TEXAS
WATER
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BOARD

REPORT 73

# GROUND-WATER RESOURCES OF NUECES AND SAN PATRICIO COUNTIES, TEXAS

MAY 1968

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# GROUND-WATER RESOURCES OF NUECES AND SAN PATRICIO COUNTIES, TEXAS

By

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United States Geological Survey

Prepared by the U.S. Geological Survey
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GROUND-WATER RESOURCES OF NUECES AND SAN PATRICIO COUNTIES, TEXAS


## ABSTRACT

Nueces and San Patricio Counties are in south Texas in the Coastal Bend region of the West Gulf Coastal Plain. The Nueces River is the boundary between the two counties, which have a land area of 1,518 square miles. Corpus Christi, the county seat of Nueces County, had a population of 167,690 in 1960.

The principal water-bearing units in Nueces and San Patricio Counties are the Goliad Sand, Lissie Formation, and Beaumont Clay (the Gulf Coast aquifer). The units crop out in belts that roughly parallel the coast and dip to the southeast at an angle greater than the slope of the land surface.

Ground water in the two counties moves southeastward from the areas of recharge to areas of discharge. Several communities use ground water for public supply, but the largest public supplies are obtained from the Nueces River. During 1964, about 17,500 acre-feet (15.6 million gallons per day) of ground water was pumped for all purposes in the two counties. About 2,600 acre-feet (2.3 mgd) was for public supply, 9,200 acre-feet (8.2 mgd) for irrigation, 2,300 acre-feet (2.1 mgd) for industrial use, and 3,400 acre-feet (3.0 mgd) for domestic and livestock use.

Aquifer tests show that the coefficient of transmissibility ranges from 1,500 to 24,000 gallons per day per foot in the Gulf Coast aquifer.

Small additional supplies of ground water, perhaps on the order of a few million gallons per day, are probably available for development in the two-county area without depleting the aquifer. The area most favorable for additional development is north and northwest of Sinton in San Patricio County. In this area, yields of as much as 1,700 gallons per minute might be expected from wells tapping the full thickness of the aquifer. Elsewhere in the two-county area, only small additional supplies are available on a perennial basis.

In addition to the amount of water that can be withdrawn perennially in the two counties, a large quantity of water is in storage; perhaps as much as a few million acre-feet might be available to wells within economic pumping lifts.

Large quantities of moderate saline water are available for development in the two-county area. The economic use of this water depends on the development of economic demineralization processes.

The most satisfactory method of salt-water disposal to prevent contamination of ground water is through the use of injection wells, but in 1961, only 23.9 percent of the total quantity of salt water produced from oil wells in Nueces County and 9 percent of that produced in San Patricio County was disposed of by this method.

# GROUND-WATER RESOURCES OF NUECES AND SAN PATRICIO COUNTIES, TEXAS

## INTRODUCTION

### Location and Extent of Area

Nueces and San Patricio Counties are in south Texas in the Coastal Bend region of the West Gulf Coastal Plain (Figure 1). The Nueces River is the boundary between the two counties. Nueces County is bounded on the south and southwest by Kleberg County, on the west by Jim Wells County, on the southeast by the Gulf of Mexico, and on the northeast by Aransas County. San Patricio County is bounded on the west by Jim Wells County, on the northwest by Live Oak County, on the north by Bee and Refugio Counties, and on the northeast by Refugio and Aransas Counties.

Corpus Christi, situated on Nueces and Corpus Christi Bays, is the county seat of Nueces County. Other communities in Nueces County include Robstown, Bishop, Port Aransas, Driscoll, Flour Bluff, Banquete, and Agua Dulce. The land area of the county is 838 square miles.

Sinton, the county seat of San Patricio County, is centrally located within the county about 27 miles northwest of Corpus Christi. Communities in San Patricio County are Mathis, Aransas Pass, Portland, Taft, Odem, and Gregory. The area of the county is 680 square miles.

### Purpose and Scope of Investigation

The purpose of this study was to determine the occurrence, availability, dependability, quality, and quantity of the ground-water resources of Nueces and San Patricio Counties. The results of the study are published as a guide for developing, protecting, and obtaining maximum benefits from the available ground-water supplies.

The investigation specifically included: A delineation of the location and extent of sands containing fresh to slightly saline water; determination of the chemical quality of the water; compilation of the quantity of water being withdrawn and an assessment of the effect of these withdrawals on water levels and quality; determination of the hydraulic characteristics of the important water-bearing sands; and an estimate of the quantity of ground water available for development.

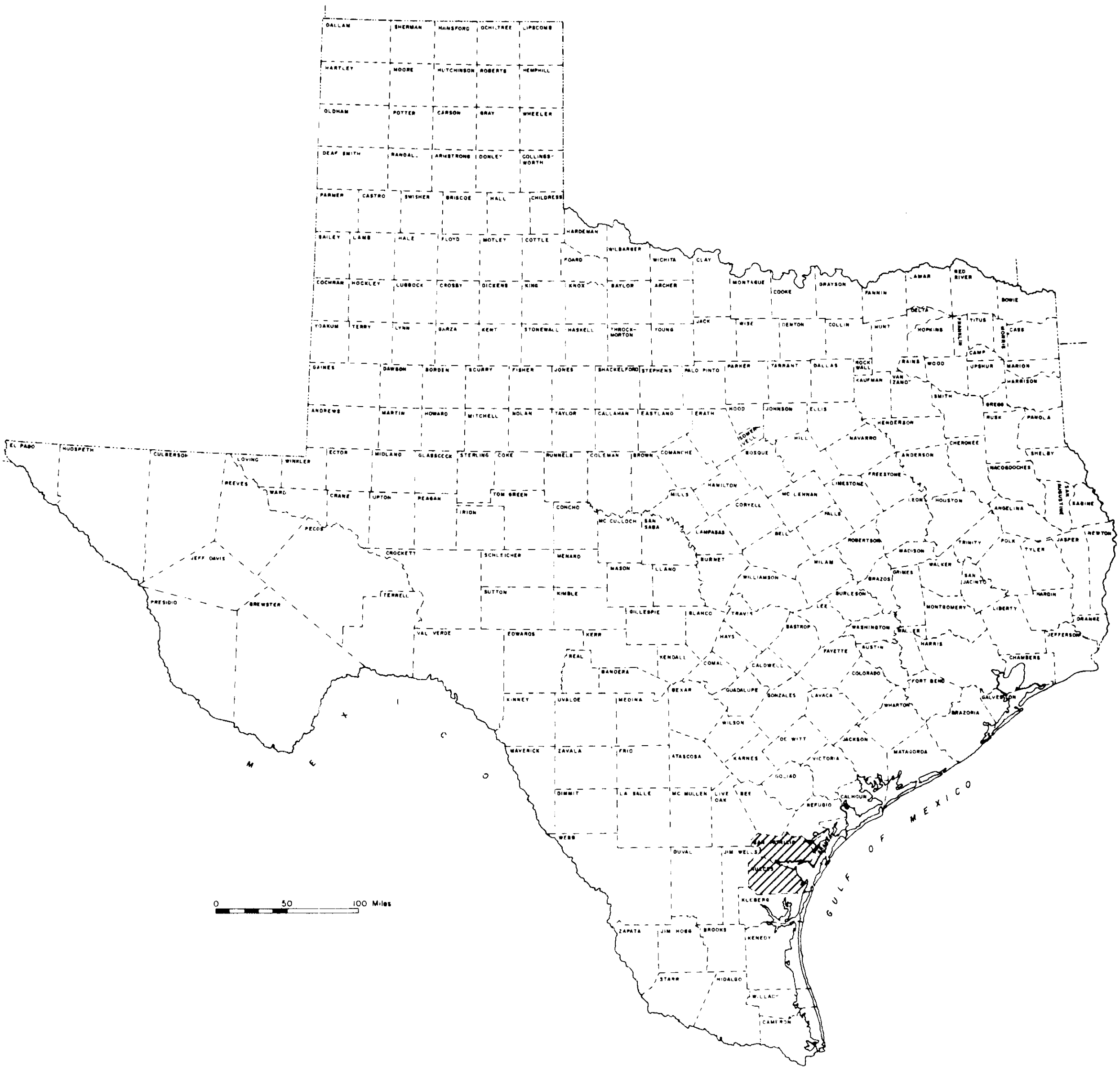



Figure 1

Location of Nueces and San Patricio Counties

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

## Methods of Investigation

To accomplish the main objectives of the investigation:

1. An inventory was made of 579 water wells and 148 oil tests (Table 11). The locations of the wells are shown in Figure 15, and drillers' logs of 25 wells are given in Table 13.

2. More than 600 electrical logs were examined for correlation of stratigraphic units and for determination of the water-bearing properties of the formations.

3. An inventory was made of present and past ground-water pumpage.

4. Pumping tests were run and data were compiled from previous pumping tests to determine the hydraulic characteristics of the water-bearing sands.

5. Elevations for altitude control were obtained from topographic maps.

6. Measurements of water levels were made in wells and compared with available records of past fluctuations of water levels.

7. Climatological and streamflow data were collected and compiled.

8. Analyses of water samples collected during this and previous investigations were used to determine the chemical quality of the water (Table 14).

9. A geologic map was prepared (Figure 5).

10. Three geologic sections were made from electrical logs (Figures 16, 17, and 18).

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

12. Problems related to the development and protection of ground-water supplies were studied.

## Previous Investigations

A ground-water report and an inventory of water wells in Nueces County was made in 1934 by Walter A. Lynch. It contains records of 176 wells, drillers' logs of 7 wells, analyses of water from 28 wells, and a map showing well locations. In 1939 a similar report on wells in San Patricio County was made by Carl E. Johnson. Table 1 shows the well numbers used by Johnson and Lynch and the corresponding numbers used in this report.

Studies relating to ground water have been made previously in both Nueces and San Patricio Counties. The public water supplies of several cities in the two counties were described briefly by Broadhurst, Sundstrom, and Rowley (1950, p. 87-90 and 93-98). A reconnaissance study of the ground-water resources of the Gulf Coast region, which includes Nueces and San Patricio Counties, was made by Wood, Gabrysch, and Marvin (1963), and the ground-water resources of an area including most of Nueces and San Patricio Counties are discussed in the

Table 1.--Well numbers used in this report and corresponding numbers previously used in Nueces County by Lynch (1934), and in San Patricio County by Johnson (1939)

| New number | Old number | New number | Old number | New number | Old number |
|---|---|---|---|---|---|
| **Nueces County** | | | | | |
| UB-83-01-901 | 6 | UB-83-18-402 | 120 | UB-83-20-904 | 196 |
| UB-83-02-701 | 2 | UB-83-18-403 | 46 | UB-83-28-501 | 220 |
| UB-83-10-303 | 72 | UB-83-18-701 | 122 | UB-83-29-201 | 214 |
| UB-83-11-501 | 91 | UB-83-20-101 | 109 | | |
| UB-83-12-901 | 172 | UB-83-20-902 | 197 | | |
| **San Patricio County** | | | | | |
| WW-70-59-206 | 334 | WW-79-61-805 | 403 | WW-83-05-101 | 410 |
| WW-70-59-207 | 331 | WW-79-61-904 | 396 | WW-83-05-103 | 411 |
| WW-70-59-309 | 336 | WW-79-61-905 | 421 | WW-83-05-201 | 417 |
| WW-70-59-503 | 329 | WW-79-62-701 | 213 | WW-83-05-901 | 273 |
| WW-70-59-506 | 330 | WW-79-62-702 | 219 | WW-83-06-101 | 260 |
| WW-70-59-607 | 327 | WW-79-62-703 | 212 | WW-83-06-102 | 262 |
| WW-70-59-802 | 304 | WW-79-62-704 | 244 | WW-83-06-103 | 263 |
| WW-79-60-111 | 344 | WW-79-62-801 | 208? | WW-83-06-201 | 257 |
| WW-79-60-209 | 342 | WW-79-62-802 | 223 | WW-83-06-401 | 280 |
| WW-79-60-210 | 356 | WW-79-62-803 | 221 | WW-83-06-601 | 283 |
| WW-79-60-211 | 357 | WW-79-62-804 | 241 | WW-83-06-701 | 278 |
| WW-79-60-402 | 325 | WW-79-62-901 | 233 | WW-83-07-104 | 33 |
| WW-79-60-504 | 319 | WW-83-03-203 | 306 | WW-83-07-402 | 38 |
| WW-79-60-903 | 318 | WW-83-03-303 | 307 | WW-83-07-509 | 52 |
| WW-79-60-904 | 317 | WW-83-03-606 | 308 | WW-83-07-801 | 78 |
| WW-79-61-602 | 389 | WW-83-04-205 | 314 | WW-83-07-833 | 80 |
| WW-79-61-603 | 386 | WW-83-04-206 | 313 | WW-83-07-834 | 92 |
| WW-79-61-706 | 408 | WW-83-04-301 | 409 | WW-83-07-919 | 135 |

reconnaissance study of the Guadalupe, San Antonio, and Nueces River basins by Alexander, Myers, and Dale (1964). Swartz (1957) tabulated records of water levels in observation wells in San Patricio County.

Detailed reports have been published on the ground-water resources of several counties adjacent to Nueces and San Patricio Counties, including Live Oak County (Anders and Baker, 1961), Refugio County (Mason, 1963a), Bee County (Myers and Dale, 1966), and Kleberg County (Livingston and Bridges, 1936). Mason (1963b) reported on the availability of ground water from the Goliad Sand in the Alice area of Jim Wells County. Some of the data resulting from these studies are contained in this report.

Descriptions of geologic features in Nueces and San Patricio Counties are included in reports by Deussen (1924), and Sellards, Adkins, and Plummer (1932). The geology of the area is shown on the geologic map of Texas (Darton and others, 1937).

## Economic Development

The economy of the combined area of Nueces and San Patricio Counties is dependent mainly upon oil production, petrochemical industries, fishing, livestock raising, and farming. Oil was discovered in San Patricio and Nueces Counties in 1930. During 1963 more than 20 million barrels of oil was produced in the two counties. Cotton and grain sorghum are the principal crops, but flax, cabbage, onions, and other crops are also grown for market or home consumption.

Water transportation is a major factor in the economic growth of the Nueces-San Patricio area because Port Aransas and Corpus Christi are both deep-water ports. The area is also served by air, rail, and bus lines; paved State and Federal highways; and secondary roads.

Corpus Christi, the county seat of Nueces County, had a population of 167,690 in 1960. It is an important seaport and industrial-commercial center. Corpus Christi and other towns, particularly those situated along the coast, attract many tourists and sportsmen.

## Topography and Drainage

The topography of Nueces and San Patricio Counties is at most places nearly flat or gently rolling; the land surface slopes to the southeast. The altitude in the two-county area ranges from sea level along the shoreline of the bays to about 200 feet above sea level near the northern tip of the Live Oak-San Patricio County line. At some places dissection of the plain by stream erosion has produced a moderately hilly terrain. The Nueces River has cut a valley floor more than 3 miles wide in places, and more than 80 feet below the level of the plain in the western part of the area. Vegetation is scant at most places, but there are oak clusters and other vegetation in the more sandy areas and in the uplands and along the streams. On the Gulf side of Mustang Island, and for a short distance inland, sand dunes break the flatness of the terrain.

Nueces and San Patricio Counties are drained by low-gradient streams. The Aransas River and its tributaries drain the northern part of San Patricio

County, and Chiltipin Creek drains the central part. The Nueces River drains the western part of San Patricio County and a part of Nueces County. A few short streams drain directly into the bays. Much of the land surface south of the Nueces River in Nueces County is drained by Petronila and Oso Creeks. Artificial drainage is provided in a large part of the area.

In August 1939, the U.S. Geological Survey established a stream-gaging station on the Nueces River, 0.6 mile downstream from Wesley E. Seale Dam and 4 miles southwest of Mathis in San Patricio County. Wesley E. Seale Dam creates Lake Corpus Christi which has a capacity of 302,100 acre-feet. Water is released from the reservoir, flows past the stream-gaging station, and is diverted downstream for use at numerous places. During the water year 1964, the maximum daily discharge from the reservoir was 272 cubic feet per second on September 1, 1964; the minimum daily discharge was 43 cubic feet per second on July 20, 1964. The average daily discharge was 104 cubic feet per second, and the total discharge for the year was 75,370 acre-feet.

## Climate

Both Nueces and San Patricio Counties have a dry subhumid climate according to the classification of Thornthwaite (1941, p. 2). The area is occasionally subject to tropical disturbances which move in from the Gulf of Mexico during summer and fall. Destructive winds and torrential rains may occur during these storms. Incomplete records show the average monthly rainfall at Sinton during the period 1931 to 1965 to be greatest in September (4.5 inches) and least in March (1.5 inches). (See Figure 2.)

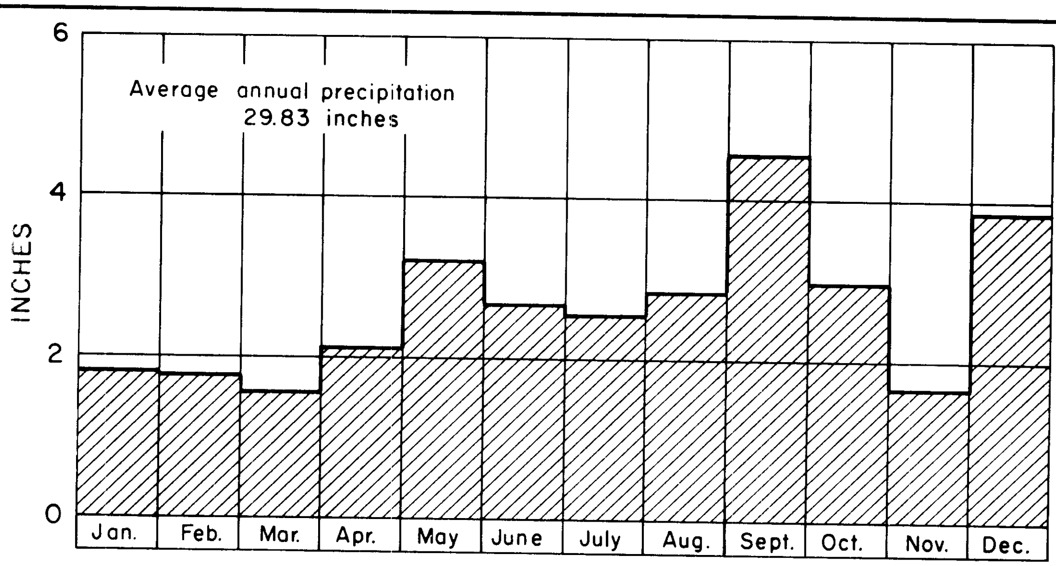
The average annual gross lake surface evaporation rate in the two counties from 1940 to 1957 was about 57 inches (Lowry, 1960), nearly twice the mean annual precipitation (Figure 2). The annual normal temperature and the monthly normal temperature at Corpus Christi from 1931-60 are shown in Figure 3. The growing season is 309 days in Nueces County and 303 days in San Patricio County.

## Well-Numbering System

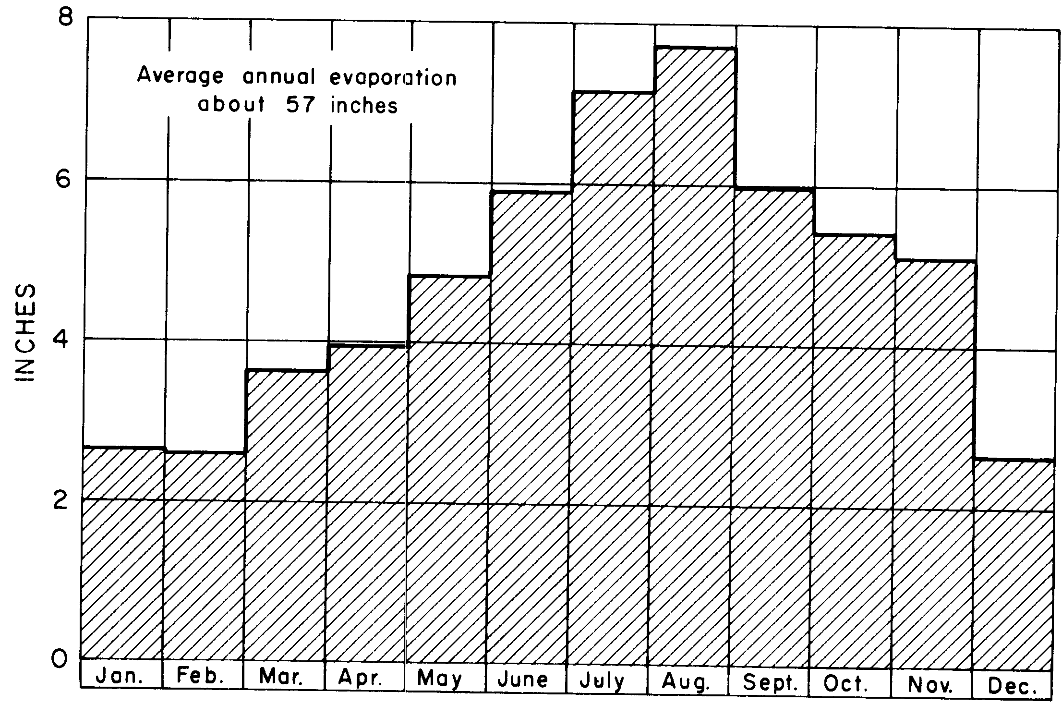
The well-numbering system used in this report is the one adopted by the Texas Water Development Board for use throughout the State (Figure 4). Under this system, which is based upon the divisions of latitude and longitude, each 1-degree quadrangle in the State is given a number consisting of two digits, from 01 to 89. These are the first two digits appearing in the well number.

Each 1-degree quadrangle is divided into 7-1/2 minute quadrangles which are given 2-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each 7-1/2 minute quadrangle is divided into 2-1/2 minute quadrangles which are given a single-digit number from 1 to 9. This is the fifth digit of the well number. Each well within a 2-1/2 minute quadrangle is given a 2-digit number in the order in which it is inventoried. These are the last two digits of the well number. The 1-degree and 7-1/2 minute quadrangles are shown on the well-location map of this report (Figure 15).

In addition to the 7-digit well number, a 2-letter prefix is used to identify the county. The prefix for Nueces County is UB, and the prefix for San Patricio County is WW.




