharging 4.8 gpm 8-31-67.
* 29-101	J. C. Dunagan Est.	--	1967	103	4	A	2,695	90.1	Oct. 17, 1963	C,W	S	
* 102	do	--	--	45	6	A	2,632	17.2	Feb. 19, 1967	C,W	S	
* 103	do	Rector Oil Co.	1933	60	6	A	2,641	35.6 34.8	Apr. 19, 1967 Oct. 17, 1967	C,W	S	Drilled for rig-supply. Well W-3 in P. R. J. Inv.
* 201	do	--	old	92	6	A	2,670	58.2	Apr. 19, 1967	S,E, 1/3	D,S	Well W-6 in P. R. J. Inv. South well at ranch headquarters. Casing perforated 90-92 ft. Discharging 12 gpm 4-19-67.
* 202	do	--	old	86	8	A	2,670	57.0 58.9	Dec. 5, 1940 Oct. 4, 1967	C,W	D,S	Well W-5 in P. R. J. Inv. North well at ranch headquarters. Well was reportedly tested at 50 gpm without sucking air.
* 203	do	--	old	68	8	A	2,649	53.3 54.0	Oct. 25, 1939 Mar. 23, 1950	C,W	S	Well W-8 in P. R. J. Inv. Obstacle in casing at 45 ft in 1967.
* 301	do	--	old	144	6	A	2,692	128.4 125.1 128.4	Oct. 26, 1939 Jan. 24, 1950 Oct. 3, 1967	C,W	S	Well W-20 in P. R. J. Inv.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-29-302	J. C. Dunagan Est.	Clyde Simmonds	1941	176	6	A	2,747	136.9 137.3 139.6	Apr. 15, 1941 Jan. 24, 1950 Apr. 20, 1967	C,W	S	Well W-226 in P. R. J. Inv. Well is on Triassic outcrop covered with veneer of wind-blown sand. Reported drill cuttings were "largely fine-grained red sand and deep purplish red clay with scattering of small selenite crystals."
* 401	Burkholder Bros.	Holder Water Well Serv.	1966	60	6	A	2,624	37.54	Apr. 20, 1967	C,W	S	Casing perforated 40-60 ft. Driller reported caliche to 38 ft, clay and gravel 38-46 ft, and sand and gravel 46-60 ft.
* 402	do	Rector Oil Co.	1933	100	6	A	2,624	29.79 37.94	Nov. 6, 1939 Oct. 17, 1967	N	N	Well W-11 in P. R. J. Inv. Drilled for rig-supply. Converted to livestock well. Abandoned and replaced by well YX-46-29-401 in 1941. Obstacle in casing at 40 ft in 1967. 2/
* 501	John G. Burkholder	--	--	75	6	A	2,629	46.6	Apr. 21, 1967	C,W	S	Drilled to replace well W-17 in P. R. J. Inv. which was at this location. Water level in W-17 was 40.6 ft below land surface in 1940.
502	C. L. Monroe Est.	Clyde Simmonds	1936	125	6	A	2,642	47.05	Oct. 25, 1939	N	N	Well W-16 in P. R. J. Inv. Historical observation well. Destroyed.
503	do	--	1929	71	6	A	2,656	59.40 63.32	Nov. 6, 1939 Oct. 17, 1967	N	N	Well W-12 in P. R. J. Inv. Historical observation well. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-46-29-504	Hissom Drlg. Co.	Owner	1957	64	6	A	2,605	23.1	Oct. 17, 1967	N	N	Formerly supplied drilling rigs.
* 601	J. C. Dunagan Est.	--	1941	100	6	A	2,640	50.1 52.2	May 14, 1941 Aug. 8, 1949	C,W	S	Well W-227 in P. R. J. Inv.
* 602	Landa Oil Co.	--	1965	48	6	A	2,573	15.1	Oct. 17, 1967	N	N	Formerly supplied drilling rigs. Bailed sample of water 10-17-67.
* 701	M. I. Vida Farms, Inc.	Lang Buchanan	1940	115	16	A	2,600	4.69 15.66	Sept. 8, 1941 Oct. 18, 1967	T,E, 20	--	Well W-174 in P. R. J. Inv. Unused irrigation well. Drawdown of 16.3 ft pumping 1,300 gpm for 25 days in Sept. 1941. Current observation well. 2/
* 702	Ward Co. Irr. Dist. No. 1	C. C. & H. Drlg. Co.	1946	186	16	A	2,592	13.73 20.48	Sept. 30, 1946 Dec. 1, 1967	N	N	Dist. well No. 8. Discharged 1,350 gpm in Oct. 1946. Current observation well. 1/ 2/