AVERAGE MONTHLY PRECIPITATION AT SINTON, TEXAS
1931-1965




AVERAGE MONTHLY GROSS LAKE SURFACE EVAPORATION
IN SAN PATRICIO AND NUECES COUNTIES, 1940-1957

Figure 2

Average Monthly Precipitation at Sinton, and Gross Lake Surface Evaporation in San Patricio and Nueces Counties

(Data from U.S. Weather Bureau and Lowry, 1960)

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

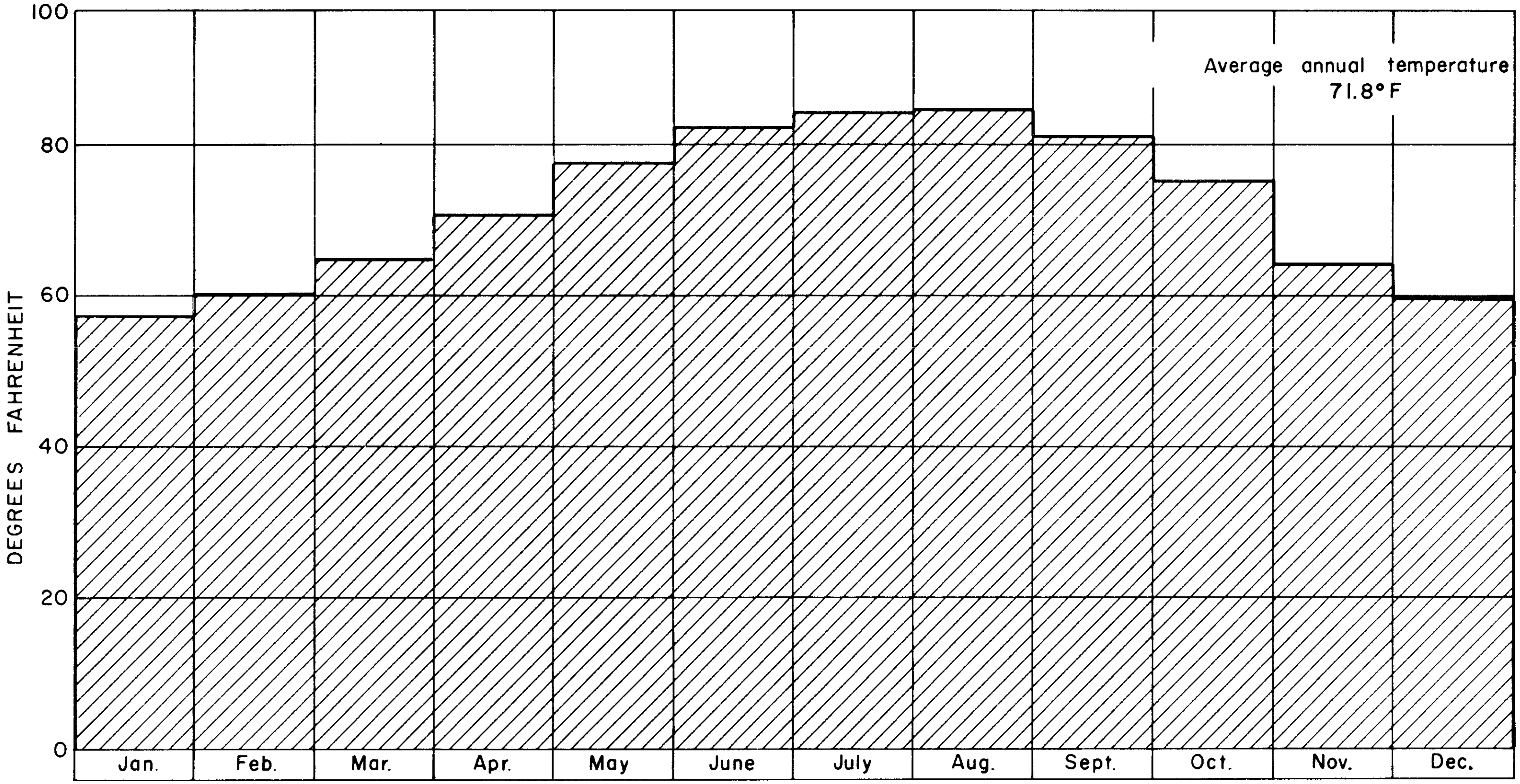



Figure 3

**Average Monthly Temperature at Corpus Christi, 1931-60**

( Data from U.S. Weather Bureau )

U. S. Geological Survey in cooperation with the Texas Water Development Board
and the San Patricio Municipal Water District

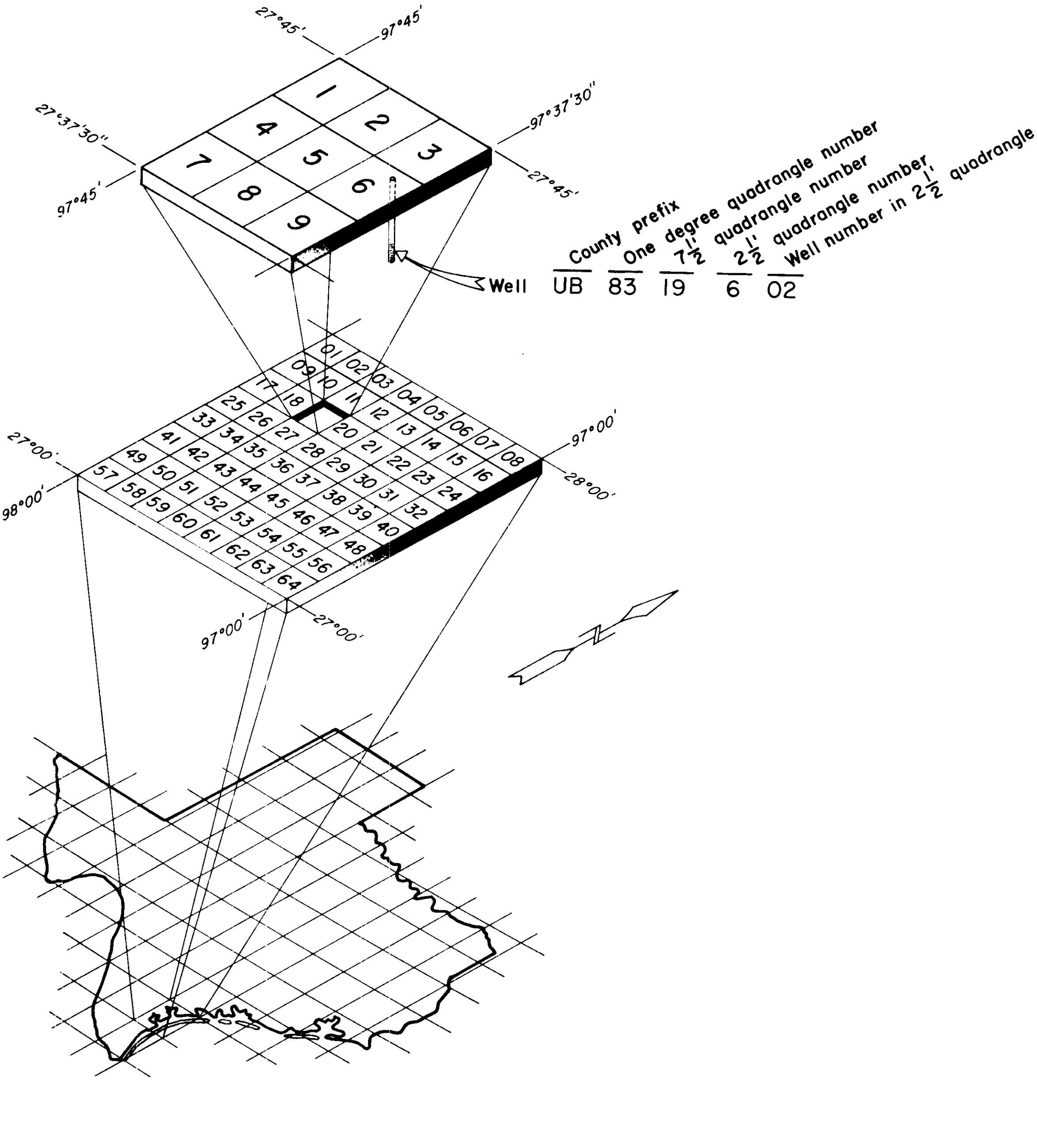



Figure 4

Well – Numbering System

U.S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

## Acknowledgments

The writer gratefully acknowledges the cooperation of the many landowners and industrial and city officials in Nueces and San Patricio Counties in furnishing assistance and information and in permitting access to wells for water-level measurements, pumping tests, and power tests. Water-well drillers in the area contributed drillers' logs and well-completion data. The cooperation of the U.S. Soil Conservation Service and the San Patricio county agent greatly facilitated completion of the project.

## Definitions of Terms

In the following sections of the report certain technical terms or terms subject to different interpretations are used. For convenience and clarification, these terms are defined as follows:

Aquiclude.--A geologic formation, group of formations, or a part of a formation which, although porous and capable of absorbing water slowly, will not transmit water fast enough to furnish an appreciable supply for a well or spring.

Aquifer.--A geologic formation, group of formations, or part of a formation that is water bearing.

Artesian water.--Ground water that is under sufficient pressure to rise above the level at which it is found in a well; it does not necessarily rise to or above the surface of the ground.

Permeability, coefficient of.--The rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot of the aquifer under a unit hydraulic gradient.

Piezometric surface.--An imaginary surface that everywhere coincides with the static level of the water in an aquifer. The surface to which the water from a given aquifer will rise under its full head.

Resistivity (electrical log).--The resistance of the rocks and their fluid contents to induced electrical currents, measured in ohms per square meter per meter (ohms $m^2/m$). Permeable rocks containing fresh water have high resistivities.

Specific capacity.--The discharge of a well expressed as the rate of yield per unit of drawdown, generally in gallons per minute per foot of drawdown. If the yield is 250 gpm and the drawdown is 10 feet, the specific capacity is 25 gpm per foot.

Specific conductance (conductivity).--A measure of the ability of a solution to conduct electricity, expressed in micromhos per centimeter at 25°C. The specific conductance is approximately proportional to the content of dissolved solids.

Specific yield.--The quantity of water that an aquifer yields by gravity if it is first saturated and then allowed to drain; the ratio is expressed in percentage of the volume of water drained to the volume of the aquifer drained.

Spontaneous potential (electrical log).--The difference in electrical potential across the boundaries of different types of material, measured in millivolts.

Storage, coefficient of.--The volume of water an aquifer releases from or takes into storage per unit of surface area of the aquifer per unit change in the component of head normal to that surface. Storage coefficients of artesian aquifers may range from about 0.00001 to 0.001; those for water-table aquifers may range from about 0.05 to 0.30.

Transmissibility, coefficient of.--The number of gallons of water which will move in 1 day through a vertical strip of the aquifer 1 foot wide extending through the thickness of the aquifer under a hydraulic gradient of 1 foot per foot at the prevailing temperature of the water. The coefficient of transmissibility is equal to the field coefficient of permeability times the saturated thickness of the aquifer.

Transmission capacity.--The quantity of water which can be transmitted through a given width of an aquifer at a given hydraulic gradient, usually expressed in acre-feet per year or million gallons per day.

Water level; static level; hydrostatic level.--In an unconfined aquifer, the water level is the distance from the land surface to the water table (or depth to the top of the zone of saturation). In a confined (artesian) aquifer, the water level, which may be above or below the land surface, is a measure of the pressure in the aquifer.

Water table.--The upper surface of a zone of saturation except where that surface is formed by an impermeable body of rock.

Yield.--The following ratings apply to the yields of wells in Nueces and San Patricio Counties.

| Description | Yield (gallons per minute) |
|---|---|
| Small | Less than 50 |
| Moderate | 50 to 500 |
| Large | More than 500 |

## GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

### The Gulf Coast Aquifer

Ground water in Nueces and San Patricio Counties occurs principally in the Goliad Sand, Lissie Formation, and Beaumont Clay. These units are in hydrologic continuity, and in this report they are collectively classified as the Gulf Coast aquifer.

## Stratigraphic Units and Their Water-Bearing Properties

The stratigraphic units that contain fresh to slightly saline or moderately saline water (see page 35) in Nueces and San Patricio Counties are, from oldest to youngest, the Goliad Sand of Pliocene age, the Lissie Formation and Beaumont Clay of Pleistocene age, and the alluvium and beach and dune sands of Pleistocene or Recent age (Figure 5). The approximate thickness, lithology, age, and water-bearing properties of the stratigraphic units are summarized in Table 2. The variations in lithology are shown in the geologic sections (Figures 16, 17, and 18).

The Goliad Sand, Lissie Formation, and Beaumont Clay crop out in belts that trend roughly northeast, parallel to the coast (Figure 5). The Goliad Sand is farthest from the coast, and the Beaumont Clay is nearest the coast. All units dip to the southeast at an angle greater than the slope of the land surface, most of them becoming thicker and finer grained downdip.

The heterogeneous character of the stratigraphic units makes correlation of individual beds difficult even within short distances. The deposits are generally lenticular; the lenses of clay, sand, or gravel pinch out, coalesce, or grade into each other within short distances. The contacts between the units are difficult to pick on drillers' logs or electrical logs, but for all practical purposes, the contacts are of no particular importance in this report because the units are in hydrologic continuity. The thicknesses of the individual units were not determined. The thicknesses shown in Table 2 are based largely on the thicknesses in adjacent counties.

Recent alluvium in the Nueces River valley, which in most places is about 35 to 40 feet thick, consists of clay, silt, sand, and gravel. Throughout the valley, there are many active and abandoned gravel pits in which the alluvium is exposed. Some of the gravel pits have been excavated to the water table. The chemical analysis of a water sample from the pit shown in Figure 15 is given in Table 14. The alluvium and beach and dune sands yield small supplies of fresh to slightly saline water to a few wells.

The U.S. Geological Survey is making a detailed study of the alluvium in the Nueces River valley between Lake Corpus Christi and Calallen to determine the hydraulic relationship between the alluvium and the flow in the river. The results of this study will be presented in a separate report.

# GROUND-WATER HYDROLOGY

General hydrologic principles have been described in considerable detail by Meinzer (1923), Meinzer and others (1942), Tolman (1937), Leopold and Langbein (1960), Baldwin and McGuinness (1963), and a number of other authors in the United States and elsewhere. The following discussion applies these principles to the ground-water hydrology of Nueces and San Patricio Counties.

## Source and Occurrence of Ground Water

The source of ground water in Nueces and San Patricio Counties is precipitation on the outcrop of the aquifer within the two counties and in the counties to the northwest and west. Most of the precipitation runs off, evaporates, or is transpired by vegetation. A relatively small part of the precipitation

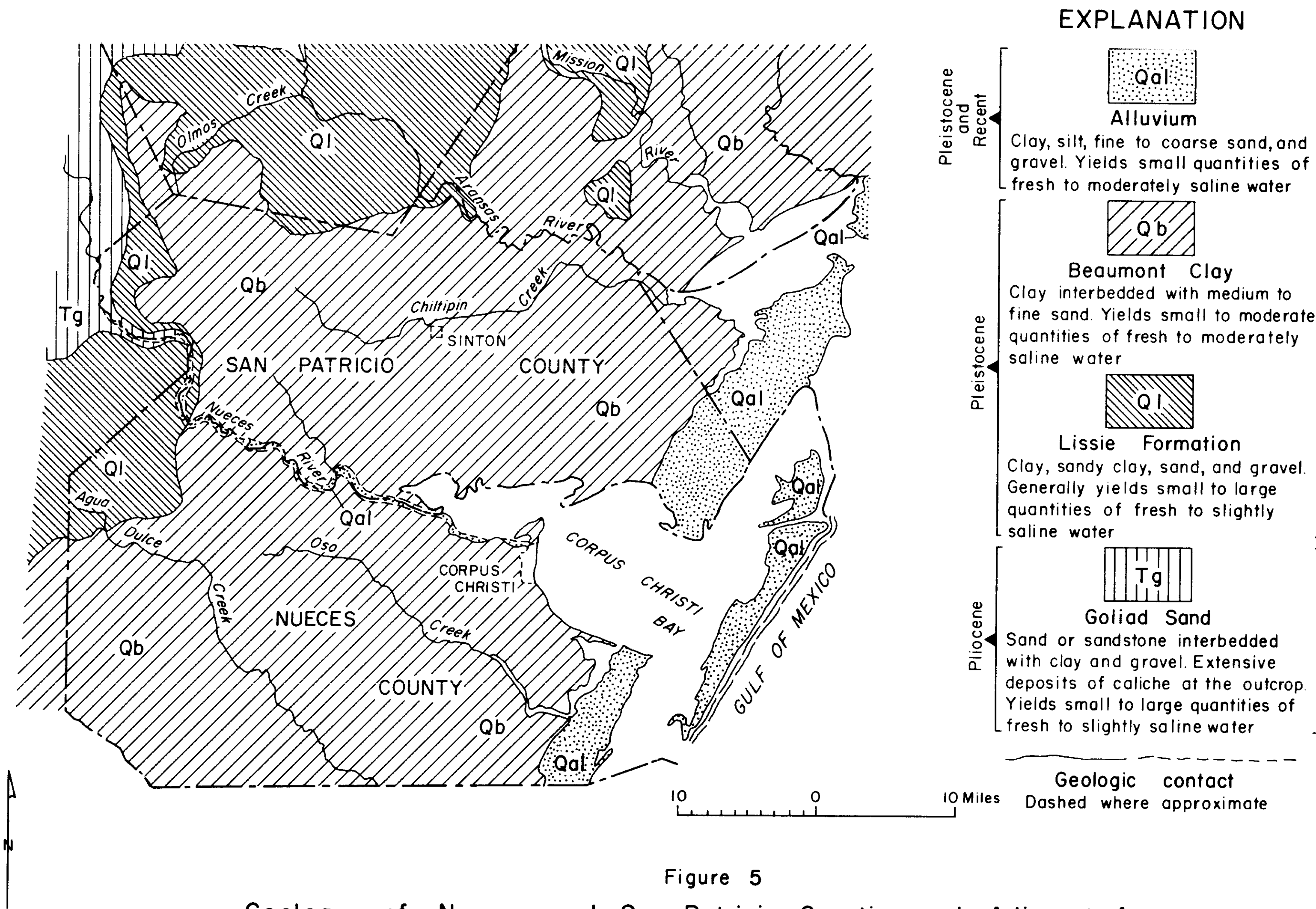



Figure 5

Geology of Nueces and San Patricio Counties and Adjacent Areas

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

Geology from Geoglogic Map of Texas (Darton and others, 1937)

Table 2.--Stratigraphic units and their water-bearing properties, Nueces and San Patricio Counties

| System | Series | Stratigraphic unit | | Estimated thickness (ft) | Lithology | Water-bearing properties |
|---|---|---|---|---|---|---|
| Quaternary | Recent and Pleistocene | Alluvium and beach and dune sands | | 40-100(?) | Fine to coarse sand, silt, clay, and gravel. Very coarse gravel in basal part in Nueces River valley. | Generally yields small quantities of fresh to slightly saline water to wells throughout the Nueces River valley, and slightly saline to moderately saline water to wells in beach and dune sands near the coast. |
| | Pleistocene | Gulf Coast aquifer | Beaumont Clay | 500(?) | Predominantly clay interbedded with layers of medium to fine sand. In some places contains thick lenses of sand. | Yields small to moderate quantities of fresh to moderately saline water. Sands in upper part formerly supplied water for public use in Aransas Pass and Ingleside |
| | | | Lissie Formation | 600(?) | Alternating thick to thin beds of sand, gravel, sandy clay, and clay. Contains caliche locally. | Generally yields small to large quantities of fresh to slightly saline water, moderately saline at some places. Supplies water for many irrigation and industrial wells. |
| Tertiary | Pliocene | | Goliad Sand | 600(?) | Sand or sandstone interbedded with layers of gravel and clay. Contains an abundance of caliche at the outcrop. | Yields small to large quantities of fresh to slightly saline water. Frequently screened with Lissie Formation to increase yields of wells. |

infiltrates the land surface and reaches the zone of saturation, thereby becoming ground water. Factors that affect the amount of precipitation that becomes ground water, or recharge to the aquifer, include the amount and intensity of rainfall, the slope of the land surface, the type of soil, the permeability of the aquifer, the quantity of water in the aquifer, and the rate of evapotranspiration.

Ground water occurs under water-table and artesian conditions. Under water-table conditions the water is unconfined and does not rise above the level at which it is first encountered in a well. Under artesian conditions, the aquifer is overlain by relatively impermeable beds, and the water is confined under hydrostatic pressure. Where the elevation of the land surface at a well is considerably lower than the level of the outcrop of the aquifer, the pressure may be sufficient to cause the water to flow at the surface. Although the terms "water table" and "piezometric surface" are synonymous in the area of outcrop of an aquifer, the term piezometric surface, as used in this report, is applied only to the artesian parts of the aquifers.

In the areas where the beds of permeable material in the Gulf Coast aquifer crop out, ground water is unconfined and, therefore, under water-table conditions. Downdip from the outcrop areas, the permeable beds may be overlain by less permeable material, and the water is, therefore, confined or under artesian conditions.

In Nueces and San Patricio Counties, the Gulf Coast aquifer cannot be considered at any one place to have a single water level. The land surface rises to the west, and the successively deeper beds crop out and are recharged at increased distances to the west. As a generalization, the piezometric surfaces tend to be progressively higher with increased depth to the permeable beds.

## Movement of Ground Water

Ground water moves, under the force of gravity, from the areas of recharge to the areas of discharge. After initial infiltration of water at the land surface, its dominant direction of movement, through the zone of aeration, is vertical. After reaching the zone of saturation, water moves in the direction of the hydraulic gradient--the slope of the piezometric surface.

In Nueces and San Patricio Counties, the rate of movement of ground water ranges from tens to hundreds of feet per year, depending upon the hydraulic gradient, permeability of the sediments, and temperature of the water. The direction of movement is generally southeastward toward the Gulf of Mexico, although locally, the effects of pumping have altered this regional pattern (Figure 8).

## Aquifer Tests

Aquifer tests were made in wells in Nueces and San Patricio Counties to determine the coefficients of transmissibility and storage of the Gulf Coast aquifer. The results of the tests are shown in Table 3. The test data were analyzed by the Theis nonequilibrium method (Theis, 1935, p. 519-524). The coefficients of transmissibility in wells tapping the Gulf Coast aquifer ranged from 1,500 gpd (gallons per day) per foot to 24,000 gpd per foot (Table 3).

Table 3.--Summary of aquifer tests in Nueces and San Patricio Counties

| Well | Screened interval (ft) | Average discharge during test (gpm) | Coefficient of transmissibility (gpd/ft) | Specific capacity (gpm/ft) | Coefficient of storage | Remarks |
|---|---|---|---|---|---|---|
| **Nueces County** | | | | | | |
| UB-83-26-503 | 600-622, 642-720 | -- | 6,000 | 2.8 | $1.4 \times 10^{-4}$ | Drawdown interference from pumping well UB-83-26-510 at 155 gpm for 23 hours. |
| 83-26-507 | 655-681, 684-715, 736-745, 756-786, 796-826 | 200 | 4,400 | 1.9 | $8 \times 10^{-5}$ | Drawdown of pumped well. |
| 83-26-507 | 655-681, 684-715, 736-745, 756-786, 796-826 | -- | 3,500 | -- | -- | Recovery after pumping 200 gpm for 70 hours. |
| 83-26-508 | 855-895 | -- | 4,400 | 2.2 | $8.4 \times 10^{-5}$ | Drawdown interference from pumping well UB-83-26-507 at 200 gpm for 70 hours. |
| 83-26-508 | 855-895 | -- | 4,800 | -- | $7.8 \times 10^{-5}$ | Recovery after pumping 200 gpm from well UB-83-26-507 for 70 hours. |
| 83-26-509 | 817-845, 870-892, 897-950 | 200 | 4,200 | 2.7 | $8.5 \times 10^{-4}$ | Drawdown interference from pumping well UB-83-26-507 at 200 gpm for 70 hours. |
| 83-26-509 | 817-845, 870-892, 897-950 | -- | 4,400 | -- | $8 \times 10^{-4}$ | Recovery after pumping 200 gpm from well UB-83-26-507 for 70 hours. |
| 83-26-511 | -- | -- | 5,000 | -- | $1.2 \times 10^{-4}$ | Drawdown interference from pumping well UB-83-26-510 at 155 gpm for 23 hours. |
| **San Patricio County** | | | | | | |
| WW-79-51-705 | 280-331, 347-588, 639-696, 711-751 | 1,600 | 22,000 | 10.7 | -- | Recovery of pumped well. |
| 79-58-201 | 224-239, 259-269, 283-310, 334-380, 404-450 | 544 | 11,000 | 6.1 | -- | Do. |
| 79-58-502 | 168-288 | 315 | 12,000 | 5.4 | -- | Do. |
| 79-58-903 | 185-254, 273-332, 348-375 | 1,200 | 24,000 | 14.0 | -- | Do. |
| 79-60-602 | 342-369, 378-409, 430-461, 500-561, 601-683 | -- | 23,000 | 10.4 | $2.95 \times 10^{-4}$ | Recovery after pumping 435 gpm from well WW-79-60-604. |
| 79-60-603 | 344-431, 484-615, 635-676 | 286 | 3,700 | 5.0 | -- | Recovery of pumped well. |
| 83-07-829 | 50-182 | 120 | 3,000 | 1.7 | $2.2 \times 10^{-3}$ | Drawdown of pumped well. |
| 83-07-829 | 50-182 | -- | 3,000 | -- | -- | Recovery after pumping 120 gpm. |
| 83-07-835 | -- | -- | 1,500 | -- | $9.6 \times 10^{-3}$ | Drawdown interference from pumping well WW-83-07-829 at 120 gpm. |
| 83-07-835 | -- | -- | 3,700 | -- | $2.9 \times 10^{-3}$ | Recovery after pumping 120 gpm from well WW-83-09-829. |
| 83-07-836 | -- | -- | 3,400 | -- | $8.6 \times 10^{-3}$ | Drawdown interference from pumping well WW-83-07-829 at 120 gpm. |
| 83-07-836 | -- | -- | 3,900 | -- | $7.1 \times 10^{-4}$ | Recovery after pumping 120 gpm from well WW-83-07-829. |

Coefficients of storage in the aquifer ranged from $7.8 \times 10^{-5}$ to $9.6 \times 10^{-3}$. The coefficients of transmissibility are representative of the producing interval screened in the well and not of the entire sand section in the aquifer. Some of the wells tested were not screened throughout the entire sand section. Coefficients of transmissibility of 22,000 and 24,000 gpd per foot, respectively, were measured in wells WW-79-51-705 and WW-79-58-903; these wells are probably representative of similarly screened wells in that part of the county. In other parts of Nueces and San Patricio Counties, the coefficients of transmissibility are less.