703	U-Bar Land & Cattle Co.	--	old	9	--	A	2,604	4.27	Aug. 11, 1941	N	N	Historical observation well. Destroyed.
* 704	M. I. Vida Farms, Inc.	--	--	54	4	A	2,610	7.90 17.98	Sept. 19, 1939 Oct. 18, 1967	N	N	Historical observation well. Well W-182 in P. R. J. Inv. Formerly used for watering livestock. 2/
* 705	do	C. C. & H. Drlg. Co.	1946	152	14	A	2,601	15.01 20.70	Oct. 28, 1946 Oct. 18, 1967	N	N	Unused irrigation well. Casing perforated 52-152 ft. Drawdown of 16.2 ft pumping 1,430 gpm for 3 days in 1947. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-29-706	Ward Co. Irr. Dist. No. 1	C. C. & H. Drlg. Co.	1946	162	16	A	2,591	11.36 16.80	Sept. 30, 1946 Oct. 18, 1967	N	N	Dist. Well No. 9. Casing: 16-in. to 67 ft, perforated liner 51 to 162 ft. Reported pumped 1,650 gpm in 1946. Not used since 1946. 1/ 2/
* 707	M. I. Vida Farms, Inc.	Leonard Schooler	1947	165	--	A	2,607	28.0 19.9	Apr. 24, 1967 Oct. 18, 1967	N	N	Unused irrigation well.
* 708	Ward Co. Irr. Dist. No. 1	C. C. & H. Drlg. Co.	1946	195	16	A	2,592	9.24 14.19	Sept. 30, 1946 Oct. 18, 1967	N	N	Dist. well No. 10. Historical observation well. Reported discharged 700 gpm in Oct. 1946. 2/
* 709	M. I. Vida Farms, Inc.	Hopper	1926	59	16	A	2,610	14.78	Dec. 5, 1940	N	N	Historical observation well. Destroyed.
710	do	--	--	198	16	A	2,611	26.7 22.3	Apr. 24, 1967 Oct. 18, 1967	N	N	Unused irrigation well.
711	do	C. C. & H. Drlg. Co.	1948	400	16	A	2,613	26.5	Oct. 18, 1967	N	N	Do.
* 712	do	do	1947	165	16	A	2,600	18.0 14.2	Apr. 24, 1967 Oct. 18, 1967	T,G	Irr	Casing: 20-in. to 80 ft, perforated 15-80 ft; 16-in. liner to 165 ft, perforated 70-165 ft. Irrigated 115 acres of cotton from this well and well YX-46-29-717 in 1966. 1/
713	do	--	--	155	18	A	2,600	26.5 18.5	Apr. 25, 1967 Oct. 18, 1967	N	N	Unused irrigation well.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-29-714	M. I. Vida Farms, Inc.	C. C. & H. Drlg. Co.	1948	158	20	A	2,599	23.9 16.4	Apr. 25, 1967 Oct. 18, 1967	T,G	Irr	Casing: 20-in. to 69 ft, perforated 10-69 ft; 18-in. perforated liner 59-158 ft. Set 100 ft of 10-in. column pipe with 2 stages of 14-in. bowls. Reported pumped 3 weeks in 1966. Not pumped in 1967.
715	do	--	--	150	18	A	2,590	15.4	Mar. 5, 1950	N	N	Unused irrigation well.
716	do	--	--	150	18	A	2,590	16.8	do	N	N	Do.
717	do	--	--	150	18	A	2,603	21.8 17.1	Apr. 24, 1967 Oct. 18, 1967	T,G	Irr	
* 718	Edith Jenson	Lang Buchanan	1940	50	6	A	2,597	5.4 14.3	Sept. 9, 1941 Oct. 18, 1967	S,E	S	Well W-187 in P. R. J. Inv. Casing perforated 40-50 ft. Irrigates garden and waters livestock. Not used for drinking.
719	M. I. Vida Farms, Inc.	C. C. & H. Drlg. Co.	1947	360	16	A	2,613	17.5	Oct. 18, 1967	N	N	Unused irrigation well.
720	do	do	1947	180	16	A	2,612	16.9	do	T	N	Do.
* 721	do	--	old	18	6	A	2,597	5.3 15.4	Aug. 29, 1939 Oct. 18, 1967	N	N	Unused livestock well. Well W-171 in P. R. J. Inv.
801	R. Burkholder	J. H. Hardaway	1946	130	20	A	2,597	17.70 25.34	Nov. 25, 1946 Dec. 1, 1967	N	N	Drilled for irrigation but reported insufficient supply (400 gpm). Current observation well. 2/

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-29-802	O. C. Majors Est.	C. C. & H. Drlg. Co.	1947	162	16	A	2,598	23.6 15.6	Apr. 26, 1967 Oct. 18, 1967	T,G	N	Unused irrigation well. Casing: 20-in. to 38 ft, perforated; 16-in. to 162 ft, perforated 50-162 ft.
803	do	Lang Buchanan	--	115	6	A	2,596	7.0	Aug. 11, 1941	N	N	Well W-170 in P. R. J. Inv. Owner reported good livestock water from "quicksand" at 115 ft, but supply was weak. Strong supply at 60 ft but quality was bad. Obstruction in casing at 7 ft in 1967.
* 804	do	C. C. & H. Drlg. Co.	1946	153	14	A	2,596	16.9 28.1	Oct. 30, 1946 Apr. 26, 1967	T,G	N	Unused irrigation well. Casing perforated 70-130 ft; open hole 130-153 ft. Reported 48 ft of drawdown pumping 1,550 gpm for 7 hours in 1946. Drawdown of 24.2 ft pumping 960 gpm for 1 hour in Apr. 1947.
* 805	Ralph Burkholder	--	1930	73	6	A	2,593	16.0 22.7	Oct. 23, 1939 Oct. 18, 1967	C,W	S	Well W-167 in P. R. J. Inv. Reported "small springs of mineralized water 1/2 to 3/4 mile east of well" in 1939.
901	R. W. & J. G. Burkholder	--	old	23	--	A	--	18.62	Dec. 28, 1942	N	N	Well W-168 in P. R. J. Inv. Historical observation well. Dug to 23 ft and cribbed 4 ft in diameter. Destroyed.
* 902	B. J. Pevehouse	--	--	57	4	A	2,561	+0.6 +0.6 4.5	Aug. 8, 1949 Mar. 23, 1950 Apr. 22, 1967	C,W	S	Flowed small quantities of water in 1949 and 1950. Well is near south end of Soda Lake.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-29-903	Atlantic Refg. Co.	Dixon Pump & Equip. Co.	1966	190	9	A	2,569	14 R	Jan. 1966	S,E 25	Ind	Quito unit water supply well. Casing perforated 140-190 ft. Reported pumped 410 gpm for 21 hours and had 44 ft of drawdown in Jan. 1966. Drawdown of 26 ft pumping 4 million barrels during 18 months in 1966 and 1967. 1/
904	do	Mesa-Noll Drlg. Co.	1965	204	9	A	2,568	12.6 14.0	Apr. 26, 1967 Oct. 17, 1967	N	N	Casing perforated 170-204 ft. Reported tested at 400 gpm when drilled.
* 30-101	J. C. Dunagan Est.	--	--	235	6	A	2,717	159.2 162.2 162.0	Aug. 8, 1949 Mar. 23, 1950 Oct. 3, 1967	C,W	S	
* 201	Anderson Ranch	--	--	104	5	A	2,785	56.8	Oct. 2, 1967	C,W	S	"P-lake well." Replaced well W-21 in P. R. J. Inv. at this location. On eastern edge of playa.
* 301	do	--	old	98	6	A	2,772	84.7 84.8 85.7	Aug. 22, 1940 June 23, 1961 Sept. 28, 1967	C,W	D,S	South well of two at ranch headquarters. Well W-25 in P. R. J. Inv.
* 302	do	--	old	168	8	A	2,772	85.7 86.5	Aug. 22, 1940 Sept. 28, 1967	C,W	S	North well at ranch headquarters. Well W-24 in P. R. J. Inv.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
YX-46-30-303	Anderson Ranch	R. C. (Dick) Murray	1965	154	5	A	2,772	120.1	Oct. 2, 1967	C,W	S	Drilled to supply water for road construction. Driller's log: hard conglomerate (red sandstone and shale fragments) to 6 ft; caliche 6-21 ft; red rock (Santa Rosa Sandstone) 21-44 ft; sandy clay 44-88 ft; red rock 88-109 ft; red sand (water-bearing) 109-114 ft; red rock and clay breaks 114-154 ft. 1/
* 401	J. C. Dunagan Est.	F. H. Murphy	1937	121	5	A	2,660	104.8 106.0 109.2	Dec. 5, 1940 Aug. 8, 1949 Oct. 3, 1967	C,W	S	Replaced well W-19 in P. R. J. Inv. at this location.
* 402	Anderson Ranch	--	old	188	6	A	2,672	97.3	Oct. 3, 1967	C,W	S	Well W-26 in P. R. J. Inv.