The coefficients of transmissibility and storage determined from aquifer tests may be used to predict the drawdown of water levels caused by pumping a well or by a general increase of pumping in an area. Figure 6 shows the theoretical relation between drawdown and distance based on different coefficients of transmissibility. The calculations of drawdown are based on a withdrawal of 1,000 gpm (gallons per minute) continuously for 1 year from an infinite aquifer having a coefficient of storage of 0.0001 and coefficients of transmissibility as shown. As a result of pumping 1,000 gpm continuously for 1 year from the theoretical aquifer having a coefficient of transmissibility of 15,000 gpd per foot, the water level would decline about 74 feet at a distance of 1,000 feet from the pumped well. Assuming a coefficient of transmissibility of 20,000 gpd per foot, the decline would be about 57 feet at 1,000 feet from the well and about 32 feet at 10,000 feet from the well.

Figure 7 shows the relation between drawdown and time in a well pumping 1,000 gpm from an infinite aquifer having a coefficient of storage of 0.0001 and a coefficient of transmissibility of 15,000 gpd per foot. Most of the drawdown in the well takes place in the first few days of pumping. The water level will continue to decline indefinitely but at a decreasing rate. Because drawdown is directly proportional to the pumping rate, the drawdowns for rates other than 1,000 gpm can be determined by multiplying the values in Figure 7 by the proper multiple or fraction of 1,000.

The specific capacities of 11 wells are shown in Table 3. The specific capacity, an expression of the yield of a well in gallons per minute per foot of drawdown, is useful in estimating the yield of a well at various drawdowns. Most of the specific capacities shown in the table were determined from pumping tests; they ranged from 1.7 to 14.0 gpm per foot. The specific capacities of wells penetrating the same aquifer may vary widely, depending upon the thickness of sand screened, the degree of well development, and the rate and duration of pumping.

## Ground-Water Development

The well inventory in Nueces and San Patricio Counties included all the municipal, industrial, and irrigation wells, and a representative number of domestic and livestock wells. The records of 579 wells are given in Table 11.

Nearly all the ground water used in the counties is taken from the Gulf Coast aquifer. Table 4 gives the amounts of ground water pumped for different uses in 1958, 1963, 1964, and 1965. The principal use of ground water in Nueces County has generally been for industry; the principal use in San Patricio County is for irrigation.

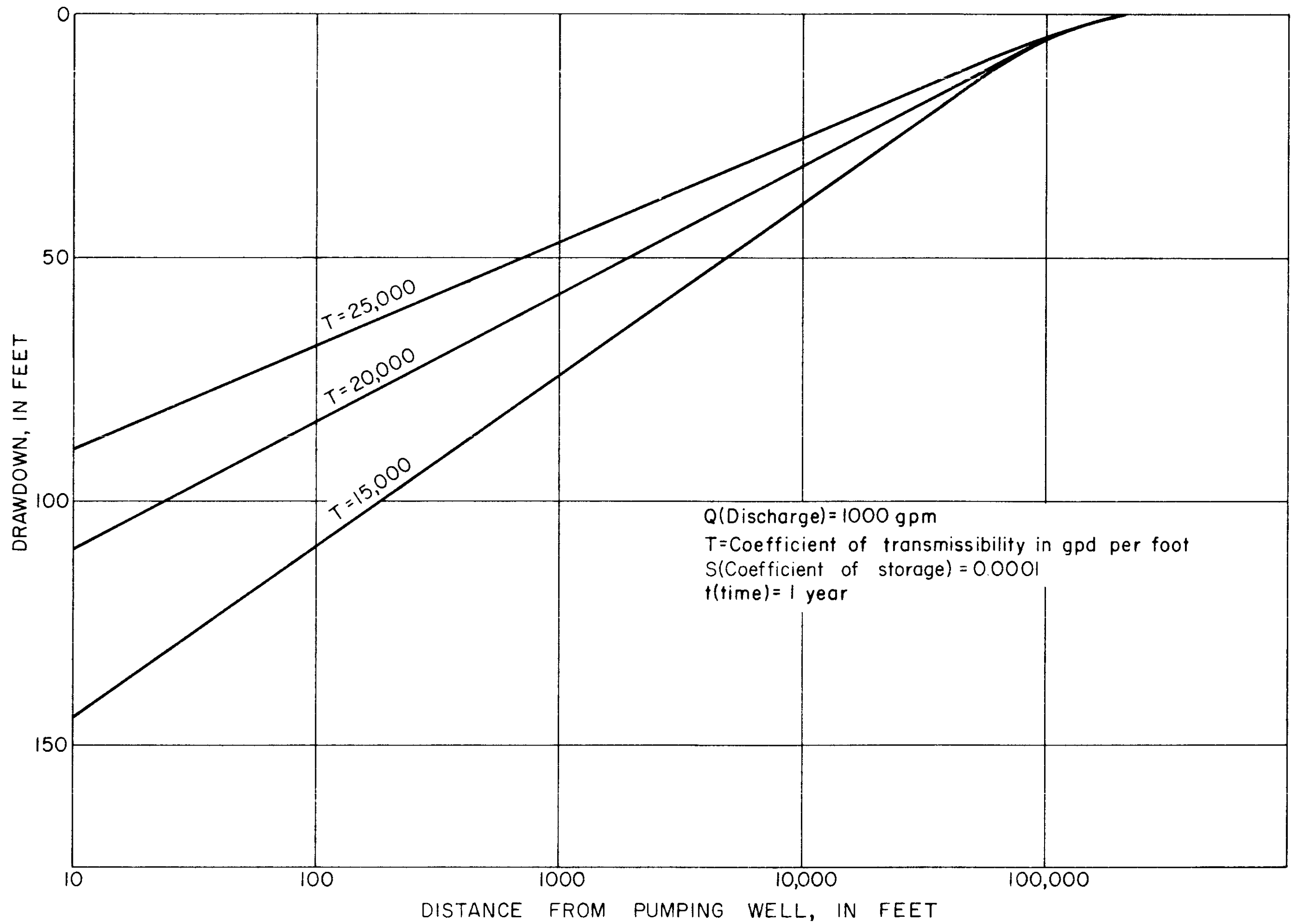



Figure 6

Relation of Drawdown to Distance for Various Coefficients of Transmissibility and Storage in an Infinite Aquifer

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

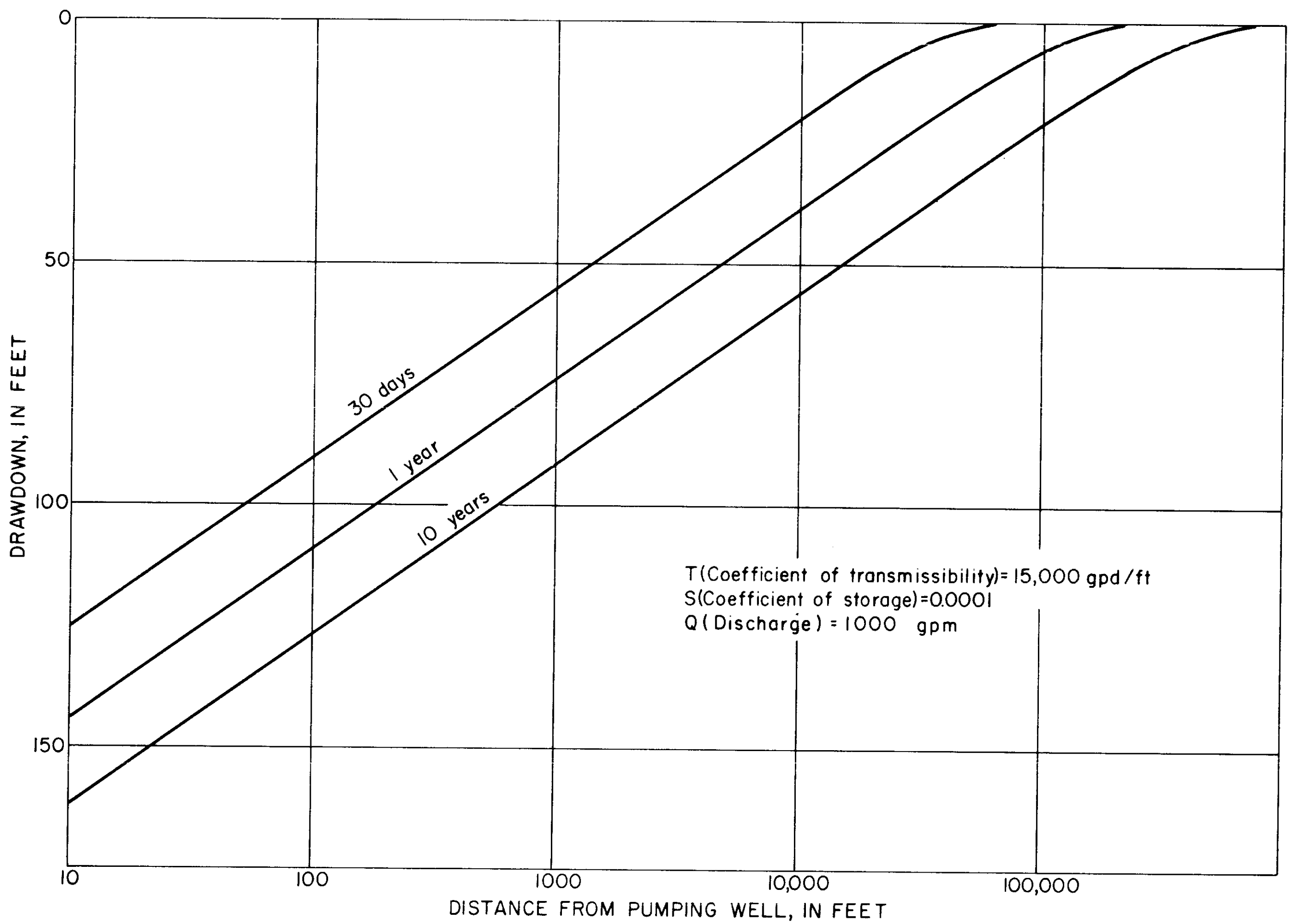



Figure 7

Relation of Drawdown to Distance for Various Periods of Time

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

Table 4.--Use of ground water in Nueces and San Patricio Counties, 1958 and 1963-65

| Year | Public supply | | Irrigation | | Industrial | | Rural domestic and livestock | | Totals* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr |
| **Nueces County** | | | | | | | | | | |
| 1958 | 0.07 | 723 | 0.20 | 227 | 1.89 | 2,119 | 1.8 | 2,000 | 4.0 | 5,000 |
| 1963 | 1.11 | 1,247 | -- | -- | 2.03 | 2,268 | 1.8 | 2,000 | -- | -- |
| 1964 | .94 | 1,045 | .66 | 742 | 1.92 | 2,167 | 1.8 | 2,000 | 5.3 | 5,900 |
| 1965 | .92 | 1,030 | 3.5 | 4,000 | 1.88 | 2,105 | 1.8 | 2,000 | 8.1 | 9,100 |
| **San Patricio County** | | | | | | | | | | |
| 1958 | 1.77 | 1,995 | 18.5 | 20,785 | 0.15 | 175 | 1.2 | 1,400 | 22 | 24,000 |
| 1963 | 1.72 | 1,928 | 15 | 16,900 | .15 | 169 | 1.2 | 1,400 | 18 | 20,000 |
| 1964 | 1.43 | 1,599 | 7.5 | 8,440 | .16 | 174 | 1.2 | 1,400 | 10 | 12,000 |
| 1965 | 1.05 | 1,181 | 6.0 | 6,739 | .16 | 175 | 1.2 | 1,400 | 8.4 | 9,500 |

* Figures are approximate because some of the pumpage is estimated. Public supply and industrial pumpage figures are shown to the nearest 0.01 mgd, and to the nearest acre-foot. Totals are rounded to two significant figures.

## Public Supply

In Nueces County, the towns of Agua Dulce, Banquete, Bishop, Chapman Ranch, and Driscoll used ground-water supplies during 1965 (Table 5). In 1945, Agua Dulce and Bishop used about 36 acre-feet (0.03 mgd) and 307 acre-feet (0.27 mgd), respectively (Broadhurst, Sundstrom, and Rowley, 1950, p. 87-88). In 1965, the use of ground water by Agua Dulce increased to about 225 acre-feet (0.20 mgd). The amount used by Bishop increased to about 469 acre-feet (0.42 mgd). The total amount of ground water used by the communities in Nueces County declined from 1,200 acre-feet (1.1 mgd) in 1963 to about 1,000 acre-feet (0.92 mgd) in 1965. The greater usage in 1963 is probably due to the low rainfall (0.05 inch in March, 0.05 inch in April, 0.51 inch in July, and 0.20 inch in August) and the use of large quantities of water for irrigating lawns. Port Aransas used ground water in 1945, but started using water from the Nueces River in November 1960.

In 1963, Aransas Pass, Mathis, Sinton, and Taft used ground-water supplies in San Patricio County (Table 6). Prior to 1965, Aransas Pass (April, 1959) and Taft (December, 1964) started using water from the Nueces River. In 1945, Aransas Pass used about 224 acre-feet (0.2 mgd); Odem, 45 acre-feet (0.04 mgd); Sinton, 258 acre-feet (0.23 mgd); and Taft, 729 acre-feet (0.65 mgd). No record was available for the amount used by Mathis (Broadhurst, Sundstrom, and Rowley, 1950, p. 93-98). During 1965, Mathis and Sinton were the only cities in San Patricio County still using ground water. Aransas Pass, Gregory, Odem, Taft, Portland, and Ingleside used water from Lake Corpus Christi on the Nueces River near Mathis.

## Irrigation

In Nueces County, ground water is not used extensively for irrigation, but when precipitation is below normal during the growing season, ground-water or surface-water supplies are used to supplement rainfall.

There were only two irrigation wells in use in Nueces County in 1958, and according to Gillett and Janca (1965, p. 21), about 600 acres was irrigated with 227 acre-feet (0.20 mgd) of ground water. Table 4 shows the amount of ground water used for irrigation during the years 1958 and 1963-65. All of the ground water used for irrigation is pumped from the Gulf Coast aquifer. The principal source of supply for irrigation in Nueces County is surface water from the Nueces River, but there has been an increase in the number of irrigation wells and the quantity of ground water used since 1958. During 1964, the number of acres irrigated with ground water increased to about 1,200 acres, and the amount of ground water used increased to about 740 acre-feet. Development has been greatest in the northwestern part of the county. Most of the water is used to irrigate grasslands, pastures, and feed crops. Future development of ground-water supplies for irrigation might be expected in the western and northwestern part of Nueces County because of the relatively shallow depth to water, the larger yields of the wells, and the relatively good quality of water--eastward the mineral content of the water becomes increasingly greater.

In San Patricio County, the principal use of ground water is for irrigation. In 1964, about 8,400 acre-feet (7.5 mgd) was pumped for irrigation, while only about 3,200 acre-feet (2.8 mgd) was used for public supply, industry, and domestic and livestock needs combined.

Table 5.--Municipal pumpage of ground water in Nueces County, 1963-65

| Year | Agua Dulce | | Banquete | | Bishop | | Chapman Ranch | | Driscoll | | Totals* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr |
| 1963 | 0.21 | 235 | 0.01 | 16 | 0.60 | 674 | 0.01 | 14 | 0.27 | 307 | 1.1 | 1,200 |
| 1964 | .22 | 246 | .01 | 16 | .42 | 466 | .01 | 10 | .27 | 307 | .93 | 1,000 |
| 1965 | .20 | 225 | .02 | 19 | .42 | 469 | .01 | 9 | .27 | 307 | .92 | 1,000 |

* Figures are approximate because some of the pumpage is estimated. Figures are shown to the nearest 0.01 mgd and to the nearest acre-foot. Totals are rounded to two significant figures.



Table 6.--Municipal pumpage of ground water in San Patricio County, 1963-65

| Year | Aransas Pass | | Mathis | | Sinton | | Taft | | Totals* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr | mgd | ac-ft/yr |
| 1963 | 0.05 | 63 | 0.26 | 295 | 0.90 | 1,010 | 0.44 | 534 | 1.7 | 1,900 |
| 1964 | .01 | 2 | .38 | 430 | .65 | 726 | .37 | 418 | 1.4 | 1,600 |
| 1965 | 0 | 0 | .41 | 460 | .63 | 701 | 0 | 0 | 1.1 | 1,200 |

* Figures are approximate because some of the pumpage is estimated. Figures are shown to the nearest 0.01 mgd and to the nearest acre-foot. Totals are rounded to two significant figures.

The first irrigation well in San Patricio County was drilled in 1952 near Mathis. In 1964, there were about 87 irrigation wells in the county. Development has been greatest in the area northwest and west of Sinton and northeast of Mathis. The use of ground water for irrigation is largely to supplement rainfall, and thus the amount of water used may vary greatly from one year to the next, depending upon rainfall during the growing season. The irrigation wells in use in 1965 ranged in depth from about 250 to 700 feet. Yields of the wells, most of which are equipped with electric pumps, ranged from about 300 to 1,800 gpm. The Gulf Coast aquifer supplies practically all of the water, a large part of which would not be acceptable for irrigation according to the standards suggested by the Department of Agriculture for use in semiarid areas. Because most of the water has either a high salinity or alkalinity hazard, or both, soil conditioning may become necessary to overcome the harmful cumulative effects of using the water for irrigation. Despite the unsuitable quality of a large part of the water, San Patricio County has developed its ground-water resources more fully than the adjacent counties. It is not likely, however, that development of ground water will be extended much beyond the limits of the present area because of the small quantities of water available and because of the unsuitable quality of the water.

### Industrial

The pumpage of ground water for industrial use in Nueces County in 1965 was about 2,100 acre-feet, or 1.9 mgd. This is about 23 percent of the total withdrawals for all purposes in that year. Since 1963 there has been a slight decline in the use of ground water by industries, which is probably due to the increased use of surface-water supplies.

Most of the water pumped for industrial use in the county is used by the petroleum industry, principally for cooling purposes. According to records of the Texas Water Development Board, in 1965 the Celanese Plant near Bishop used 649 acre-feet (0.58 mgd); the Champlin (Gulf Plains) Plant used 421 acre-feet (0.37 mgd), and the Southern Minerals Corp. used 323 acre-feet (0.29 mgd).

In San Patricio County the use of ground water for industry is relatively small. In 1965, only 175 acre-feet (0.16 mgd) was used, mostly for cooling purposes.

### Rural Domestic and Livestock

Rural domestic and livestock use of ground water in Nueces County in 1965 was estimated to be 2,000 acre-feet (1.8 mgd). This is about 22 percent of the total withdrawals for that year. Most of the wells used for domestic and livestock supplies are equipped with windmills, small electric motors, or small gasoline engines that are designed to pump no more than a few gallons a minute. At some places, although ground water is available in sufficient quantities, poor quality limits its use and discourages further development.

The pumpage of ground water for domestic and livestock use in San Patricio County during 1965 was estimated to be 1,400 acre-feet (1.2 mgd), or about 15 percent of the total withdrawals for that year. The wells that supply most of the water for domestic and livestock use in San Patricio County are equipped with pumps designed for small yields. There are a few uncontrolled flowing wells that discharge about 1 to 5 gpm.

## Changes in Water Levels

Water levels in wells in the Gulf Coast aquifer in Nueces and San Patricio Counties fluctuate almost continuously as a result of changes in the rates of recharge, discharge, and barometric pressure. Changes in water levels which occur in a few hours or a few days and which affect a small area are probably caused by local changes in the rate of discharge of wells. Long-term changes in water levels, which occur over a period of years and which affect a large area, are caused by major changes in ground-water withdrawals or by long-term changes in ground-water recharge.

Water levels in some wells in Nueces and San Patricio Counties were measured in 1934, 1938, 1939, and 1960 during previous ground-water investigations and in 1964, 1965, and 1966 during this investigation. Periodic water-level measurements have been made in selected observation wells in San Patricio County since 1938 as a part of the statewide observation-well program conducted by the U.S. Geological Survey and the Texas Water Development Board (Table 12).

Table 7 gives the water levels and the changes in water levels for wells in Nueces County measured in 1934 and 1960 or 1965, and for wells measured in 1960 and 1965. Table 8 gives the water levels and the changes in water levels for wells in San Patricio County measured in more than one of the periods 1938 or 1939, 1960, 1964, and 1965.

Figure 8 shows the approximate altitudes of the water levels in wells in the Gulf Coast aquifer in Nueces and San Patricio Counties in 1964 or 1965.

Figure 8 shows that the water levels in southwest Nueces County are considerably deeper than those in other parts of the two-county area. In this area, which contains wells of the Celanese Corporation of America and for the public supply at Bishop, the rate of pumping has been larger and has extended over a longer period of time than in the rest of Nueces County or in San Patricio County. The lowest water level, approximately 146 feet below sea level, was measured in a well near the Celanese Corporation plant. The maximum decline of water level is estimated to be between 150 and 200 feet, occurring approximately as follows: 1934-44, a decline of 10 feet; 1944-60, a decline of 110 feet; and 1960-65, a decline of 55 feet.

In the rest of Nueces County and in San Patricio County, the water levels in the Gulf Coast aquifer in 1964-65 were higher than those in the southwest part of Nueces County. However, in most of the area they were less than 30 feet above sea level. The water levels form a broad shallow trough centered near the Nueces River. Towards the northwest in San Patricio County, the water levels are more than 75 feet above sea level.

Prior to extensive use of ground water in San Patricio County, a large number of wells tapping the Gulf Coast aquifer were flowing wells; by 1965 the number of flowing wells was greatly reduced and the discharge of wells that continued to flow was decreased. Most of the remaining flowing wells are in the Nueces River valley.

In heavily pumped irrigation areas in San Patricio County, fairly large changes in water levels occur because of seasonal pumping. At the end of the irrigation season, when pumping is discontinued, the water levels rise and tend to approach their former levels.

Table 7.--Comparison of water levels in selected wells in Nueces County measured in 1934, 1960, and 1965

| Well | Water level, in feet below land surface | | | Change, in feet | | |
|---|---|---|---|---|---|---|
| | 1934 | 1960 | 1965 | 1934-1960 | 1934-1965 | 1960-1965 |
| UB-83-01-901 | 90.2 | 88.8 | 91.4 | + 1.4 | - 1.2 | - 2.6 |
| 83-02-701 | 92.9 | 91.8 | 91.1 | + 1.1 | + 1.8 | + .7 |
| 83-02-801 | 90.9 | 93.0 | -- | - 2.1 | -- | -- |
| 83-09-501 | -- | 99.7 | 90.8 | -- | -- | + 8.9 |
| 83-10-301 | -- | 75.8 | 72.5 | -- | -- | + 3.3 |
| 83-10-303 | 70.9 | 69.2 | 67.2 | + 1.7 | + 3.7 | + 2.0 |
| 83-10-401 | 86.5 | 87.2 | 85.9 | - .7 | + .8 | + 1.3 |
| 83-11-501 | 65.3 | 68.3 | 67.4 | - 3.0 | - 2.1 | + .9 |
| 83-12-701 | -- | 45.5 | 44.7 | -- | -- | + .8 |
| 83-18-502 | 33.2 | 110.1 | 122.1 | -76.9 | - 88.9 | +12.0 |
| 83-19-801 | -- | 50.0 | 70.2 | -- | -- | -22.2 |
| 83-20-101 | 35.7 | 45.1 | -- | -- | - 9.4 | -- |
| 83-20-401 | -- | 37.9 | 36.9 | -- | -- | + 1.0 |
| 83-20-904 | 27.1 | -- | 32.4 | -- | - 5.3 | -- |
| 83-27-101 | 9.4 | 74.5 | 85.0 | -65.1 | - 75.6 | -10.5 |
| *83-27-402 | 16.9 | 113.5 | 127.8 | -96.6 | -110.8 | -14.3 |
| 83-27-602 | -- | 61.7 | 77.8 | -- | -- | -16.1 |

* Replacement for well 152 in 1934 Nueces County report.

Table 8.--Comparison of water levels in selected wells in San Patricio County measured in 1938 or 1939, 1960, 1964, and 1965

| Well | Water level, in feet below land surface | | | | | Change, in feet | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1938 | 1939 | 1960 | 1964 | 1965 | 1938-39 to 1960 | 1938-39 to 1965 | 1960 to 1965 | 1964 to 1965 |
| WW-79-50-903 | -- | -- | -- | 107.9 | 106.2 | -- | -- | -- | +1.7 |
| 50-907 | -- | -- | 100.9 | -- | 98.6 | -- | -- | +2.3 | -- |
| 50-909 | -- | -- | -- | 96.0 | 102.4 | -- | -- | -- | -6.4 |
| 51-704 | -- | -- | -- | 92.6 | 93.1 | -- | -- | -- | - .5 |
| 57-602 | -- | -- | -- | 52.7 | 49.7 | -- | -- | -- | +3.0 |
| 58-302 | -- | -- | -- | 95.9 | 94.3 | -- | -- | -- | +1.6 |
| 59-103 | -- | -- | 76.9 | 79.2 | 79.0 | -- | -- | -2.1 | + .2 |
| 59-304 | -- | -- | -- | 77.1 | 68.5 | -- | -- | -- | +8.6 |
| 59-402 | -- | -- | -- | 93.8 | 97.0 | -- | -- | -- | -3.2 |
| 59-501 | -- | -- | 90.7 | 83.3 | 83.5 | -- | -- | +7.2 | - .3 |
| 60-103 | -- | -- | 72.5 | 74.4 | 68.6 | -- | -- | +3.9 | +5.8 |
| 60-104 | -- | -- | -- | 61.2 | 62.4 | -- | -- | -1.9 | -1.2 |
| 60-210 | -- | 52.8 | -- | -- | 51.5 | -- | + 1.3 | -- | -- |
| 60-401 | -- | -- | -- | 58.1 | 59.4 | -- | -- | -8.2 | -1.3 |
| 60-503 | -- | -- | -- | 43.9 | 43.7 | -- | -- | -- | + .2 |
| 61-901 | -- | -- | 41.6 | 40.0 | 39.0 | -- | -- | +2.6 | +1.0 |
| 62-103 | -- | -- | 20.7 | 22.7 | 22.2 | -- | -- | -1.5 | + .5 |
| 62-601 | -- | -- | 11.9 | 11.9 | 12.1 | -- | -- | + .2 | + .2 |
| 62-701 | -- | 20.8 | 29.0 | 28.7 | 28.4 | - 8.2 | - 7.6 | + .6 | + .3 |
| 62-901 | 16.8 | -- | 15.2 | -- | -- | + 1.6 | -- | -- | -- |
| 83-05-101 | -- | 20.9 | 43.6 | -- | 43.7 | -22.7 | -22.8 | - .1 | -- |
| 05-601 | -- | -- | 39.4 | -- | 36.7 | -- | -- | +2.7 | -- |
| 06-201 | 24.0 | -- | 20.6 | 20.0 | 19.4 | + 3.4 | + 4.6 | +1.2 | + .6 |
| 06-601 | 18.3 | -- | 16.3 | 14.3 | 14.3 | + 2.0 | + 4.0 | 2.0 | .0 |

The available data show a decline in the water levels in the Gulf Coast aquifer near Sinton from 1939 to 1960. The maximum decline is about 23 feet. Data are not adequate to indicate a significant decline in other parts of the county from 1939 to 1960.

In Nueces County, in other than the previously discussed southwest part of the county, water levels generally declined during the period 1934-60, the maximum decline being about 9 feet.

In general the water levels have risen during the period 1960 to 1964-65 in Nueces and San Patricio Counties. In 24 wells in which comparisons of water levels could be made, the levels rose 1 to 9 feet in 17 wells, remained the same in 3 wells, and declined in 4 wells. The maximum decline was 4 feet. The wells in which comparisons could be made are distributed over the area and seem to indicate a widespread rise in water levels rather than local variations. In most of Nueces County the water levels in 1964-65 were essentially the same as they were in 1934.

Figure 9 shows the record of rainfall at Aransas Pass and the depth-to-water changes in wells WW-83-07-808 and WW-83-07-919. The water levels are affected principally by local rainfall because these wells draw water from beach sands. During the period 1938 to 1965, the water level in well WW-83-07-808 was lowest (18.2 feet) on December 4, 1956, and highest (11.9 feet) on March 19, 1962.

## Construction of Wells

Almost all wells in Nueces and San Patricio Counties are drilled wells, the few exceptions being the wells about 30 feet deep that were dug in the alluvial deposits along the Nueces River, and the driven or sand-point wells used principally in sand dune areas.

The irrigation wells, some of which are underreamed and gravel packed, are generally designed to pump large quantities of water. In many wells, large diameter casing is set in the upper parts of the wells and 6- and 8-inch casing is set in the lower parts. In most irrigation wells, slotted casing is installed opposite the water-bearing sands, but a few wells are equipped with screens. Generally little effort is made to correlate the width of the slots with the diameter of the sand particles. If the slots are too large, sand is allowed to enter freely, resulting in wear of the pumps and casing. If the slots are too small, or if there are not enough of them, excessive losses in head may result, and the specific capacities of the wells will be reduced.

Most of the recently drilled municipal wells are underreamed, screened, and gravel packed. Gravel packing increases the effective diameter of the well, aids in preventing sand from entering the well, and protects the casing from caving of the surrounding formations.

Domestic and livestock wells are generally completed with 10 or 20 feet of small-diameter slotted casing or stainless steel screen near the bottom. A large number of the domestic and livestock wells in Nueces and San Patricio Counties are provided with "shale traps," a device similar to a packer which prevents loose shale or other formation material from falling to the screen level and clogging the screen openings.

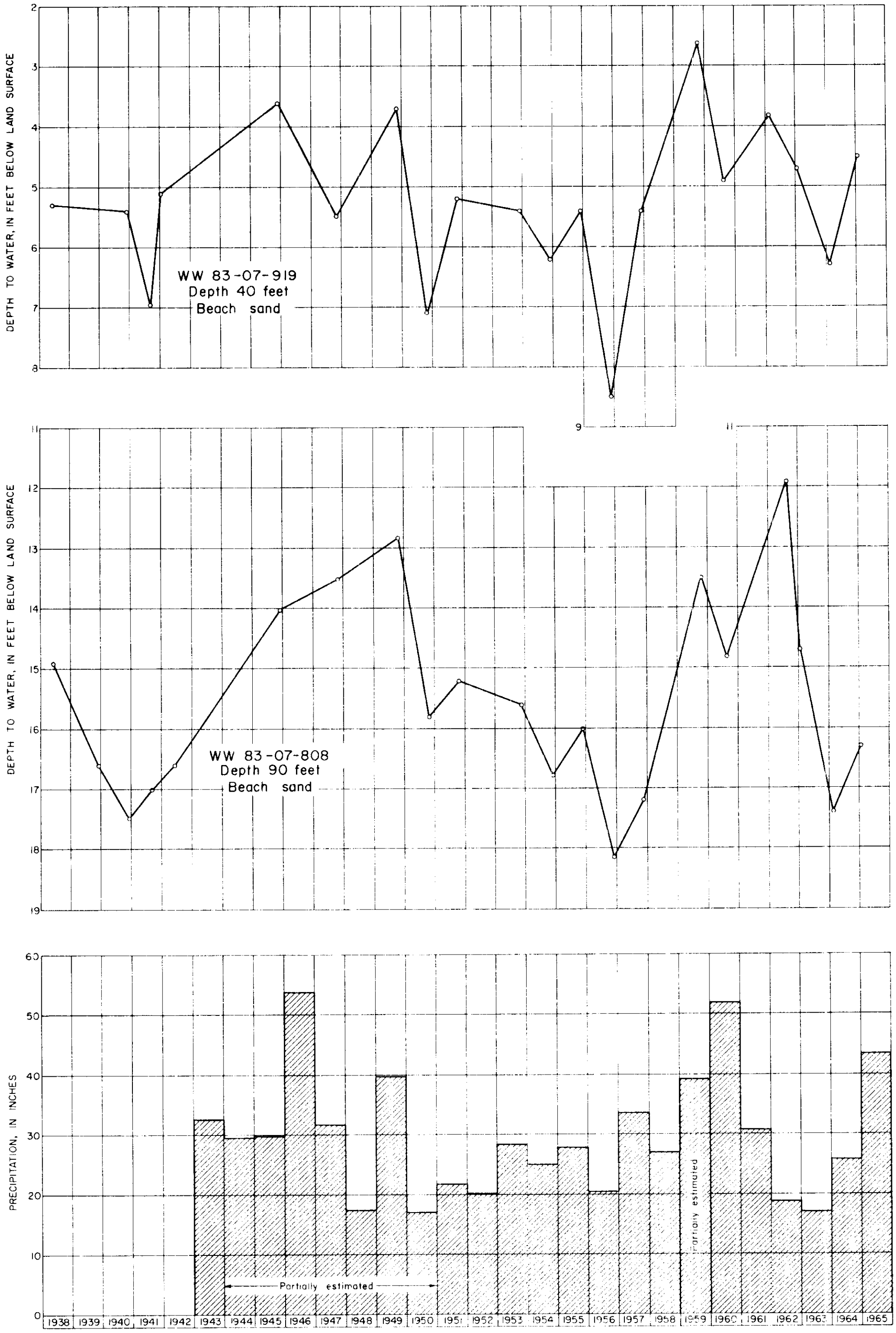



Figure 9

## Water Levels in Wells WW-83-07-808 and WW-83-07-919, and Annual Precipitation at Aransas Pass

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

The casings for drilled wells are made of plastic, wrought iron, or galvanized iron. To resist corrosion, a heavy duty type of casing, called "drill-stem" pipe by well drillers, is used in some of the domestic and livestock wells. The casings in dug wells, which have a diameter of 30 to 50 inches, generally consist of concrete rings, brick tile, or native rock. In Nueces and San Patricio Counties, the casings generally used in domestic wells last only a few years because of the corrosive properties of the ground water at most places.

## USE OF SURFACE WATER

The Nueces River is the main source of water supply for the city of Corpus Christi and a large part of its metropolitan area. The water is released from storage in Lake Corpus Christi near Mathis to a low-water reservoir at Calallen. Finally the water is delivered through distribution systems to various points in both Nueces and San Patricio Counties, principally for public supply, industry, and irrigation; a small part is used on farms for domestic supplies.

The city of Corpus Christi supplies water either directly or indirectly to the following communities in Nueces and San Patricio Counties: Calallen, Clarkwood, Flour Bluff, Taft, Ingleside, Gregory, Portland, Odem, Aransas Pass, and Port Aransas. Flour Bluff, Calallen, and a part of Clarkwood were annexed by the city of Corpus Christi in 1963. Robstown is supplied by the Nueces County Water Control and Improvement District No. 3.

In 1965, the total amount of surface water used for public and domestic supply, industry, and irrigation was about 73,500 acre-feet (65 mgd).

According to the records of the Texas Water Rights Commission, the city of Corpus Christi and its dependent communities used about 34,000 acre-feet (30 mgd) of water from the Nueces River, and the Nueces County Water Control and Improvement District No. 3 used about 1,400 acre-feet (1.2 mgd). About 35,600 acre-feet (32 mgd) of water was used for industry, and about 2,500 acre-feet (2.2 mgd) was used for irrigation on about 2,600 acres. Most of the surface water used for industry and irrigation was in Nueces County; only 8 acre-feet was used for irrigation in San Patricio County.

## QUALITY OF GROUND WATER

The chemical constituents in the fresh to slightly saline ground water in Nueces and San Patricio Counties are derived principally from solution of material in the soil and rocks through which the water has moved. The differences in the chemical character of the water reflect, in a general way, the types of soil and rocks that have been in contact with the water. Usually, as the water moves deeper, the chemical content is increased by solution and by mixing with more concentrated waters. The source and significance of the dissolved-mineral constituents and other properties of ground water are summarized in Table 9, which is modified from Doll, Meyer, and Archer (1963, p. 39-43). Chemical analyses of 203 water samples from 175 selected wells in Nueces and San Patricio Counties are given in Table 14. The wells from which samples were taken are identified in Figure 15 by bars over the well numbers.

Table 9.--Source and significance of dissolved-mineral constituents and properties of water (from Doll and others, 1963, p. 39-43)

| Constituent or property | Source or cause | Significance |
|---|---|---|
| Silica ($SiO_2$) | Dissolved from practically all rocks and soils, commonly less than 30 ppm. High concentrations, as much as 100 ppm, 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. | On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 ppm stains laundry and utensils reddish brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. USPHS (1962) drinking water standards state that iron should not exceed 0.3 ppm. 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 oil-field 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 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. USPHS (1962) drinking water standards recommend that the sulfate content should not exceed 250 ppm. |
| Chloride (Cl) | Dissolved from rocks and soils. Present in sewage and found in large amounts in oil-field 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. USPHS (1962) drinking water standards recommend that the chloride content should not exceed 250 ppm. |
| 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, the amount of drinking water consumed, and susceptibility of the individual (Maier, 1950, p. 1120-1132). |
| Nitrate ($NO_3$) | Decaying organic matter, sewage, fertilizers, and nitrates in soil. | Concentration much greater than the local average may suggest pollution. USPHS (1962) drinking water standards suggest a limit of 45 ppm. 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 (Maxcy, 1950, p. 271). 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. |
| Boron (B) | A minor constituent of rocks and of natural waters. | An excessive boron content will make water unsuitable for irrigation. Wilcox (1955, p. 11) indicated that a boron concentration of as much as 1.0 ppm is permissible for irrigating sensitive crops; as much as 2.0 ppm for semitolerant crops; and as much as 3.0 for tolerant crops. Crops sensitive to boron include most deciduous fruit and nut trees and navy beans; semitolerant crops include most small grains, potatoes and some other vegetables, and cotton; and tolerant crops include alfalfa, most root vegetables, and the date palm. |
| Dissolved solids | Chiefly mineral constituents dissolved from rocks and soils. | USPHS (1962) drinking water standards recommend that waters containing more than 500 ppm dissolved solids not be used if other less mineralized supplies are available. For many purposes the dissolved-solids content is a major limitation on the use of water. A general classification of water based on dissolved-solids content, in ppm, is as follows (Winslow and Kister, 1956, p. 5): Waters containing less than 1,000 ppm of dissolved solids are considered fresh; 1,000 to 3,000 ppm, slightly saline; 3,000 to 10,000 ppm, moderately saline; 10,000 to 35,000 ppm, very saline saline; and more than 35,000 ppm, brine. |
| Hardness as $CaCO_3$ | In most waters nearly all the hardness is due to calcium and magnesium. All of 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 up to 60 ppm are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; more than 180 ppm, very hard. |
| Sodium-adsorption ratio (SAR) | Sodium in water. | A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil (U.S. Salinity Laboratory Staff, 1954, p. 72, 156). Defined by the following equation: $$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}},$$ where $Na^+$, $Ca^{++}$, and $Mg^{++}$ represent the concentrations in equivalents per million (epm) of the respective ions. |
| Residual sodium carbonate (RSC) | Sodium and carbonate or bicarbonate in water. | As calcium and magnesium precipitate as carbonates in the soil, the relative proportion of sodium in the water is increased (Eaton, 1950, p. 123-133). Defined by the following equation: $$RSC = (CO_3^{--} + HCO_3^{-}) - (Ca^{++} + Mg^{++}),$$ where $CO_3^{--}$, $HCO_3^{-}$, $Ca^{++}$, and $Mg^{++}$ represent the concentrations in equivalents per million (epm) of the respective ions. |
| 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. |

## Suitability of the Water for Use

The suitability of a water supply depends upon the chemical quality of the water and the limitations associated with the contemplated use of the water. Various requirements have been established for most categories of water quality--including bacterial content; physical characteristics such as turbidity, color, odor, and temperature; chemical substances; and radioactivity. Usually, the problems of bacteria and physical characteristics can be remedied economically, but the removal or neutralization of undesirable chemical constituents may be difficult and expensive.

The dissolved-solids or "total salts" content is a major limitation on the use of water for many purposes. The classification of water based on the dissolved-solids content in ppm (parts per million) as used in this report is as follows (Winslow and Kister, 1956, p. 5):

| Description | Dissolved-solids content (ppm) |
|---|---|
| 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 |

### Public Supply

Water used for public supply should not contain harmful chemical substances; should be free of turbidity, odor, and color to the extent that it is not objectionable to the user; and must not be excessively corrosive to the water-supply system.

The U.S. Public Health Service has established and periodically revises the standards for drinking water used on common carriers engaged in interstate commerce. The standards are designed to protect the traveling public and are used to evaluate public water supplies. According to the standards, chemical substances should not be present in a water supply in excess of the listed concentrations whenever more suitable supplies are available or can be made available at reasonable cost. These limits apply to the water at a free-flowing outlet of the consumer. The major chemical standards adopted by the U.S. Public Health Service (1962, p. 7-8) are as follows.

| Substance | Concentration (ppm) |
|---|---|
| Chloride (Cl) | 250 |
| Fluoride (F) | (*) |
| Iron (Fe) | .3 |
| Manganese (Mn) | .05 |
| Nitrate ($NO_3$) | 45 |
| Sulfate ($SO_4$) | 250 |
| Total dissolved solids | 500 |

* Based on the 1931-60 average daily maximum air temperature at Corpus Christi, the concentration of fluoride should not be more than 0.8 ppm in drinking water in Nueces and San Patricio Counties.

Water having a chloride content in excess of 250 ppm is objectionable because with an equal amount of sodium it has a salty taste to many people and may be excessively corrosive to the water-supply system. The chloride content of 203 water samples from wells in Nueces and San Patricio Counties ranged from 54 to 5,000 ppm, exceeding 250 ppm in 174 samples. The chloride content exceeded 250 ppm in 7 public-supply wells. In most of Nueces and San Patricio Counties, it is very difficult to obtain ground water having a chloride content less than 250 ppm. In general, the chloride content of ground water is greater in areas nearest the bays. Figure 10 shows the chloride content of water samples from wells and the well depths or screened intervals.

Water containing optimum fluoride content reduces the incidence of tooth decay when the water is used during the period of enamel calcification. Depending on the age of the child, amount of drinking water consumed, and susceptibility of the individual, excessive concentrations of fluoride may cause mottling of the teeth (Maier, 1950, p. 1120-1132). The optimum fluoride level for a given area depends on climatic conditions because the amount of drinking water (and consequently the amount of fluoride) consumed is influenced primarily by air temperature. Based on the annual average of the maximum daily air temperatures at Corpus Christi of 81.1°F from 1931-60, the lower, optimum, and upper control limits of fluoride concentrations established by the U.S. Public Health Service are 0.6, 0.7, and 0.8 ppm, respectively. The presence of fluoride in concentrations greater than two times the optimum value (1.4 ppm) for Nueces and San Patricio Counties would constitute grounds for rejection of the water supply by the U.S. Public Health Service. The fluoride content in water from 80 wells ranged from 0.2 to 2.9 ppm, exceeding 0.8 ppm in 46 wells; in 23 samples the concentration exceeded 1.4 ppm.

Water containing iron in excess of 0.3 ppm and manganese in excess of 0.05 ppm may cause reddish-brown or dark-gray stains on laundry, utensils, and plumbing fixtures. Iron in large amounts gives water an objectionable taste. The total iron content in water from 22 wells ranged from 0 to 12 ppm, exceeding

0.3 ppm in 8 wells. The only two wells tested for manganese showed 0.00 ppm each, indicating that the concentration of manganese in the ground water in Nueces and San Patricio Counties is not a problem.

Water having a nitrate content in excess of 45 ppm is potentially dangerous to infants because it has been related to infant cyanosis or "blue baby" disease (Maxcy, 1950, p. 271). More than several parts per million of nitrate may indicate contamination by sewage (Lohr and Love, 1954, p. 10), decaying organic matter, fertilizers, or nitrates in the soil. The nitrate content in water from 102 wells ranged from 0.00 to 24 ppm. Most of the higher concentrations of nitrate were in wells in the western part of Nueces County that ranged from about 200 to 600 feet deep. At no place in Nueces or San Patricio Counties, however, were the concentrations of nitrate in excess of 45 ppm.

Sulfate in water in excess of 250 ppm may produce a laxative effect. The sulfate content in water from 171 wells ranged from 0.2 to 1,280 ppm; the concentration exceeded 250 ppm in 38 wells, 34 of which were in Nueces County. Four of the samples from public-supply wells had a sulfate content in excess of 250 ppm. In only 4 of the samples from wells in San Patricio County did the sulfate content exceed 250 ppm.

Water having a dissolved-solids content in excess of 500 ppm is not recommended for public supply if other less mineralized supplies are available or can be made available at reasonable cost. Water having less than 500 ppm dissolved solids is not always available, and it is recognized that supplies having a dissolved-solids content in excess of the recommended limits are used in many places without any obvious ill effects. Usually, water containing more than 1,000 ppm dissolved solids is unsuitable for many purposes. The dissolved-solids content in water from 173 wells ranged from 305 to 9,580 ppm, exceeding 500 ppm in 171 wells. In 133 wells it exceeded 1,000 ppm, in 55 wells it exceeded 2,000 ppm, and in 19 wells it exceeded 3,000 ppm. In all but one of the public-supply wells tested, the dissolved-solids content exceeded 1,000 ppm. Only about 25 percent of the samples collected in Nueces and San Patricio Counties contained fresh water (less than 1,000 ppm dissolved solids). Some communities in Nueces and San Patricio Counties that formerly depended upon ground water for their supplies have changed to surface supplies, principally because of the unsuitability of the ground water.

The hardness of water is important in a water supply although no suggested limits have been established by the U.S. Public Health Service. The principal constituents causing hardness of water are calcium and magnesium. As the hardness of water increases, the desirability of the water for most household purposes decreases. Hard water is particularly undesirable for cleaning because of the increased soap consumption, and for heating because of the increased formation of scale in hot water heaters and water pipes. Water used for ordinary household purposes does not become particularly objectionable until it reaches about 100 ppm hardness (Hem, 1959, p. 147). A commonly accepted classification of water hardness is given in the following table.

| Hardness range (ppm) | Classification |
|---|---|
| 60 or less | Soft |
| 61 - 120 | Moderately hard |
| 121 - 180 | Hard |
| More than 180 | Very hard |

The hardness of water from 151 wells ranged from 12 to 2,340 ppm, exceeding 60 ppm in 120 wells and exceeding 100 ppm in 94 wells. The hardness of water from 72 wells was more than 180 ppm. Apparently there is little relationship in Nueces and San Patricio Counties between hardness and the depth or location of the well.

In summary, a large part of the ground water used for public supplies and other purposes in Nueces and San Patricio Counties does not meet the quality standards of the U.S. Public Health Service.