* 403	do	Cactus Drlg. Co.	1954	180	4	A	--	--	--	C,E, 5	D	Drilled for rig supply. Currently supplies oilfield lease house. Discharged 4.6 gpm 10-3-62. Reported good quality of water. Some of the residents of Barstow hauled drinking water from the well before the pipeline to the city of Pecos was completed.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-30-501	Anderson Ranch	R. C. (Dick) Murray	1966	141	7	A	--	99.6	Oct. 3, 1967	C,W	S	Drilled for road construction. Log shows: caliche to 18 ft; hard conglomerate shell 18-34 ft; red rock (Santa Rosa Sandstone) 34-46 ft; red, sandy clay 46-66 ft; hard sand rock 66-89 ft; red, sandy clay 89-118 ft; redbed with shells 118-126 ft; and red sand and gravel (water-bearing) 126-141 ft.
601	Humble Oil & Refg. Co.	--	1954	975	7	Pr	2,820	261.0	Oct. 2, 1967	N	N	State univ. "AC" water well No. 1. Open hole 749-975 ft in Rustler Formation. Supplied water for drilling oil tests. Reported pumped 25 barrels per hour (18 gpm) when drilled.
* 701	J. C. Dunagan Est.	--	--	113	5	A	2,646	87.2 91.7	Aug. 8, 1949 Oct. 17, 1967	C,W	S	
* 702	John Wilson	Jim Miles	1920	172	6	A	2,722	162.1 164.5 169.5	Sept. 26, 1939 Jan. 24, 1950 Nov. 14, 1967	C,W	S	Replaced well W-161 in P. R. J. Inv. Open hole 10-172 ft.
* 801	do	Shell Oil Co.	1939	161	4	A	2,735	94.5 96.8	Oct. 8, 1940 Nov. 13, 1967	C,W	S	Owner's "Shell Well." Reported "30 ft of gravel then into rock (Santa Rosa Sandstone)." Tested at 50 gpm when drilled.
* 802	do	Tom Simmonds	1938	220	8	A	2,695	108.7 109.5 126.2	Sept. 26, 1939 Oct. 8, 1940 Oct. 3, 1967	C,W	S	Well W-153 in P. R. J. Inv. Open hole 140-220 ft. Reported strong supply but gyppy.

See footnotes at end of table.

Table 6.--Records of Wells and Test Holes in Ward County and Adjacent Areas--Continued

WELL	OWNER	DRILLER	DATE COMPLETED	DEPTH OF WELL (FT)	CASING DIAMETER (IN.)	WATER-BEARING UNIT	ALTITUDE OF LAND SURFACE (FT)	WATER LEVEL		METHOD OF LIFT	USE OF WATER	REMARKS
								ABOVE (+) OR BELOW LAND SURFACE DATUM (FT)	DATE OF MEASUREMENT			
*YX-46-30-901	Bird S. Hayes Well No. 1	Kenneth Slack	1939	5,088	10	A?	2,710	40.9	Dec. 14, 1967	N	N	Abandoned oil test. Reported cased to 6 ft. Left open hole 5-1,100 ft. Bailed water sample 12-14-67.
* 31-101	Anderson Ranch	--	old	147	5	A	2,695	119.3	Sept. 28, 1967	C,W	S	Owner's "Oats Well."
301	Paul Walker	--	1953	120	6	A	2,677	101.32 103.38	Mar. 6, 1956 Dec. 6, 1957	N	N	Historical observation well. Filled with trash to about 20 ft from surface in 1967.
302	M. A. Williford	C. O. Richardson	1956	300	16	A	2,675	104.95 105.94	Mar. 6, 1956 Oct. 30, 1967	T	N	Current observation well. Not pumped since 1956. 2/
303	T. B. H. Development Co.	--	1951	264	14	A	--	105.8	Sept. 12, 1967	T,G	N	Discharged an estimated 400 gpm in 1956. Irrigated 50 acres of cotton and grain in 1965. Not used in 1967.
* 304	Jack Baugus	--	1955	300	12	A	--	96.4	do	T,E, 40	Irr	Estimated discharged 300 gpm 9-12-67. Irrigating 80 acres of feed.
* 305	Anderson Ranch	--	old	96	5	A	2,660	89.8	Sept. 27, 1967	C,W	S	Owner's "Hookedy Well." Pumping 3.3 gpm 9-12-67. Replaced well W-34 in P. R. J. Inv.
* 306	A. D. Quillin	--	1927	153	6	A	2,661	--	--	C,W	S	Well W-36 in P. R. J. Inv. Drilled for rig-supply. Converted to livestock well.
* 401	Anderson Ranch	--	1939	130	5	A	2,681	116.1 115.7	Aug. 15, 1940 Sept. 28, 1967	C,W	S	Owner's "Borax Well." Well W-30 in P. R. J. Inv.

See footnotes at end of table.