## Irrigation

The suitability of water for irrigation depends upon the chemical quality of the water and other factors such as soil texture and composition, types of crops, irrigation practices, and climate. The most important chemical characteristics of water used for irrigation are the sodium concentration, an index of the sodium or alkali hazard; the concentration of soluble salts, an index of the salinity hazard; the residual sodium carbonate; and the concentration of boron. Sodium is significant in evaluating the quality of irrigation water because of its potential effect on the soil. A high percentage of sodium in water tends to make the soil plastic, thus restricting the movement of water through it and giving rise to problems of drainage and cultivation.

A system of classification commonly used for judging the quality of water for irrigation was proposed by the U.S. Salinity Laboratory Staff (1954, p. 69-82). The classification is based on the salinity hazard as measured by the electrical conductivity of the water and the sodium or alkali hazard as measured by the SAR (sodium-adsorption ratio). Wilcox (1955, p. 15) stated that this system of classification "...is not directly applicable to supplemental waters used in areas of relatively high rainfall," and that with respect to salinity and sodium hazards, water generally may be used safely for supplemental irrigation if its conductivity is less than 2,250 micromhos per centimeter at 25°C, and its SAR is less than 14.

The system of classification (Figure 11) shows that all 40 of the representative water samples from Nueces and San Patricio Counties have a high to very high salinity hazard, and that more than 50 percent of the samples have a high to very high sodium hazard. Although some of the water is being used for irrigation, it should be used with restraint, mainly as a supplement to rainfall.

An excessive concentration of boron renders water unsuitable for irrigation. Scofield (1936, p. 286) indicated that boron concentrations of as much

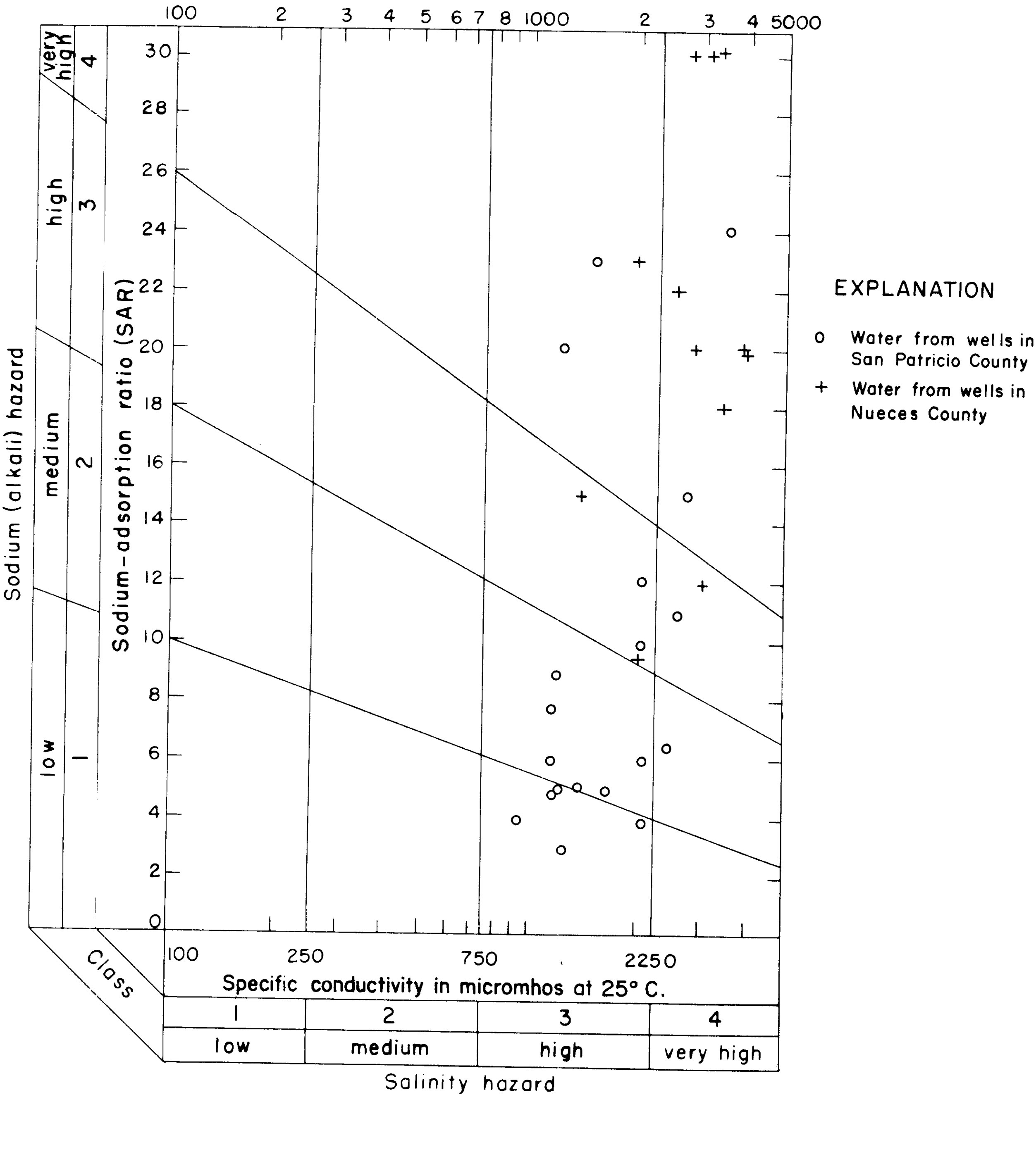



Figure 11

## Classification of Irrigation Waters

U. S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

as 1 ppm are permissible for irrigating most boron-sensitive crops, and that concentrations of as much as 3 ppm are permissible for the more boron-tolerant crops. The boron concentration in water from 29 wells ranged from 0.40 to 3.4 ppm.

Another factor used in assessing the suitability of water for irrigation is the RSC (residual sodium carbonate). Excessive RSC will cause the water to be alkaline, and the organic content of the soil on which it is used may become a grayish black. The soil thus affected is referred to as "black alkali." Wilcox (1955, p. 11) states that laboratory and field studies have resulted in the conclusion that water containing more than 2.5 epm (equivalents per million) RSC is not suitable for irrigation; water containing from 1.25 to 2.5 epm is marginal, and water containing less than 1.25 epm is probably safe. However, it is believed that good irrigation practices and proper use of soil amendments might make it possible to use the marginal water successfully. Furthermore, the degree of leaching will modify the permissible limit to some extent (Wilcox, Blair, and Bower, 1954, p. 265). The RSC as determined in 86 wells ranged from 0.00 to 7.15 epm. Forty samples contained more than 2.5 epm, and 31 samples contained less than 1.25 epm.

The data for well WW-79-60-102 (Table 14) show the chemical composition of the water in the major sand zones penetrated while drilling an irrigation well in San Patricio County. Wood, Gabrysch, and Marvin (1963, p. 82) called attention to the abrupt change in calcium-magnesium content and SAR below 443 feet. By careful placement of screens in such a well, irrigation water with a small potential for soil or plant damage can be obtained, but the quantity of water will probably be too small for irrigation needs. For this reason, well screening or slotting is usually indiscriminate.

The Gulf Coast aquifer supplies all of the ground water used for large-scale irrigation in Nueces and San Patricio Counties. Generally, irrigation is practiced only during periods of deficient rainfall for the principal crops of cotton and grain sorghum. In the area west and northwest of Sinton, large quantities of ground water are being withdrawn for irrigation, and evidence of soil damage has been reported on some farms. Because of the high salinity and alkalinity hazards, the water should be used with restraint.

### Industrial

Water used for industry is classified as cooling water, process water, and boiler water. In Nueces and San Patricio Counties, most of the industrial use of water is for cooling.

The suitability of water for use in cooling is determined by its chemical quality and temperature. Hardness, silica, and iron may cause scale to form on the heat-exchange surfaces; and sodium chloride, acids, oxygen, and carbon dioxide may make the water corrosive. The temperature of ground water depends upon the mean air temperature of the area and the depth of the well. In Nueces and San Patricio Counties, the mean air temperature is about 72°F. The temperature of the water in 16 wells ranged from 77°F in well WW-79-60-103, which is 640 feet deep, to 84°F in well UB-83-29-201, which is 1,173 feet deep. The temperature increases almost 1°F for every 100 feet of depth.

Process water is water that is incorporated into or used in contact with the manufactured product. The quality requirements for this use may include physical and biological properties as well as chemical properties. Water that is low in dissolved solids and which contains little or no iron and manganese is highly desirable for use as process water.

Boiler water should be non-corrosive and should have a very low concentration of scale-forming constituents such as silica, calcium, and magnesium. Silica is particularly undesirable in boiler water because its tendency to form a hard scale increases with the pressure in a boiler. The following table shows the maximum suggested concentrations of silica for water used in boilers (Moore, 1940, p. 263).

| Concentration of Silica (ppm) | Boiler Pressure (pounds per square inch) |
| --- | --- |
| 40 | Less than 150 |
| 20 | 150 to 250 |
| 5 | 251 to 400 |
| 1 | More than 400 |

In Nueces and San Patricio Counties, the concentration of silica in water samples from 128 wells ranged from 3 to 74 ppm, exceeding 20 ppm in 47 wells. Water from most of the wells in the southwestern part of Nueces County had a silica concentration of less than 20 ppm.

Much of the ground water in Nueces and San Patricio Counties is alkaline. The pH of the water exceeded 7.0 (neutral) in most of the wells sampled.

The odor of hydrogen sulfide gas ($H_2S$) was noticeable from many wells during the time they were being pumped. Although $H_2S$ is an objectionable constituent, it can be removed by aeration.

## Relation of Fresh Ground Water to Saline Ground Water

Some of the sediments composing the Gulf Coast aquifer were deposited in the Gulf of Mexico and, therefore, contained salt water at the time of deposition, or were deposited in fresh water and filled with salt water at a time of higher sea level. At some time after deposition, the sea receded and the processes of flushing, recharge, and discharge began. Fresh water, originating as precipitation on the outcrop, forced the salt water downdip until the pressure exerted by the fresh water equalled the pressure exerted by the salt water. Discharge of the salt water may have been accomplished in several ways, but Winslow and others (1957, p. 387-388) concluded that the discharge took place through the overlying clays in the Houston area. Before large withdrawals by wells were begun, the hydrologic system was probably in dynamic equilibrium--that is, the fresh water-salt water interface was almost stationary. The pressure head of the fresh water was balanced by the static head of the salt water. Figure 12 is a diagrammatic sketch of the theoretical relationship of fresh water to salt water in the area.

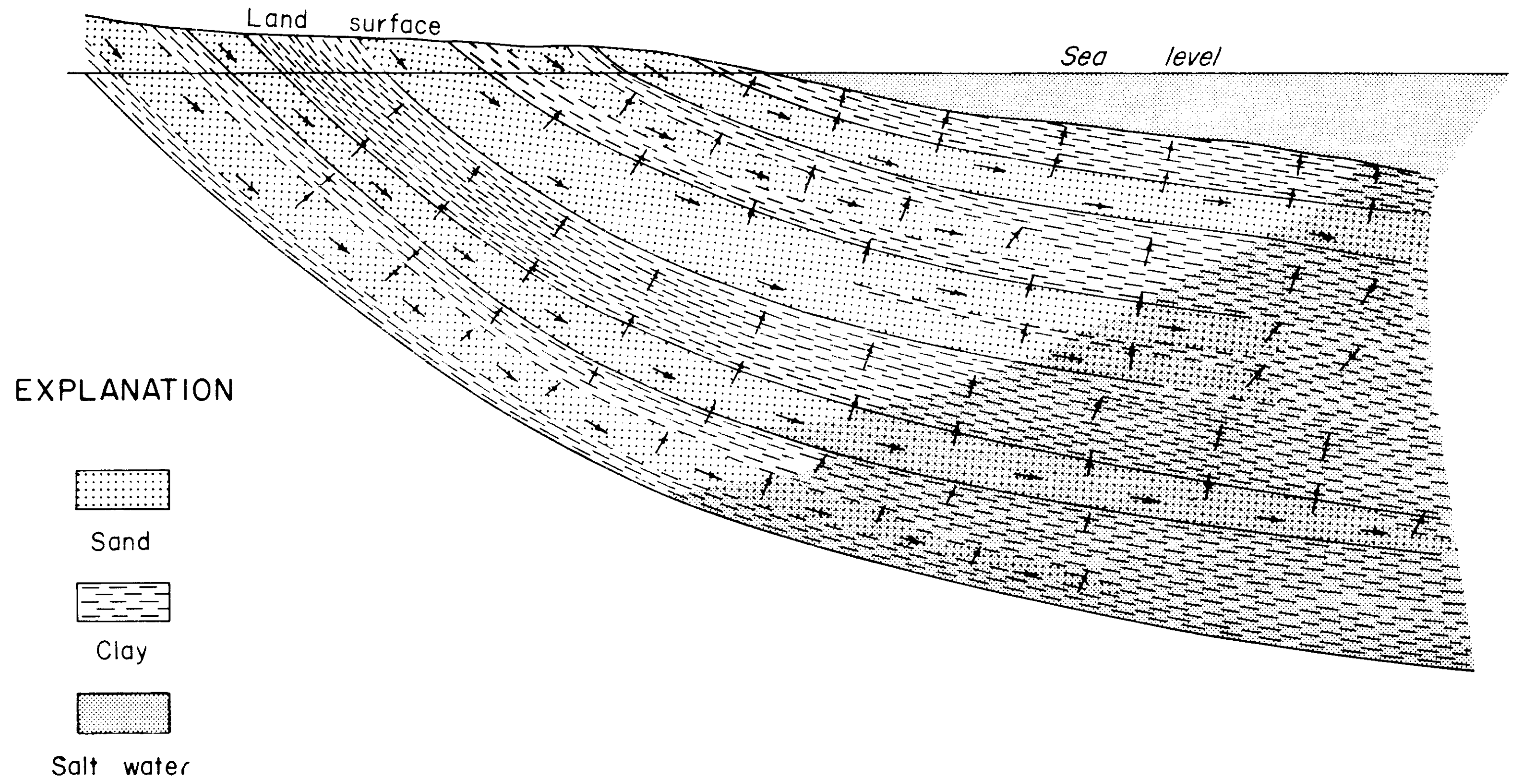



Figure 12

**Diagrammatic Sketch of the Theoretical Relationship of the Fresh Water to Salt Water**

(After Winslow and others, 1957, p.386)

U.S. Geological Survey in cooperation with the Texas Water Development Board and the San Patricio Municipal Water District

With the lowering of water levels in the Gulf Coast aquifer, the condition of dynamic equilibrium at the fresh water-salt water interface may be disturbed so that salt water will tend to move towards the areas of pumping. The present data, however, do not show any movement of salt water towards the areas of pumping.

## DISPOSAL OF SALT WATER

According to a salt-water disposal inventory (Texas Water Commission and Texas Water Pollution Control Board, 1963), 63,097,453 barrels, or about 8,300 acre-feet of salt water was produced in conjunction with the production of oil in Nueces County in 1961. During the same year, 108,124,192 barrels, or about 14,000 acre-feet of salt water was produced in San Patricio County, making a total of 171,221,745 barrels (22,000 acre-feet) in the two counties. The methods of disposal and the quantity disposed are shown in Table 10.

The open-surface pit method of disposal is the most hazardous with regard to contamination of fresh water at shallow depths. In 1961, 46,562,421 barrels (5,995 acre-feet) of salt water was disposed in open-surface pits in Nueces and San Patricio Counties. It is probable that a part of this salt water penetrated the surface at some places and caused the ground water to become saline. Salt water in open-surface pits is allowed to evaporate, but the salt residue remains as a source of contamination.

The time required for salt water from disposal pits to affect the quality of water in nearby wells may vary considerably, depending upon the permeability of the soil and the rate of movement of the salt water. The process may take several years or only a few months. Generally, contamination of the water is indicated by an abnormal increase in the chloride content without an accompanying increase in the sulfate content. Once a source of contamination is eliminated, another problem is presented--that of water purification which, because of the slow process of leaching and dilution, may require a considerably longer time than the period of original contamination. In most oil fields throughout the State, surface pits for storing salt water are not lined with impervious materials that would prevent any seepage of salt water into the fresh-water-bearing sands.

No conclusive evidence of salt-water contamination was found in the water from wells sampled during this investigation. This should not, however, be construed to mean that contamination is not occurring. In fact, some contamination in the past has resulted in court action being taken to halt the practice of disposing of salt water in open-surface pits.

The most satisfactory method of disposal of salt water is through injection wells. In 1961, 23.9 percent of the total quantity of salt water produced in Nueces County, and 9 percent of the total quantity produced in San Patricio County was disposed of by this method. Generally, salt water is injected into salt-water sands well below the base of the slightly saline water, but in the East Mathis field (Texas Water Commission and Texas Water Pollution Control Board, 1963) in San Patricio County, salt water is injected into a well perforated from 900 to 980 feet. This depth closely approximates the base of fresh to slightly saline water in that area (Figure 14). The proper construction and operation of the injection wells are also important in assuring adequate protection of the fresh or slightly saline water.

Table 10.--Methods of disposal and quantity of salt water disposed in Nueces and San Patricio Counties in 1961

Nueces County

| Methods of disposal | Quantity disposed | | Percent |
|---|---|---|---|
| | Barrels | Acre-feet | |
| Injection wells | 15,059,462 | 1,940 | 23.9 |
| Open-surface pits | 21,228,164 | 2,730 | 33.6 |
| Surface watercourses | 26,632,120 | 3,430 | 42.2 |
| Miscellaneous | 76,467 | 98 | .1 |
| Unknown | 101,340 | 130 | .2 |

San Patricio County

| | | | |
|---|---|---|---|
| Injection wells | 9,703,070 | 1,250 | 9.0 |
| Open-surface pits | 25,334,257 | 3,265 | 23.4 |
| Surface watercourses | 72,837,557 | 9,390 | 67.4 |
| Miscellaneous | 1,095 | .14 | 0.0 |
| Unknown | 248,213 | 320 | .2 |

In 1961, almost 100,000,000 barrels (12,800 acre-feet) of salt water was discharged directly into surface watercourses. This method of disposal is widely used in oil fields situated near natural bodies of salt water where there is little or no danger of contamination of ground water.

The water-bearing units in Nueces and San Patricio Counties may also be invaded by salt water from improperly cased oil wells and oil tests. The Oil and Gas Division of the Railroad Commission of Texas is responsible for the proper construction of oil wells. The Texas Water Development Board supplies data to oil operators and to the Railroad Commission so that all fresh-water strata may be protected. The term "fresh water" as used by the Railroad Commission may include water that is more mineralized than the "fresh to slightly saline water" used in this report.

An examination of the published field rules of the Railroad Commission of Texas indicates that the surface-casing requirements are inadequate in only a few of the many oil and gas fields in Nueces and San Patricio Counties. Under the present rules, about 220 feet of sand containing fresh to slightly saline water is unprotected in the Hodges field in San Patricio County; about 250 feet in the Howell field; about 110 feet in the Mathis East field; about 150 feet in the North Pasture field; about 40 feet in the San Patricio field; and about 320 feet in the Williman North field. In Nueces County, about 350 feet of sand containing fresh to slightly saline water is unprotected in the Clara Driscoll field and about 550 feet in the Ramada field. This investigation did not reveal any salt-water contamination as a result of inadequately cased oil wells.

## AVAILABILITY OF GROUND WATER FOR FUTURE DEVELOPMENT

The Gulf Coast aquifer is the principal source of ground water for future development in Nueces and San Patricio Counties; it is the source of practically all of the water presently being pumped. The alluvial deposits along the Nueces River valley and the beach and dune sands yield only small quantities of water locally.

The most favorable areas for future development of ground water in Nueces and San Patricio Counties are generally where the thicknesses of saturated sand in the Gulf Coast aquifer are the greatest. Figure 13 shows that the areas of greatest thickness are in the north-central part of San Patricio County where the thickness reaches a maximum of about 600 feet. In this area where the average thickness might be about 500 feet, a properly constructed well tapping the full thickness of sand in the Gulf Coast aquifer might be expected to yield as much as 1,700 gpm with 100 feet of drawdown. This is assuming a well efficiency of about 70 percent.

In much of the southern part of the two-county area, the sand thickness averages probably not more than about 200 feet. Here a properly constructed well tapping the full section might be expected to yield about 500 gpm with 100 feet of drawdown, assuming the same 70 percent efficiency.

Throughout the remainder of the two counties, potential well yields would vary, depending on the water-yielding properties of the sand as well as on the thickness of saturated sand. To properly estimate the potential well yields in every area would require pumping tests to learn the water-yielding properties of the sand. During the investigation, sufficient tests could not be run because available test sites were not properly located to permit the estimation of potential well yields throughout Nueces and San Patricio Counties.

The amount of water that can be pumped annually in Nueces and San Patricio Counties without depleting the ground-water supply depends on several factors, one of the most important of which is the average effective rate of recharge. This cannot be determined with the data at hand; however, estimates can be made through the use of several assumptions. The effective rate of recharge can actually be measured in areas where there is little or no ground-water development by calculating the amount of water moving through the aquifers. In the Nueces and San Patricio county area, there has been a considerable amount of ground-water development which has disturbed the natural hydraulic gradients. Except for an area in the southwestern part of Nueces County, however, the gradient has probably not been greatly disturbed from the original natural gradient.

The amount of water moving through the aquifer can be calculated by the use of the formula $Q = TIW$, in which $Q$ is the quantity of water in gallons per day moving through the aquifer, $T$ is the coefficient of transmissibility in gallons per day per foot, $I$ is the hydraulic gradient of the piezometric surface in feet per mile, and $W$ is the width of the aquifer in miles normal to the hydraulic gradient. If it is assumed that the average hydraulic gradient is about 5.6 feet per mile and that the coefficient of transmissibility of the aquifer along a line nearly coinciding with the +30-foot contour on Figure 8 is about 20,000 gpd per foot and the width of the aquifer along this line is about 50 miles, the average rate of movement of water through the aquifer then was approximately 6 mgd (million gallons per day) or about 5,400 acre-feet per year before any ground-water development. This compares with the present rate of ground-water withdrawal in the two-county area of 16 mgd.

The 6 mgd is a minimum value, however, because it is based on the assumption that all of the recharge occurred in the area north and west of the 30-foot contour. Actually, there is probably a substantial amount of recharge directly from rain that falls within the counties east and south of the 30-foot contour. The fact that recharge is occurring in this area is suggested by the records of water levels in wells in the northern part of San Patricio County. In this area, large quantities of water have been withdrawn annually from the aquifer for irrigation. The water levels in the wells have not declined appreciably during the period of irrigation, indicating that the rate of recharge to this particular area probably has not been exceeded. On the other hand, in the southwestern part of Nueces County, water levels have declined substantially. This probably indicates that the withdrawals in that area and in the Kingsville area to the south have been considerably greater than the rate of annual recharge. Furthermore, the development in this area has probably intercepted recharge which formerly moved eastward and northeastward into the Nueces-San Patricio county area.

Another important factor in determining the amount of ground water available for development in the two-county area is the amount of water in storage in the aquifer. Assuming a porosity of 30 percent, it is estimated that about 18 million acre-feet of fresh to slightly saline water is in storage in the aquifer in the two-county area. However, probably only a few million acre-feet of this water is available for development because of the great depth at which much of the water occurs.

Another factor controlling the ground-water development in Nueces and San Patricio Counties is the threat of salt-water encroachment in a large part of the two-county area. Figure 14 shows the altitude of the base of the fresh to slightly saline water. This map and the cross sections (Figures 16, 17, and 18) show that the aquifer contains moderately or highly saline water in its downdip portions and that the highly saline water is nowhere very far from the fresh-water-bearing parts of the aquifer. In much of Nueces County, the fresh to slightly saline water-bearing sands are overlain by sands containing at least moderately saline water. It was not possible to map the extent of these shallow saline water sands; however, they occur generally in approximately the southern two-thirds of Nueces County and in a small area in northeastern San Patricio County.

Large-scale ground-water developments in the areas near the fresh water-salt water interface in the aquifer should be avoided. Before there was any ground-water development in the two-county area, the hydraulic gradient in the aquifer was towards the southeast. In other words, the water was moving in that direction. The natural hydraulic gradients have been disturbed by pumping, and in some areas, particularly in the southwest part of Nueces County, the gradient has been reversed so that highly or moderately saline water is moving toward this area of heavy development.

In summary, the area most favorable for additional ground-water development in the two-county area is in the north-central part of San Patricio County north and northwest of Sinton. It is shown on Figure 13 enclosed by the 400-foot line of thickness of sands. This is the area of greatest sand thickness in the two counties, and it is probably the area where the sands are more permeable than in most of the rest of the two counties. Even though there has been a considerable amount of ground-water development for irrigation, the water levels have not declined significantly, indicating that the area has not been pumped beyond the recharge rate. Probably an additional few million gallons a day could be developed in the area without overpumping, providing that development in adjoining areas is not excessive. In addition to the amount of water that can be withdrawn perennially, a large quantity of water is in storage in the area; perhaps as much as a million acre-feet might be available to wells within economic pumping lifts. The area is reasonably remote from the threat of salt-water contamination.

It is not possible to determine quantitatively the availability of ground water in Nueces and San Patricio Counties with the data which are available. A program of hydrologic data collection should be established to refine the estimates of availability which have been made above. This program should include an expansion of the program of observation of water levels to cover the area more adequately; it should also include a program of annual inventory of ground-water pumpage. A continuing inventory should be made of new wells as they are drilled. Wells should be selected for resampling purposes in order to keep abreast of changes in quality of water as a result of development.

The Nueces and San Patricio county area is one in which, as a whole, only small additional quantities of ground water can be developed. In this area where the industrial and agricultural future potential is great, it would perhaps be well to consider the saline water underlying the counties as a resource. The fresh to slightly saline water-bearing beds throughout the entire two counties are underlain by zones containing moderately to highly saline water. Much of the moderately saline water is readily available to wells. If the demineralization of saline water becomes economically feasible, large additional quantities of water are available anywhere in the two-county area. For example, the electrical log of an oil test about 10 miles southwest of Corpus Christi indicates the presence of at least 500 feet of sand containing moderately saline water (3,000 to 10,000 ppm dissolved solids). If it can be assumed that the permeability of these saline water-bearing sands is similar to the permeability in the fresh-water section, then well yields of from 1,000 to 2,000 gpm should be easily obtainable from this part of the section.

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Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties

Nueces County

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Well UB-83-09-909 | | | | | |
| Owner: City of Agua Dulce well 3. Driller: Richardson Bros. | | | | | |
| Shale, sandy, and caliche -------- | 60 | 60 | Shale, sandy -------- | 73 | 556 |
| Sand ---------------- | 5 | 65 | Sand --------------- | 44 | 600 |
| Caliche ------------- | 10 | 75 | Shale --------------- | 20 | 620 |
| Caliche and shale ---- | 102 | 177 | Sand --------------- | 24 | 644 |
| Shale, sticky -------- | 88 | 265 | Shale --------------- | 32 | 676 |
| Shale --------------- | 61 | 326 | Sand --------------- | 6 | 682 |
| Sand ---------------- | 18 | 344 | Shale --------------- | 13 | 695 |
| Shale, sandy --------- | 11 | 355 | Shale, sandy -------- | 25 | 720 |
| Sand ---------------- | 15 | 370 | Shale --------------- | 51 | 771 |
| Shale --------------- | 42 | 412 | Shale, sandy -------- | 9 | 780 |
| Sand ---------------- | 17 | 429 | Shale --------------- | 30 | 810 |
| Shale, sandy --------- | 12 | 441 | Shale, sandy -------- | 10 | 820 |
| Sand ---------------- | 12 | 453 | Shale --------------- | 7 | 827 |
| Shale, and sand ------ | 4 | 457 | Shale, sandy -------- | 1 | 828 |
| Sand ---------------- | 11 | 468 | Shale --------------- | 6 | 834 |
| Shale --------------- | 15 | 483 | Sand --------------- | 28 | 862 |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-10-301

Owner: George Prochaska. Driller: Welty Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Clay | 85 | 85 | Sand | 13 | 295 |
| Sand and gravel | 30 | 115 | Sand, shale streaks | 60 | 355 |
| Shale, sand streaks | 85 | 200 | Shale, sand streaks | 37 | 392 |
| Sand | 12 | 212 | Shale | 58 | 450 |
| Hard break | 1 | 213 | Sand, shale streaks, thin | 58 | 508 |
| Sand | 28 | 241 | Shale | 32 | 540 |
| Shale | 13 | 254 | Sand, fine | 55 | 595 |
| Sand | 11 | 265 | Sand | 55 | 650 |
| Shale | 17 | 282 | | | |

Well UB-83-10-602

Owner: Joe McNair. Driller: Welty Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 3 | 3 | Shale | 20 | 187 |
| Shale | 47 | 50 | Sand | 27 | 214 |
| Sand | 6 | 56 | Shale | 45 | 259 |
| Shale | 24 | 80 | Sand | 26 | 285 |
| Sand | 30 | 110 | Shale | 3 | 288 |
| Shale | 17 | 127 | Sand | 23 | 311 |
| Sand | 13 | 140 | Shale | 4 | 315 |
| Shale | 8 | 148 | Sand | 10 | 325 |
| Sand | 19 | 167 | Shale | 6 | 331 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-10-602--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand | 56 | 387 | Shale | 11 | 587 |
| Shale | 12 | 399 | Sand | 2 | 589 |
| Sand | 19 | 418 | Shale | 5 | 594 |
| Shale | 40 | 458 | Sand | 5 | 599 |
| Sand | 32 | 490 | Shale | 3 | 602 |
| Shale | 72 | 562 | Sand | 18 | 620 |
| Sand | 14 | 576 | Sand and shale | 3 | 623 |

Well UB-83-11-101

Owner: Natural Gas Pipeline Co. of America. Driller: Layne-Texas Co.

| | | | | | |
|---|---|---|---|---|---|
| Clay | 20 | 20 | Sand, clay streaks | 18 | 168 |
| Sand and caliche | 60 | 80 | Sand, broken | 12 | 180 |
| Clay, sandy | 32 | 112 | Clay | 15 | 195 |
| Sand | 23 | 135 | Sand | 27 | 222 |
| Clay | 15 | 150 | | | |

Well UB-83-11-801

Owner: W. B. Mohle. Driller: Welty Well Service.

| | | | | | |
|---|---|---|---|---|---|
| Surface soil | 3 | 3 | Sand | 10 | 69 |
| Shale | 12 | 15 | Shale | 29 | 98 |
| Sand | 25 | 40 | Sand | 26 | 124 |
| Shale | 19 | 59 | Shale | 9 | 133 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-11-801--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand | 25 | 158 | Sand and shale | 14 | 290 |
| Shale | 3 | 161 | Shale | 4 | 294 |
| Sand | 19 | 180 | Sand | 2 | 296 |
| Shale | 34 | 214 | Sand, fine | 8 | 304 |
| Sand | 6 | 220 | Sand | 8 | 312 |
| Shale | 11 | 231 | Shale | 1 | 313 |
| Sand | 45 | 276 | | | |

Well UB-83-12-401

Owner: Steve Swetlick. Driller: Welty Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 3 | 3 | Shale | 12 | 145 |
| Shale | 17 | 20 | Sand | 16 | 161 |
| Sand | 14 | 34 | Shale | 10 | 171 |
| Shale | 42 | 76 | Sand | 8 | 179 |
| Sand | 8 | 84 | Shale | 41 | 220 |
| Shale | 28 | 112 | Sand and shale | 6 | 226 |
| Sand | 21 | 133 | Sand | 7 | 233 |

Well UB-83-12-701

Owner: Jacob Ranly. Driller: Welty Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Topsoil | 3 | 3 | Sand | 35 | 53 |
| Shale | 15 | 18 | Shale | 45 | 98 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-12-701--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand | 7 | 105 | Shale | 16 | 190 |
| Shale | 5 | 110 | Sand | 10 | 200 |
| Sand and shale | 3 | 113 | Shale and sand | 11 | 211 |
| Shale | 6 | 119 | Sand and shale | 19 | 230 |
| Sand | 29 | 148 | Shale | 35 | 265 |
| Shale | 3 | 151 | Sand and shale | 10 | 275 |
| Sand | 23 | 174 | Sand | 27 | 302 |

Well UB-83-17-501

Owner: Champlin Oil & Refining Co. and Gulf Plains Plant.
Driller: Carl Vickers.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 2 | 2 | Shale | 9 | 592 |
| Clay | 169 | 171 | Sand, shale streaks | 10 | 602 |
| Sand | 45 | 216 | Sand | 39 | 641 |
| Shale | 227 | 443 | Shale | 12 | 653 |
| Sand | 11 | 454 | Shale, sand streaks | 43 | 696 |
| Shale | 76 | 530 | Sand | 65 | 761 |
| Sand | 32 | 562 | Shale, and sand, hard | 7 | 768 |
| Sand, shale streaks | 21 | 583 | | | |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-17-901

Owner: Champlin Oil & Refining Co., Wardner Plant well 6.
Driller: Layne-Texas Co.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil and clay - | 12 | 12 | Shale, sticky -------- | 12 | 456 |
| Sand ----------------- | 25 | 37 | Shale, sandy --------- | 27 | 483 |
| Clay, sandy ----------- | 29 | 66 | Clay and shale ------- | 84 | 567 |
| Clay ----------------- | 20 | 86 | Sand and shale, sandy ------------- | 30 | 597 |
| Shale, sandy ---------- | 41 | 127 | Sand(?) ------------- | 93 | 690 |
| Shale and sand -------- | 70 | 197 | Sand ---------------- | 9 | 699 |
| Shale, sticky --------- | 40 | 237 | Shale --------------- | 108 | 707 |
| Sand and shale -------- | 30 | 267 | Sand ---------------- | 36 | 743 |
| Shale, sticky shale --- | 117 | 384 | Shale --------------- | 10 | 753 |
| Sand, shale layers ---- | 60 | 444 | | | |

Well UB-83-18-802

Owner: C. A. Lowman. Driller: Stanley S. Haynes.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface sand and clay - | 120 | 120 | Sand ---------------- | 24 | 405 |
| Sand ----------------- | 15 | 135 | Shale, sticky -------- | 91 | 496 |
| Shale, sandy, sand streaks ------------ | 55 | 190 | Sand, broken --------- | 14 | 510 |
| Shale and sticky shale --------------- | 108 | 298 | Shale --------------- | 15 | 525 |
| Sand ----------------- | 10 | 308 | Sand, broken --------- | 55 | 580 |
| Shale ---------------- | 73 | 381 | Shale --------------- | 6 | 586 |

Nueces County

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|

Well UB-83-19-602

Owner: W. N. Parr. Driller: Buck Page & Co.

| | | | | | |
|---|---|---|---|---|---|
| Clay ------------------ | 23 | 23 | Clay ----------------- | 3 | 331 |
| Sand ------------------ | 121 | 144 | Sand ----------------- | 34 | 365 |
| Clay ------------------ | 27 | 171 | Clay, sandy ---------- | 3 | 368 |
| Sand ------------------ | 57 | 228 | | | |

Well UB-83-20-201

Owner: Jac Baker. Driller: Buck Page & Co.

| | | | | | |
|---|---|---|---|---|---|
| Clay ------------------ | 18 | 18 | Shale ---------------- | 17 | 265 |
| Sand ------------------ | 166 | 184 | Sand ----------------- | 26 | 291 |
| Shale ----------------- | 35 | 219 | Shale ---------------- | 40 | 331 |
| Sand ------------------ | 29 | 248 | Sand ----------------- | 51 | 382 |

Well UB-83-20-701

Owner: Robert LaPrelle. Driller: Buck Page & Co.

| | | | | | |
|---|---|---|---|---|---|
| Shale ----------------- | 81 | 81 | Sand (tested dry) ---- | 44 | 351 |
| Shale, sandy ---------- | 120 | 201 | Shale ---------------- | 22 | 373 |
| Shale ----------------- | 106 | 307 | Sand ----------------- | 27 | 400 |

Well UB-83-26-505

Owner: City of Bishop well 5. Driller: Carl Vickers.

| | | | | | |
|---|---|---|---|---|---|
| Surface soil ---------- | 4 | 4 | Sand ----------------- | 23 | 49 |
| Clay, yellow ---------- | 22 | 26 | Clay ----------------- | 82 | 131 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

Nueces County

Well UB-83-26-505--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Shale | 117 | 248 | Shale | 10 | 765 |
| Sand, shale streaks | 242 | 490 | Sand | 5 | 770 |
| Shale | 80 | 570 | Shale | 20 | 790 |
| Sand | 20 | 590 | Sand | 21 | 811 |
| Shale | 60 | 650 | Shale | 10 | 821 |
| Sand, fine | 47 | 697 | Sand | 28 | 849 |
| Sand and shale | 53 | 750 | Shale | 5 | 854 |

Well UB-83-29-201

Owner: J. O. Chapman. Driller: A. C. Downs.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 5 | 5 | Sand | 10 | 410 |
| Clay and caliche | 20 | 25 | Clay, red | 150 | 560 |
| Sand, white | 20 | 45 | Sand | 10 | 570 |
| Clay | 65 | 110 | Clay, red | 320 | 890 |
| Clay, blue | 90 | 200 | Clay, blue | 110 | 1,000 |
| Sand | 15 | 215 | Clay, red | 161 | 1,161 |
| Clay, white | 185 | 400 | Sand | 12 | 1,173 |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

Well WW-79-50-802

Owner: J. C. Griffin. Driller: Howard Fortram.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 7 | 7 | Sand, clay layers, blue | 78 | 358 |
| Clay | 18 | 25 | Clay | 12 | 370 |
| Caliche | 14 | 39 | Sand | 20 | 390 |
| Sand, gravel, and caliche | 33 | 72 | Clay and sand | 47 | 437 |
| Clay | 38 | 110 | Sand | 10 | 447 |
| Sand | 20 | 130 | Clay, sandy | 18 | 465 |
| Gravel and sand | 30 | 160 | Clay | 20 | 485 |
| Sand, coarse | 31 | 191 | Sand | 22 | 507 |
| Hard streaks | 11 | 202 | Clay | 4 | 511 |
| Gravel | 8 | 210 | Sand | 9 | 520 |
| Clay | 4 | 214 | Clay | 4 | 524 |
| Sand, hard streaks | 66 | 280 | | | |

Well WW-79-51-704

Owner: F. H. Vahlsing, Inc. well 2. Driller: Layne-Texas Co.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 6 | 6 | Clay and caliche | 45 | 105 |
| Clay | 14 | 20 | Sand and caliche | 18 | 123 |
| Sand | 7 | 27 | Rock, hard | 2 | 125 |
| Gravel | 9 | 36 | Sand, gravel, and clay | 30 | 155 |
| Caliche | 24 | 60 | | | |

(Continued on next page)

San Patricio County

Well WW-79-51-704--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand, caliche, and gravel ---------- | 35 | 190 | Shale, sandy --------- | 33 | 550 |
| Clay and caliche ------ | 20 | 210 | Sand ----------------- | 16 | 566 |
| Lime, hard, and shale --------------- | 15 | 225 | Clay, sticky --------- | 10 | 576 |
| Sand and lime --------- | 60 | 285 | Clay, sandy clay ----- | 46 | 622 |
| Shale, sandy ---------- | 15 | 300 | Sand, and shale layers ------------- | 41 | 663 |
| Sand and lime --------- | 46 | 346 | Lime, hard ----------- | 4 | 667 |
| Lime, sandy, and shale --------------- | 32 | 378 | Shale, and sandy shale -------------- | 13 | 680 |
| Clay ------------------ | 32 | 410 | Clay, sticky --------- | 9 | 689 |
| Shale, sandy ---------- | 15 | 425 | Clay, and sandy clay --------------- | 19 | 708 |
| Shale, sandy shale, and lime ------------ | 31 | 456 | Sand ----------------- | 20 | 728 |
| Shale ----------------- | 61 | 517 | Shale ---------------- | 13 | 741 |

Well WW-79-57-602

Owner: City of Corpus Christi (Boy Scouts of America).
Driller: Layne-Texas Co.

| | | | | | |
|---|---|---|---|---|---|
| Surface soil ---------- | 2 | 2 | Sand, and caliche ---- | 12 | 60 |
| Clay, brown, and caliche ------------- | 10 | 12 | Sand, gravel, and clay --------------- | 66 | 126 |
| Sand ------------------ | 17 | 29 | Clay ----------------- | 6 | 132 |
| Sand, and clay layers, thin -------- | 19 | 48 | Sand, and clay layers ------------- | 10 | 142 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

Well WW-79-57-602--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand and clay streaks | 53 | 195 | Sand | 8 | 299 |
| Clay, sandy clay | 58 | 253 | Clay, sandy | 27 | 326 |
| Sand, fine | 11 | 264 | Clay and caliche | 27 | 353 |
| Clay, and sandy clay | 27 | 291 | Clay, hard | 23 | 376 |
| | | | Clay | 2 | 378 |

Well WW-79-58-903

Owner: Floyd Webb. Driller: H. & S. Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Clay | 35 | 35 | Sand | 14 | 254 |
| Clay and gravel streaks | 30 | 65 | Sand, shale streaks | 14 | 268 |
| Shale, hard | 40 | 105 | Hard streaks | 5 | 273 |
| Shale | 50 | 155 | Gravel | 7 | 281 |
| Sand | 15 | 170 | Sand, and shale streaks | 22 | 303 |
| Shale | 50 | 220 | Sand | 29 | 332 |
| Sand | 10 | 230 | Shale | 16 | 348 |
| Shale and sand streaks | 10 | 240 | Sand, coarse | 27 | 375 |

Well WW-79-59-505

Owner: Lloyd Kastner. Driller: H. & S. Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 4 | 4 | Sand | 21 | 51 |
| Clay | 26 | 30 | Clay and caliche | 22 | 73 |

(Continued on next page)

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

Well WW-79-59-505--Continued

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand and caliche ------ | 32 | 105 | Sand ----------------- | 41 | 240 |
| Clay and caliche ------ | 15 | 120 | Shale ---------------- | 18 | 258 |
| Hard streaks ---------- | 2 | 122 | Shale, sandy --------- | 7 | 265 |
| Caliche --------------- | 16 | 138 | Sand ----------------- | 47 | 312 |
| Hard streaks ---------- | 2 | 140 | Shale ---------------- | 8 | 320 |
| Caliche --------------- | 10 | 150 | Sand ----------------- | 26 | 346 |
| Sand streaks, caliche, hard ------- | 15 | 165 | Shale and sand ------- | 36 | 382 |
| Shale and caliche ----- | 20 | 185 | Sand ----------------- | 58 | 440 |
| Sand and shale -------- | 14 | 199 | Shale ---------------- | 5 | 445 |

Well WW-79-60-503

Owner: E. R. Cantwell. Driller: H. & S. Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| No record ------------- | 55 | 55 | Shale ---------------- | 22 | 245 |
| Sand ------------------ | 12 | 67 | Sand and shale streaks ------------ | 38 | 283 |
| Clay ------------------ | 11 | 78 | Shale ---------------- | 7 | 290 |
| Shale, sandy ---------- | 14 | 92 | Sand ----------------- | 62 | 352 |
| Shale ----------------- | 10 | 102 | Shale ---------------- | 13 | 365 |
| Shale, sandy, and sand streaks -------- | 58 | 160 | Sand ----------------- | 35 | 400 |
| Shale ----------------- | 22 | 182 | Shale ---------------- | 7 | 407 |
| Sand ------------------ | 41 | 223 | Sand ----------------- | 50 | 457 |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

Well WW-79-61-804

Owner: Reynolds Metal Co. Driller: Layne-Texas Co.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 3 | 3 | Sand | 35 | 689 |
| Clay, sandy | 94 | 97 | Shale | 135 | 824 |
| Sand, clay layers | 85 | 182 | Sand, coarse | 25 | 849 |
| Clay, sandy | 143 | 325 | Shale | 31 | 880 |
| Sand, gray, coarse | 49 | 374 | Sand, coarse | 18 | 898 |
| Shale, sandy | 76 | 450 | Shale | 26 | 924 |
| Sand, gray | 47 | 497 | Sand, fine | 15 | 939 |
| Shale, sandy | 111 | 608 | Shale | 31 | 970 |
| Sand, gray | 24 | 632 | Sand, coarse | 40 | 1,010 |
| Shale, sandy | 22 | 654 | Shale | 44 | 1,054 |

Well WW-83-02-203

Owner: C. E. Caddell. Driller: H. & S. Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Sand and gravel | 22 | 22 | Sand | 20 | 162 |
| Caliche | 20 | 42 | Shale | 19 | 181 |
| Sand | 2 | 44 | Sand | 28 | 209 |
| Shale and caliche | 26 | 70 | Shale | 11 | 220 |
| Sand, and shale | 30 | 100 | Sand | 22 | 242 |
| Sand, clay streaks | 25 | 125 | Shale, sand streaks | 28 | 270 |
| Shale | 17 | 142 | Sand | 40 | 310 |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

Well WW-83-03-201

Owner: Irwin Hart. Driller: H. & S. Well Service.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Clay | 25 | 25 | Sand | 28 | 280 |
| Sand and clay | 70 | 95 | Shale | 25 | 305 |
| Shale | 11 | 106 | Sand and shale | 15 | 320 |
| Sand and clay | 34 | 140 | Sand | 45 | 365 |
| Shale | 28 | 168 | Sand and shale | 15 | 380 |
| Sand | 14 | 182 | Shale | 38 | 418 |
| Shale | 40 | 222 | Sand | 32 | 450 |
| Sand and shale | 30 | 252 | | | |

Well WW-83-04-204

Owner: Oscar Mayfield. Driller: Carl Vickers.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil | 4 | 4 | Shale | 15 | 163 |
| Shale | 11 | 15 | Sand | 24 | 187 |
| Sand | 45 | 60 | Shale | 8 | 195 |
| Shale | 73 | 133 | Sand | 65 | 260 |
| Sand | 15 | 148 | | | |

Table 13.--Drillers' logs of wells in Nueces and San Patricio Counties--Continued

San Patricio County

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|

Well WW-83-05-301

Owner: City of Taft well 10. Driller: Layne-Texas Co.

| | Thickness (feet) | Depth (feet) | | Thickness (feet) | Depth (feet) |
|---|---|---|---|---|---|
| Surface soil ---------- | 3 | 3 | Shale ---------------- | 20 | 206 |
| Caliche --------------- | 12 | 15 | Sand, gray, fine ----- | 10 | 216 |
| Caliche, sand streaks - | 10 | 25 | Shale ---------------- | 13 | 229 |
| Sand, brown, fine ----- | 17 | 42 | Sand, gray, fine ----- | 15 | 244 |
| Caliche --------------- | 12 | 54 | Shale ---------------- | 6 | 250 |
| Sand, brown, fine ----- | 21 | 75 | Sand, gray, fine ----- | 19 | 269 |
| Clay, sand streaks ---- | 25 | 100 | Shale ---------------- | 19 | 288 |
| Sand, gray, coarse ---- | 36 | 136 | Sand ----------------- | 13 | 301 |
| Shale ----------------- | 9 | 145 | Shale ---------------- | 17 | 318 |
| Sand, gray, coarse ---- | 19 | 164 | Sand ----------------- | 11 | 329 |
| Shale ----------------- | 17 | 181 | Shale ---------------- | 14 | 343 |
| Sand ------------------ | 5 | 186 | | | |

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties

(Analyses given are in parts per million except specific conductance, pH, percent sodium, sodium adsorption ratio, and residual sodium carbonate)

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nueces County** | | | | | | | | | | | | | | | | | | | | | |
| UB-83-01-901 | 290 | Aug. 17, 1965 | 29 | -- | 64 | 54 | * 528 | -- | 764 | 232 | 460 | 2.9 | 6.4 | -- | 1,750 | 382 | 75 | 12 | 4.89 | 3,030 | 7.3 |
| 02-701 | 170 | June 21, 1934 | -- | 12 | 54 | 32 | * 295 | -- | 418 | 129 | 300 | -- | 9.6 | -- | 1,025 | 266 | -- | -- | -- | -- | -- |
| 702 | 207 | Aug. 19, 1965 | 17 | -- | 50 | 28 | * 399 | -- | 442 | 146 | 322 | 2.0 | 4.2 | -- | 1,130 | 240 | 75 | 9.5 | 2.44 | 1,950 | 7.3 |
| 09-602 | 473 | Nov. 19, 1965 | 18 | -- | 171 | 144 | *1,210 | -- | 386 | 610 | 1,900 | -- | 13 | -- | 4,260 | 1,020 | 72 | 16 | .00 | 7,010 | 7.0 |
| 902 | 596 | July --, 1945 | 8.0 | .02 | 28 | 12 | 511 | 24 | 298 | 231 | 535 | .4 | 24 | -- | 1,580 | 150 | -- | -- | -- | 2,560 | 8.0 |
| 905 | 530 | July 13, 1965 | 20 | -- | 28 | 19 | * 548 | -- | 342 | 224 | 570 | 1.1 | 23 | -- | 1,600 | 148 | 89 | 20 | 2.65 | 2,770 | 7.4 |
| 10-203 | 350 | Nov. 19, 1965 | 20 | -- | 54 | 41 | * 766 | -- | 364 | 324 | 930 | -- | 24 | -- | 2,340 | 302 | 85 | 19 | .00 | 3,910 | 7.4 |
| 501 | 610 | Aug. 9, 1960 | 16 | .11 | 21 | 5.8 | 599 | 5.2 | 268 | 324 | 600 | .9 | .0 | -- | 1,710 | 76 | 94 | 30 | 2.86 | 2,850 | 7.7 |
| 601 | 309 | Aug. 18, 1965 | 20 | -- | 52 | 34 | * 742 | -- | 340 | 336 | 880 | -- | 17 | -- | 2,250 | 270 | 86 | 20 | .18 | 3,880 | 7.6 |
| 602 | 623 | Nov. 19, 1965 | 17 | 1.7 | 24 | 9.7 | * 717 | -- | 248 | 408 | 730 | -- | 2.2 | -- | 2,030 | 100 | 94 | 31 | 2.06 | 3,320 | 7.3 |
| 806 | 650 | June 27, 1955 | 19 | -- | 21 | 7.2 | 662 | 6.9 | 277 | 336 | 680 | -- | .5 | 2.6 | 1,870 | 82 | -- | -- | -- | 3,240 | 8.1 |
| 902 | 242 | Aug. 18, 1965 | 18 | -- | 60 | 34 | * 769 | -- | 346 | 368 | 910 | 1.1 | 11 | -- | 2,340 | 290 | 85 | 20 | .00 | 3,990 | 7.5 |
| 1/ 11-101 | 222 | Sept. 12, 1964 | 14 | .1 | 57 | 18 | * 642 | -- | 306 | 355 | 705 | -- | -- | -- | 2,098 | 218 | -- | -- | -- | 3,370 | 8.28 |
| 102 | 229 | Nov. 19, 1965 | 22 | -- | 55 | 27 | * 664 | -- | 284 | 370 | 760 | -- | 2.8 | -- | 2,040 | 248 | 85 | 18 | .00 | 3,430 | 7.3 |
| 401 | 214 | Jan. 6, 1966 | 17 | -- | 45 | 24 | * 700 | -- | 306 | 364 | 780 | -- | 3.8 | -- | 2,080 | 212 | 88 | 21 | .78 | 3,560 | 7.8 |
| 601 | 150 | do | 14 | -- | 86 | 32 | *1,830 | -- | 228 | 1,280 | 2,000 | -- | -- | -- | 5,360 | 346 | 92 | 43 | .00 | 8,270 | 7.4 |
| 801 | 313 | Nov. 20, 1965 | 16 | -- | 32 | 34 | * 796 | -- | 264 | 636 | 670 | -- | 2.0 | -- | 2,290 | 94 | 95 | 36 | 2.45 | 3,740 | 7.6 |
| 901 | 240 | do | 10 | -- | 18 | 4.1 | * 919 | -- | 272 | 624 | 840 | -- | 2.0 | -- | 2,550 | 62 | 97 | 51 | 3.22 | 4,250 | 7.9 |
| 12-401 | 233 | Jan. 6, 1966 | 15 | -- | 48 | 16 | *1,160 | -- | 252 | 630 | 1,310 | -- | .0 | -- | 3,300 | 186 | 93 | 37 | .41 | 5,440 | 7.5 |
| 17-501 | 768 | Dec. 8, 1965 | 17 | .04 | 12 | 7.3 | * 407 | -- | 331 | 159 | 352 | 1.0 | 12 | -- | 1,130 | 60 | 94 | 23 | 4.23 | 1,970 | 7.6 |
| 901 | 753 | do | 17 | .05 | 34 | 15 | * 744 | -- | 218 | 520 | 740 | -- | -- | -- | 2,180 | 148 | 92 | 27 | .61 | 3,680 | 7.5 |
| 18-111 | 527 | do | 15 | -- | 13 | 6.9 | * 482 | -- | 348 | 194 | 435 | 1.1 | 7.5 | -- | 1,330 | 61 | 95 | 27 | 4.48 | 2,310 | 8.1 |
| 2/ 202 | 700 | Mar. --, 1952 | 20 | 3.2 | 27 | 8.5 | 719 | -- | 259 | 434 | 710 | -- | -- | -- | 2,034 | 103 | -- | -- | -- | -- | 8.05 |
| 2/ 204 | 620 | Apr. --, 1950 | 19 | 1.6 | 29 | 8.2 | 699 | -- | 269 | 360 | 729 | -- | -- | -- | 1,964 | 105 | -- | -- | -- | -- | 7.6 |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

Nueces County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/ UB-83-18-204 | 620 | Mar. --, 1952 | 16 | 1.4 | 25 | 8.8 | 640 | -- | 307 | 331 | 634 | -- | -- | -- | 1,806 | 98 | -- | -- | -- | -- | 7.9 |
| 404 | 642 | Dec. 7, 1965 | 17 | .92 | 22 | 8.5 | * 719 | -- | 295 | 352 | 740 | -- | 1.2 | -- | 2,000 | 90 | 95 | 33 | 3.04 | 3,320 | 6.9 |
| 602 | 740 | Dec. 8, 1965 | 17 | -- | 28 | 6.8 | * 714 | -- | 200 | 628 | 590 | -- | 1.0 | -- | 2,080 | 98 | 94 | 31 | 1.32 | 3,420 | 7.5 |
| 2/ 702 | 7,500 | Dec. 24, 1953 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3,064 | -- | -- | -- | -- | -- | -- |
| 802 | 586 | July 1, 1955 | 17 | 3 | 21 | 10 | 419 | -- | 365 | 228 | 331 | -- | -- | -- | 1,212 | 93 | -- | -- | -- | -- | 7.9 |
| 19-101 | 339 | Dec. 9, 1965 | 17 | -- | 35 | 16 | * 818 | -- | 288 | 320 | 960 | -- | 10 | -- | 2,320 | 152 | 92 | 29 | 1.68 | 3,970 | 7.6 |
| 203 | 170 | do | 17 | -- | 36 | 9.5 | * 795 | -- | 290 | 348 | 890 | -- | 1.2 | -- | 2,240 | 129 | 93 | 30 | 2.17 | 3,860 | 7.6 |
| 604 | 325 | Dec. 7, 1965 | 19 | .31 | 13 | 2.8 | * 559 | -- | 318 | 253 | 515 | 2.8 | 1.2 | -- | 1,520 | 44 | 97 | 37 | 4.33 | 2,660 | 7.6 |
| 902 | 754 | Dec. 9, 1965 | 17 | -- | 85 | 2.4 | * 483 | -- | 275 | 266 | 408 | .9 | .5 | -- | 1,320 | 31 | 97 | 38 | 3.89 | 2,270 | 7.9 |
| 20-404 | 406 | Dec. 7, 1965 | 16 | -- | 20 | 6.3 | * 753 | -- | 255 | 454 | 730 | -- | 1.0 | -- | 2,110 | 76 | 96 | 38 | 2.66 | 3,520 | 7.8 |
| 801 | 316 | Dec. 9, 1965 | 17 | -- | 30 | 10 | * 909 | -- | 356 | 635 | 790 | -- | -- | -- | 2,640 | 118 | 94 | 36 | 4.00 | 4,180 | 8.3 |
| 22-801 | 181 | Jan. 5, 1966 | 25 | .06 | 18 | 8 | * 305 | -- | 492 | 72 | 200 | -- | .0 | -- | 876 | 78 | 89 | 15 | 6.50 | 1,460 | 7.5 |
| 23-601 | -- | Jan. 25, 1966 | 12 | -- | 128 | 90 | * 761 | -- | 286 | 182 | 1,360 | -- | 3.0 | -- | 2,680 | 690 | 71 | 13 | .00 | 4,990 | 7.0 |
| 801 | -- | do | 27 | -- | 199 | 448 | *2,800 | -- | 755 | 735 | 5,000 | -- | -- | -- | 9,580 | 2,340 | 72 | -- | -- | 14,700 | 7.2 |
| 26-202 | 874 | Aug. 9, 1960 | 16 | .23 | 28 | 9.6 | 521 | 7.3 | 240 | 510 | 372 | .7 | 5.5 | 2.0 | 1,590 | 110 | 90 | 22 | -- | 2,510 | 7.7 |
| 203 | 665 | Dec. 8, 1965 | 17 | -- | 25 | 6.4 | * 421 | -- | 322 | 299 | 302 | .6 | 1.2 | -- | 1,230 | 89 | 91 | 19 | 3.50 | 2,060 | 7.6 |
| 27-103 | 1,056 | do | 15 | -- | 25 | 6.0 | * 696 | -- | 174 | 708 | 510 | -- | 1.8 | -- | 2,050 | 87 | 95 | 32 | 1.11 | 3,230 | 7.7 |
| 602 | 900 | do | 7.3 | -- | 11 | 1.1 | * 477 | -- | 121 | 419 | 365 | .8 | .8 | -- | 1,350 | 32 | 97 | 37 | 1.67 | 2,300 | 8.4 |
| 28-102 | 884 | Dec. 9, 1965 | 13 | .10 | 12 | 2.4 | * 571 | -- | 226 | 386 | 488 | 1.7 | 1.5 | -- | 1,590 | 40 | 97 | 39 | 2.90 | 2,750 | 7.9 |
| 302 | 962 | do | 19 | -- | 17 | 3.5 | * 990 | -- | 332 | 640 | 900 | -- | 1.5 | -- | 2,730 | 57 | 97 | 57 | 4.30 | 4,600 | 8.1 |
| 29-201 | 1,173 | June 12, 1934 | -- | 1.8 | 30 | 7.5 | * 962 | -- | 266 | 722 | 870 | -- | .75 | -- | 2,723 | 106 | -- | -- | -- | -- | -- |
| 202 | 1,018 | Jan. 5, 1965 | 6.8 | .00 | 18 | 4.1 | * 963 | -- | 256 | 716 | 850 | -- | .0 | -- | 2,680 | 62 | 97 | 53 | 2.96 | 4,400 | 8.1 |
| 31-101 | 10? | Apr. 15, 1963 | 16 | -- | 98 | 41 | * 300 | -- | 134 | 224 | 510 | .4 | 1.5 | -- | 1,260 | 413 | 61 | 6.4 | .00 | 2,120 | 6.4 |
| Wright Bros. Materials Co. | Gravel pit | Apr. 25, 1965 | 55 | -- | 136 | 35 | * 345 | -- | 406 | 192 | 490 | 1.1 | 9.5 | -- | 1,460 | 484 | 61 | 6.8 | .00 | 2,330 | 7.6 |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **San Patricio County** | | | | | | | | | | | | | | | | | | | | | |
| WW-79-50-704 | 338 | Sept. 1, 1950 | 26 | -- | -- | -- | * 257 | -- | 464 | 50 | 107 | -- | 0.0 | 0.96 | 632 | 25 | -- | -- | -- | 1,160 | 9.0 |
| 903 | 675 | May 12, 1965 | 16 | -- | 12 | 4.1 | * 355 | -- | 398 | 7.8 | 342 | 0.9 | .8 | 1.3 | 936 | 47 | 94 | 23 | 5.58 | 1,650 | 7.9 |
| 3/ 906 | 676 | Sept. 24, 1952 | 12 | -- | 38 | 12 | * 531 | -- | 327 | 32 | 704 | -- | -- | .87 | 1,710 | 142 | 76 | -- | -- | -- | 7.6 |
| 3/ 907 | 665 | Oct. 24, 1952 | 23 | -- | 115 | 25 | * 269 | -- | 317 | 62 | 462 | -- | -- | .60 | 1,320 | 391 | 60 | -- | -- | -- | 7.4 |
| 3/ 907 | 665 | Mar. 25, 1954 | 14 | -- | 92 | 21 | * 282 | -- | 327 | 57 | 426 | -- | -- | .82 | 1,260 | 315 | 66 | -- | -- | -- | 7.4 |
| 3/ 909 | 901 | Aug. 2, 1952 | 18 | -- | 97 | 20 | * 322 | -- | 344 | 31 | 504 | -- | -- | 1.0 | 1,370 | 324 | 68 | -- | -- | -- | 7.5 |
| 3/ 909 | 901 | Mar. 25, 1954 | 14 | -- | 100 | 22 | * 312 | -- | 337 | 28 | 506 | -- | -- | .94 | 1,350 | 340 | 67 | -- | -- | -- | 7.3 |
| 909 | 901 | July 21, 1965 | 27 | -- | 125 | 30 | * 314 | -- | 294 | 48 | 585 | .7 | .5 | 1.2 | 1,280 | 436 | 61 | 6.5 | .00 | 2,370 | 7.2 |
| 3/ 51-703 | 748 | Jan. 23, 1953 | 12 | -- | 15 | 4.3 | * 419 | -- | 403 | 9.1 | 430 | -- | -- | 2.0 | 1,350 | 55 | 94 | -- | -- | -- | 7.9 |
| 703 | 748 | May 12, 1965 | 21 | -- | 61 | 17 | * 358 | -- | 366 | 21 | 480 | .8 | .2 | 1.8 | 1,140 | 222 | 78 | 10 | 1.56 | 2,010 | 7.7 |
| 3/ 704 | 741 | Aug. 23, 1952 | 18 | -- | 94 | 20 | * 320 | -- | 398 | 14 | 444 | -- | -- | .66 | 1,340 | 317 | 67 | -- | -- | -- | 7.7 |
| 705 | 767 | Nov. 18, 1955 | 24 | -- | 53 | 14 | 480 | 4.5 | 404 | 15 | 625 | -- | .6 | 2.1 | -- | 190 | -- | 15 | -- | 2,520 | 7.9 |
| 705 | 767 | May 12, 1965 | 15 | -- | 12 | 6.8 | * 670 | -- | 498 | 2.0 | 782 | -- | .5 | 3.4 | 1,740 | 58 | 96 | 38 | 7.00 | 3,110 | 7.9 |
| 801 | 539 | do | 55 | -- | 189 | 43 | * 228 | -- | 248 | 80 | 605 | .8 | 1.8 | .40 | 1,320 | 648 | 43 | 3.9 | .00 | 2,320 | 7.2 |
| 52-706 | 670 | July 10, 1965 | 39 | -- | 66 | 18 | * 175 | -- | 292 | 41 | 238 | 1.0 | .2 | .60 | 723 | 238 | 62 | 4.9 | .02 | 1,310 | 7.1 |
| 53-704 | 200 | July 12, 1965 | 21 | -- | 42 | 20 | * 231 | -- | 360 | 93 | 210 | .5 | .2 | -- | 795 | 188 | 73 | 7.3 | 2.15 | 1,400 | 7.6 |
| 58-201 | 522 | Nov. 18, 1955 | 27 | 0.00 | 79 | 20 | 330 | 7.2 | 306 | 79 | 470 | .7 | .1 | 1.4 | 1,160 | 278 | -- | -- | -- | 2,050 | 8.1 |
| 502 | 288 | July 22, 1965 | 44 | -- | 107 | 27 | * 287 | -- | 276 | 86 | 485 | .8 | .8 | 1.1 | 1,170 | 378 | 62 | 6.4 | .00 | 2,130 | 7.0 |
| 903 | 375 | May 12, 1965 | 32 | -- | 52 | 15 | * 197 | -- | 348 | 22 | 218 | .7 | 1.8 | .91 | 710 | 191 | 69 | 6.2 | 1.88 | 1,230 | 7.7 |
| 3/ 59-101 | 706 | Dec. 12, 1952 | 15 | -- | 100 | 23 | * 308 | -- | 337 | 26 | 506 | -- | -- | 2.18 | 1,360 | 345 | 66 | -- | -- | -- | 7.5 |
| 3/ 101 | 706 | Mar. 25, 1954 | 12 | -- | 113 | 25 | * 309 | -- | 334 | 27 | 536 | -- | -- | 1.1 | 1,390 | 384 | 64 | -- | -- | -- | 7.3 |
| 3/ 102 | 710 | Feb. 6, 1953 | 6 | -- | 83 | 18 | * 360 | -- | 327 | 30 | 542 | -- | -- | 1.3 | 1,400 | 281 | 74 | -- | -- | -- | 7.6 |
| 103 | 372 | May 12, 1965 | 31 | -- | 98 | 27 | * 217 | -- | 290 | 47 | 382 | .8 | .8 | .63 | 947 | 356 | 57 | 5.0 | .00 | 1,690 | 7.6 |
| 4/ 206 | 92 | Mar. 14, 1939 | -- | -- | -- | -- | -- | -- | 348 | 75 | 460 | -- | -- | -- | 1,110 | -- | -- | -- | -- | -- | -- |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/ WW-79-59-207 | 85 | Mar. 13, 1939 | -- | -- | 162 | 49 | * 293 | -- | 244 | 52 | 700 | -- | -- | -- | 1,380 | 605 | -- | -- | -- | -- | -- |
| 303 | 290 | May 6, 1965 | 45 | -- | 76 | 20 | * 184 | -- | 328 | 52 | 245 | 1.1 | 0.2 | 0.53 | 785 | 272 | 59 | 4.9 | 0.00 | 1,310 | 7.9 |
| 4/ 309 | 98 | Mar. 14, 1939 | -- | -- | 73 | 21 | * 121 | -- | 305 | 26 | 180 | -- | -- | -- | 571 | 268 | -- | -- | -- | -- | -- |
| 309 | 98 | June 15, 1965 | 74 | -- | 72 | 22 | * 135 | -- | 332 | 26 | 185 | .9 | 2.0 | -- | 680 | 270 | 52 | 3.6 | .04 | 1,140 | 7.5 |
| 501 | 355 | May 11, 1965 | 39 | -- | 77 | 21 | * 207 | -- | 328 | 59 | 280 | .4 | 1.5 | .78 | 847 | 278 | 62 | 5.4 | .00 | 1,450 | 7.3 |
| 4/ 503 | 198 | Mar. 14, 1939 | -- | -- | 130 | 30 | * 215 | -- | 275 | 30 | 468 | -- | -- | -- | 1,010 | 449 | -- | -- | -- | -- | -- |
| 4/ 506 | 189 | do | -- | -- | -- | -- | -- | -- | 281 | 41 | 410 | -- | -- | -- | 929 | -- | -- | -- | -- | -- | -- |
| 603 | 525 | May 11, 1965 | 56 | -- | 123 | 33 | * 277 | -- | 292 | 80 | 510 | .5 | .5 | .60 | 1,220 | 442 | 58 | 5.7 | .00 | 2,080 | 7.7 |
| 4/ 607 | 93 | Mar. 14, 1939 | -- | -- | -- | -- | -- | -- | 465 | 71 | 360 | -- | -- | -- | 1,123 | -- | -- | -- | -- | -- | -- |
| 5/ 702 | 240 | Apr. 13, 1957 | -- | -- | 74 | 20 | * 214 | -- | 334 | 40 | 294 | -- | -- | -- | 977 | 266 | -- | -- | -- | -- | -- |
| 4/ 802 | 263 | Mar. 16, 1939 | -- | -- | -- | -- | -- | -- | 360 | 45 | 210 | -- | -- | -- | 687 | -- | -- | -- | -- | -- | -- |
| 2/ 60-102 | † 175-205 | --, 1954 | 41 | 4 | 137 | 47 | * 330 | -- | 218 | 75 | 708 | -- | -- | -- | 1,484 | 536 | 64.2 | -- | -- | -- | -- |
| 2/ 102 | † 260-302 | do | 41 | 7 | 75 | 20 | * 201 | -- | 318 | 65 | 268 | -- | -- | .5 | 860 | 270 | 67.9 | -- | -- | -- | -- |
| 3/ 102 | † 316-344 | do | 20 | 2 | 69 | 21 | * 186 | -- | 322 | 116 | 196 | -- | -- | .6 | 732 | 259 | 67.3 | -- | -- | -- | -- |
| 2/ 102 | † 398-443 | do | 26 | 7 | 183 | 44 | * 246 | -- | 272 | 284 | 464 | -- | -- | .6 | 1,470 | 638 | 52.0 | -- | -- | -- | -- |
| 2/ 102 | † 596-644 | do | 16 | 2 | 12 | 5 | * 329 | -- | 286 | 55 | 316 | -- | -- | 1.8 | 918 | 51 | 95.0 | -- | -- | -- | -- |
| 2/ 102 | † 750 | do | 17 | 4 | 8 | 3 | * 316 | -- | 377 | 85 | 208 | -- | -- | -- | 876 | 32 | 96.6 | -- | -- | -- | -- |
| 2/ 102 | † 916 | do | 23 | 6 | 9 | 3 | * 326 | -- | 395 | 80 | 217 | -- | -- | -- | 838 | 35 | 96.4 | -- | -- | -- | -- |
| 103 | 640 | May 5, 1965 | 40 | -- | 72 | 20 | * 181 | -- | 328 | 49 | 235 | 1.1 | .0 | .53 | 760 | 262 | 60 | 4.9 | .14 | 1,290 | 7.8 |
| 106 | 510 | May 11, 1965 | 41 | -- | 70 | 22 | * 195 | -- | 348 | 57 | 242 | .7 | .2 | .51 | 799 | 265 | 61 | 5.2 | .4 | 1,360 | 7.9 |
| 4/ 111 | 52 | Mar. 11, 1939 | -- | -- | 104 | 40 | * 371 | -- | 372 | 90 | 590 | -- | -- | -- | 1,380 | 425 | -- | -- | -- | -- | -- |
| 4/ 209 | 102 | Mar. 14, 1939 | -- | -- | 67 | 21 | * 122 | -- | 317 | 25 | 165 | -- | -- | -- | 556 | 253 | -- | -- | -- | -- | -- |
| 4/ 210 | 60 | Jan. 13, 1939 | -- | -- | 80 | 46 | * 497 | -- | 567 | 153 | 600 | -- | -- | -- | 1,660 | 389 | -- | -- | -- | -- | -- |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Cal-cium (Ca) | Magne-sium (Mg) | Sodium (Na) | Potas-sium (K) | Bicar bonate ($HCO_3$) a/ | Sul-fate ($SO_4$) | Chlo-ride (Cl) | Fluo-ride (F) | Ni-trate ($NO_4$) | Boron (B) | Dis-solved solids | Hard-ness as $CaCO_3$ | Per-cent so-dium | Sodium-adsorp-tion ratio (SAR) | Residual sodium carbon-ate (RSC) | Specific conduct-ance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WW-79-60-210 | 60 | June 15, 1965 | 60 | -- | 126 | 86 | * 691 | -- | 532 | 297 | 1,010 | -- | 0.5 | -- | 2,530 | 668 | -- | 12 | 0.00 | 4,340 | 7.2 |
| 4/ 211 | 50 | Mar. 14, 1939 | -- | -- | 50 | 26 | * 423 | -- | 512 | 127 | 420 | -- | -- | -- | 1,300 | 231 | -- | -- | -- | -- | -- |
| 4/ 402 | 96 | do | -- | -- | -- | -- | -- | -- | 360 | 45 | 420 | -- | -- | -- | 1,020 | -- | -- | -- | -- | -- | -- |
| 4/ 504 | 285 | Mar. 15, 1939 | -- | -- | 65 | 27 | * 210 | -- | 214 | 37 | 365 | -- | -- | -- | 809 | 272 | -- | -- | -- | -- | -- |
| 601 | † 416-461 | Jan. --, 1949 | 22 | -- | 9.3 | 2.8 | * 356 | -- | 372 | 62 | 285 | -- | .0 | -- | 988 | 34 | -- | -- | -- | 1,720 | -- |
| 601 | † 590-630 | do | 22 | -- | 7.5 | 2.7 | * 427 | -- | 432 | 17 | 415 | -- | .0 | -- | 1,100 | 30 | -- | -- | -- | 2,040 | -- |
| 601 | † 710-730 | do | 21 | -- | 7.9 | 2.6 | * 411 | -- | 424 | 16 | 443 | -- | .0 | -- | 1,140 | 30 | -- | -- | -- | 2,110 | -- |
| 601 | † 795-810 | do | 26 | -- | 8.3 | 3.0 | * 443 | -- | 502 | 11 | 405 | -- | .0 | -- | 1,140 | 33 | -- | -- | -- | 2,100 | -- |
| 601 | † 896-916 | do | 16 | -- | 20 | 5.9 | * 952 | -- | 512 | 4.0 | 1,220 | -- | .0 | -- | 2,470 | 74 | -- | -- | -- | 4,540 | -- |
| 601 | †1,025-1,079 | do | 26 | -- | 82 | 24 | *2,290 | -- | 347 | 6.3 | 3,540 | -- | -- | -- | 6,140 | 303 | -- | -- | -- | 11,100 | -- |
| 604 | 789 | Nov. 3, 1955 | 18 | 0.01 | 4.6 | .6 | 385 | 1.3 | 405 | 26 | 355 | 1.0 | .2 | 1.5 | 984 | 14 | -- | 45 | -- | 1,770 | 8.2 |
| 6/ 608 | 177 | Jan. 15, 1965 | 3 | -- | 3 | 1 | * 276 | -- | 260 | 15 | 230 | .8 | < .4 | -- | 690 | 12 | -- | -- | -- | 1,250 | 9.3 |
| 6/ 609 | 145 | do | 15 | -- | 18 | 8 | * 281 | -- | 332 | 74 | 239 | .9 | < .4 | -- | 800 | 80 | -- | -- | -- | 1,400 | 8.5 |
| 801 | 415 | May 11, 1965 | 17 | -- | 8.5 | 4.1 | * 238 | -- | 416 | 60 | 175 | 1.0 | .0 | 2.2 | 756 | 38 | 94 | 20 | .06 | 1,270 | 8.4 |
| 802 | 325 | do | 32 | -- | 81 | 35 | * 455 | -- | 398 | 154 | 600 | .8 | .2 | 1.8 | 1,560 | 346 | 74 | 11 | .00 | 2,640 | 7.4 |
| 6/ 902 | 204 | Jan. 14, 1965 | 35 | -- | 379 | 123 | * 336 | -- | 301 | 21 | 1,390 | .4 | < .4 | -- | 2,430 | 1,450 | -- | -- | -- | 4,200 | 7.4 |
| 4/ 903 | 220 | Mar. 15, 1939 | -- | -- | 134 | 43 | * 286 | -- | 293 | 52 | 595 | -- | -- | -- | 1,250 | 511 | -- | -- | -- | -- | -- |
| 4/ 904 | 86 | Mar. 20, 1939 | -- | -- | 72 | 39 | * 628 | -- | 458 | 30 | 920 | -- | -- | -- | 1,910 | 339 | -- | -- | -- | -- | -- |
| 6/ 905 | 45 | Jan. 14, 1965 | 33 | -- | 292 | 42 | * 193 | -- | 393 | 15 | 710 | .2 | < .4 | -- | 1,480 | 900 | -- | -- | -- | 2,650 | 7.2 |
| 6/ 906 | 40 | Jan. 16, 1965 | 31 | -- | 342 | 51 | * 268 | -- | 372 | 29 | 930 | .2 | < .4 | -- | 1,830 | 1,070 | -- | -- | -- | 3,350 | 7.1 |
| 6/ 907 | 40 | do | 53 | -- | 372 | 144 | * 399 | -- | 323 | 100 | 1,450 | .5 | < .4 | -- | 2,680 | 1,520 | -- | -- | -- | 4,550 | 7.5 |
| 6/ 908 | 42 | Jan. 15, 1965 | 12 | -- | 80 | 58 | * 408 | -- | 209 | 30 | 800 | .5 | < .4 | -- | 1,490 | 438 | -- | -- | -- | 2,750 | 7.2 |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Cal-cium (Ca) | Magne-sium (Mg) | Sodium (Na) | Potas-sium (K) | Bicar-bonate ($HCO_3$) a/ | Sul-fate ($SO_4$) | Chlo-ride (Cl) | Fluo-ride (F) | Ni-trate ($NO_4$) | Boron (B) | Dis-solved solids | Hard-ness as $CaCO_3$ | Per-cent so-dium | Sodium-adsorp-tion ratio (SAR) | Residual sodium carbon-ate (RSC) | Specific conduct-ance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/ WW-79-60-909 | 210 | Jan. 15, 1965 | 13 | -- | 5 | 4 | * 294 | -- | 315 | 38 | 242 | .9 | <0.4 | -- | 760 | 30 | -- | -- | -- | 1,350 | 8.5 |
| 6/ 910 | 180 | Jan. 16, 1965 | 15 | -- | 10 | 3 | * 298 | -- | 355 | 53 | 243 | .9 | < .4 | -- | 800 | 38 | -- | -- | -- | 1,400 | 7.8 |
| 911 | 253 | June 15, 1965 | 17 | -- | 13 | 7.4 | * 779 | -- | 436 | 16 | 980 | -- | .0 | -- | 2,030 | 63 | 96 | 43 | 5.89 | 3,750 | 8.0 |
| 61-103 | 738 | June 8, 1965 | 16 | -- | 4.8 | 2.4 | * 347 | -- | 360 | 77 | 282 | 1.1 | .8 | -- | 908 | 22 | 97 | 32 | 5.46 | 1,610 | 8.2 |
| 302 | 341 | May 12, 1965 | 15 | -- | 9.8 | 6.2 | * 302 | -- | 362 | 93 | 220 | .6 | 1.2 | -- | 826 | 50 | 93 | 19 | 4.93 | 1,410 | 7.9 |
| 303 | 322 | May 13, 1965 | 15 | -- | 7.5 | 4.3 | * 292 | -- | 360 | .4 | 265 | .5 | .2 | -- | 762 | 36 | 95 | 21 | 5.18 | 1,540 | 8.1 |
| 4/ 602 | 180 | Dec. 9, 1938 | -- | -- | 19 | 11 | * 441 | -- | 439 | 94 | 420 | -- | -- | -- | 1,200 | 92 | -- | -- | -- | -- | -- |
| 4/ 603 | 345 | Apr. 13, 1939 | -- | -- | 7 | 4 | * 299 | -- | 378 | 67 | 215 | -- | -- | -- | 782 | 32 | -- | -- | -- | -- | -- |
| 603 | 345 | June 7, 1965 | 17 | -- | 10 | 6.6 | * 338 | -- | 408 | 106 | 240 | 1.2 | .8 | -- | 921 | 52 | 93 | 20 | 5.65 | 1,610 | 8.0 |
| 605 | 396 | May 4, 1965 | 12 | -- | 5.0 | 2.1 | * 415 | -- | 404 | .4 | 415 | 2.1 | .0 | -- | 1,050 | 21 | 98 | 39 | 6.21 | 1,850 | 8.5 |
| 702 | 330 | May --, 1951 | 16 | -- | 4.0 | 4.4 | * 585 | -- | 419 | 14 | 668 | -- | 3.0 | -- | 1,410 | 28 | -- | -- | -- | 2,670 | 8.6 |
| 703 | 418 | May 14, 1965 | 15 | -- | 4.2 | 2.6 | * 351 | -- | 406 | 33 | 292 | 1.9 | 1.0 | 2.3 | 903 | 21 | 97 | 33 | 6.23 | 1,600 | 7.9 |
| 4/ 706 | 280 | Mar. 8, 1939 | -- | -- | 8 | 1 | * 667 | -- | 427 | 11 | 790 | -- | -- | -- | 1,690 | 26 | -- | -- | -- | -- | -- |
| 3/ 804 | † 260-270 | May 24, 1951 | -- | -- | -- | -- | -- | -- | -- | -- | 582 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/ 804 | † 363-373 | do | -- | -- | -- | -- | -- | -- | -- | -- | 612 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/ 804 | † 495-505 | do | -- | -- | -- | -- | -- | -- | -- | -- | 618 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3/ 804 | † 721-731 | do | -- | -- | -- | -- | -- | -- | -- | -- | 832 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4/ 805 | 200 | Mar. 8, 1939 | -- | -- | 20 | 7 | * 406 | -- | 390 | 14 | 445 | -- | -- | -- | 1,000 | 80 | -- | -- | -- | -- | -- |
| 902 | 260 | June 3, 1965 | 16 | -- | 6.5 | 3.4 | * 456 | -- | 422 | 9.2 | 468 | 2.0 | .8 | -- | 1,170 | 30 | 97 | 36 | 6.32 | 2,150 | 8.1 |
| 4/ 904 | 187 | Jan. 9, 1939 | -- | -- | 20 | 9 | * 470 | -- | 390 | 45 | 525 | -- | -- | -- | 1,260 | 85 | -- | -- | -- | -- | -- |
| 4/ 905 | 183 | Dec. 9, 1938 | -- | -- | 23 | 11 | * 472 | -- | 439 | 22 | 525 | -- | -- | -- | 1,270 | 102 | -- | -- | -- | -- | -- |
| 62-109 | 600 | May 13, 1965 | 16 | -- | 6.5 | 2.9 | * 656 | -- | 362 | 25 | 800 | 1.0 | .2 | -- | 1,690 | 28 | 98 | 54 | 5.37 | 2,980 | 7.9 |
| 301 | 277 | July 9, 1965 | 13 | -- | 5.5 | 2.6 | * 508 | -- | 416 | 4.4 | 550 | 2.2 | .8 | -- | 1,290 | 24 | 98 | 45 | 6.34 | 2,410 | 7.5 |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WW-79-62-502 | 380 | Apr. 28, 1965 | 12 | -- | 5.0 | 2.3 | * 436 | -- | 420 | 0.2 | 440 | 1.9 | 0.8 | -- | 1,110 | 22 | 98 | 40 | 5.92 | 1,900 | 8.4 |
| 4/ 701 | 185 | Jan. 13, 1938 | -- | -- | -- | -- | -- | -- | 390 | 139 | 480 | -- | -- | -- | 1,270 | -- | -- | -- | -- | -- | -- |
| 4/ 702 | 412 | Oct. 25, 1938 | -- | -- | 17 | 1 | * 852 | -- | 403 | 8 | 1,100 | 2.6 | -- | -- | 2,180 | 45 | -- | -- | -- | -- | -- |
| 702 | 412 | May 4, 1965 | 15 | -- | 8.0 | 3.4 | * 692 | -- | 400 | 11 | 850 | -- | .0 | -- | 1,780 | 34 | 98 | 52 | 5.88 | 3,110 | 8.3 |
| 4/ 703 | 173 | Dec. 9, 1938 | -- | -- | 21 | 10 | * 569 | -- | 421 | 139 | 590 | 2.2 | -- | -- | 1,540 | 91 | -- | -- | -- | -- | -- |
| 4/ 704 | 176 | Oct. 10, 1938 | -- | -- | 151 | 64 | * 894 | -- | 183 | 198 | 1,580 | -- | -- | -- | 2,980 | 640 | -- | -- | -- | -- | -- |
| 4/ 801 | 210 | Oct. 27, 1938 | -- | -- | 17 | 9 | * 552 | -- | 439 | 100 | 575 | 2.0 | -- | -- | 1,470 | 81 | -- | -- | -- | -- | -- |
| 4/ 802 | 203 | do | -- | -- | -- | -- | -- | -- | 348 | 8 | 855 | -- | -- | -- | 1,630 | -- | -- | -- | -- | -- | -- |
| 4/ 803 | 210 | Oct. 25, 1938 | -- | -- | 22 | 7 | * 794 | -- | 366 | 8 | 1,060 | 2.2 | -- | -- | 2,070 | 84 | -- | -- | -- | -- | -- |
| 4/ 804 | 190 | Oct. 17, 1938 | -- | -- | 25 | 10 | * 791 | -- | 384 | 73 | 1,010 | 2.2 | -- | -- | 2,100 | 101 | -- | -- | -- | -- | -- |
| 4/ 901 | 210 | Sept. 21, 1938 | -- | -- | 24 | 6 | * 827 | -- | 415 | 25 | 1,075 | -- | -- | -- | 2,160 | 84 | -- | -- | -- | -- | -- |
| 904 | 217 | May 4, 1965 | 11 | -- | 16 | 9.7 | * 826 | -- | 378 | 28 | 1,090 | -- | .0 | -- | 2,170 | 80 | 96 | 40 | 4.60 | 3,790 | 8.0 |
| 83-02-203 | 310 | May 12, 1965 | 31 | -- | 52 | 16 | * 387 | -- | 358 | 198 | 378 | .8 | 2.0 | 2.5 | 1,240 | 196 | 81 | 12 | 1.96 | 2,040 | 7.6 |
| 4/ 03-203 | 275 | Mar. 16, 1939 | -- | -- | 36 | 16 | * 246 | -- | 348 | 30 | 265 | .6 | -- | -- | 764 | 155 | -- | -- | -- | -- | -- |
| 4/ 303 | 220 | do | -- | -- | -- | -- | -- | -- | 378 | 34 | 280 | -- | -- | -- | 796 | -- | -- | -- | -- | -- | -- |
| 502 | 17 | Apr. 23, 1965 | 4.9 | -- | 18 | 14 | * 303 | -- | 315 | 47 | 320 | .8 | 1.2 | -- | 864 | 102 | 87 | 13 | 3.11 | 1,520 | 8.0 |
| 605 | 250 | do | 25 | -- | 60 | 23 | * 459 | -- | 326 | .2 | 690 | .8 | .8 | -- | 1,420 | 244 | 80 | 13 | .46 | 2,510 | 7.6 |
| 4/ 606 | 260 | Mar. 20, 1939 | -- | -- | -- | -- | -- | -- | 299 | 45 | 290 | -- | -- | -- | 762 | -- | -- | -- | -- | -- | -- |
| 2/ 607 | 280 | Mar. --, 1942 | -- | -- | 54 | 24 | *1,310 | -- | 373 | 2.5 | 1,960 | -- | -- | -- | 3,500 | -- | -- | -- | -- | -- | 7.4 |
| 2/ 608 | 271 | Oct. --, 1945 | -- | -- | 38 | 15 | * 545 | -- | 392 | 2.8 | 722 | -- | -- | -- | 1,640 | -- | -- | -- | -- | -- | 7.5 |
| 2/ 609 | -- | -- | -- | -- | 79 | 29 | *1,140 | -- | 335 | .8 | 1,780 | -- | -- | -- | 3,200 | -- | -- | -- | -- | -- | 7.3 |
| 904 | 265 | Apr. 27, 1965 | 18 | -- | 55 | 19 | * 547 | -- | 349 | .4 | 790 | .8 | 1.0 | -- | 1,600 | 215 | 85 | 16 | 1.42 | 2,790 | 7.6 |
| 04-103 | 120 | Apr. 22, 1965 | 28 | -- | 37 | 17 | * 601 | -- | 478 | .4 | 760 | 1.2 | 1.0 | -- | 1,680 | 162 | 89 | 21 | 4.58 | 2,910 | 7.8 |
| 2/ 203 | 263 | Aug. 16, 1963 | -- | -- | -- | -- | -- | -- | 360 | 57 | 1,462 | -- | -- | -- | 2,798 | 295 | -- | -- | -- | -- | 8.2 |
| 4/ 205 | 80 | Mar. 20, 1939 | -- | -- | 86 | 34 | * 500 | -- | 390 | 142 | 690 | 1.1 | -- | -- | 1,640 | 356 | -- | -- | -- | -- | -- |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WW-83-04-205 | 80 | June 15, 1965 | 36 | -- | 210 | 108 | * 726 | -- | 348 | 370 | 1,330 | -- | 0.8 | -- | 2,950 | 968 | 62 | -- | -- | 5,090 | 8.0 |
| 4/ 206 | 93 | Mar. 20, 1939 | -- | -- | -- | -- | -- | -- | 378 | 112 | 1,600 | -- | -- | -- | 1,410 | -- | -- | -- | -- | -- | -- |
| 2/ 207 | 135 | Aug. 28, 1956 | -- | -- | -- | -- | -- | -- | 398 | 62 | 621 | -- | -- | -- | 1,560 | 141 | -- | -- | -- | -- | 7.6 |
| 207 | 135 | June 9, 1965 | 25 | -- | 32 | 18 | * 538 | -- | 408 | 78 | 640 | 1.7 | .8 | -- | 1,530 | 154 | 88 | 19 | 3.61 | 2,760 | 7.6 |
| 4/ 301 | 200 | Mar. 8, 1939 | -- | -- | -- | -- | -- | -- | 433 | 9 | 680 | -- | -- | -- | 1,080 | -- | -- | -- | -- | -- | -- |
| 601 | 238 | Apr. 22, 1965 | 16 | -- | 49 | 28 | *1,680 | -- | 388 | 27 | 2,510 | -- | -- | -- | 4,500 | 238 | 94 | 47 | 1.61 | 7,540 | 7.8 |
| 901 | 120 | do | 49 | -- | 104 | 40 | * 732 | -- | 358 | 158 | 1,100 | -- | 8.0 | -- | 2,370 | 424 | 79 | 15 | .00 | 3,960 | 7.9 |
| 4/ 05-101 | 210 | Jan. 9, 1939 | -- | -- | -- | -- | -- | -- | 403 | 11 | 470 | -- | -- | -- | 1,080 | -- | -- | -- | -- | -- | -- |
| 4/ 103 | 200 | Mar. 8, 1939 | -- | -- | -- | -- | -- | -- | 500 | 13 | 720 | -- | -- | -- | 1,560 | -- | -- | -- | -- | -- | -- |
| 4/ 201 | 160 | Jan. 4, 1939 | -- | -- | -- | -- | -- | -- | 372 | 60 | 700 | -- | -- | -- | 1,480 | -- | -- | -- | -- | -- | -- |
| 302 | 221 | July --, 1945 | 16 | 0.02 | 17 | 7.6 | 490 | 8.8 | 395 | 66 | 508 | 1.8 | 2.2 | -- | 1,330 | 85 | -- | 23 | -- | -- | 7.8 |
| 501 | 216 | June 2, 1965 | 12 | -- | 22 | 20 | *1,290 | -- | 400 | 48 | 1,820 | -- | 2.5 | -- | 3,410 | 138 | 95 | 48 | 1.90 | 6,280 | 7.4 |
| 4/ 602 | 165 | Oct. 31, 1938 | -- | -- | 192 | 84 | * 886 | -- | 128 | 240 | 1,700 | .3 | -- | -- | 3,160 | 827 | -- | -- | -- | -- | -- |
| 4/ 901 | 160 | Nov. 1, 1938 | -- | -- | 238 | 98 | *2,386 | -- | 275 | 53 | 4,190 | -- | -- | -- | 7,100 | 1,001 | -- | -- | -- | -- | -- |
| 4/ 06-101 | 300 | Oct. 7, 1938 | -- | -- | 27 | 10 | * 493 | -- | 403 | 84 | 535 | 2.1 | -- | -- | 1,350 | 106 | -- | -- | -- | -- | -- |
| 4/ 102 | 180 | Oct. 10, 1938 | -- | -- | 42 | 13 | * 827 | -- | 378 | 73 | 1,110 | 2.0 | -- | -- | 2,250 | 158 | -- | -- | -- | -- | -- |
| 4/ 103 | 196 | do | -- | -- | 31 | 10 | *1,251 | -- | 299 | 5 | 1,830 | 2.1 | -- | -- | 3,280 | 116 | -- | -- | -- | -- | -- |
| 4/ 201 | 204 | Sept. 21, 1938 | -- | -- | 38 | 9 | * 836 | -- | 366 | 61 | 1,120 | 2.1 | -- | -- | 2,250 | 130 | -- | -- | -- | -- | -- |
| 303 | 180 | May 5, 1965 | 17 | -- | 39 | 30 | *1,230 | -- | 388 | .8 | 1,830 | -- | .5 | -- | 3,340 | 221 | 92 | 36 | 1.94 | 5,920 | 8.3 |
| 4/ 401 | 182 | Nov. 1, 1938 | -- | -- | 35 | 16 | * 917 | -- | 403 | 48 | 1,250 | 2.2 | -- | -- | 2,470 | 155 | -- | -- | -- | -- | -- |
| 4/ 601 | 220 | Oct. 8, 1938 | -- | -- | -- | -- | -- | -- | 207 | 119 | 3,350 | -- | -- | -- | 5,580 | -- | -- | -- | -- | -- | -- |
| 4/ 701 | 210 | Nov. 2, 1938 | -- | -- | -- | -- | -- | -- | 397 | 48 | 1,190 | -- | -- | -- | 2,250 | -- | -- | -- | -- | -- | -- |
| 4/ 07-104 | 280 | Oct. 13, 1938 | -- | -- | 52 | 17 | *1,281 | -- | 329 | 8 | 1,920 | -- | -- | -- | 3,440 | 201 | -- | -- | -- | -- | -- |
| 104 | 280 | June 15, 1965 | 3.9 | -- | 12 | 11 | *1,280 | -- | 294 | 4.8 | 1,850 | -- | .0 | -- | 3,310 | 75 | 97 | 64 | 3.32 | 6,100 | 8.2 |
| 4/ 402 | 175 | Sept. 19, 1938 | -- | -- | 53 | 27 | *1,632 | -- | 134 | 54 | 2,570 | -- | -- | -- | 4,400 | 242 | -- | -- | -- | -- | -- |

See footnotes at end of table.

Table 14.--Chemical analyses of water from wells in Nueces and San Patricio Counties--Continued

San Patricio County

| Well | Depth of well (ft) | Date of collection | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) a/ | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_4$) | Boron (B) | Dissolved solids | Hardness as $CaCO_3$ | Percent sodium | Sodium-adsorption ratio (SAR) | Residual sodium carbonate (RSC) | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/ WW-83-07-403 | 280 | Sept. 19, 1938 | -- | -- | 54 | 18 | *1,493 | -- | 329 | -- | 2,260 | -- | -- | -- | 3,990 | 211 | -- | -- | -- | -- | -- |
| 404 | 192 | June 4, 1965 | 14 | -- | 44 | 35 | *1,670 | -- | 540 | 328 | 2,200 | -- | -- | -- | 4,560 | 254 | 93 | 46 | 3.77 | 8,000 | 8.1 |
| 4/ 509 | 44 | Sept. 7, 1938 | -- | -- | -- | -- | -- | -- | 238 | 20 | 235 | -- | -- | -- | 591 | -- | -- | -- | -- | -- | -- |
| 510 | 124 | June 16, 1965 | 23 | -- | 12 | 11 | * 493 | -- | 420 | 37 | 540 | 1.1 | 0.2 | -- | 1,320 | 75 | 93 | 25 | 5.39 | 2,370 | 8.4 |
| 702 | 150 | July 8, 1965 | 30 | -- | 28 | 22 | * 687 | -- | 376 | 86 | 890 | -- | 1.0 | -- | 1,930 | 160 | 90 | 24 | 2.95 | 3,480 | 7.5 |
| 4/ 801 | 84 | June 23, 1938 | -- | -- | 35 | 22 | * 332 | -- | 421 | 54 | 355 | -- | -- | -- | 1,010 | 179 | -- | -- | -- | -- | -- |
| 801 | 84 | July 8, 1965 | 30 | -- | 14 | 15 | * 555 | -- | 554 | 107 | 520 | 1.5 | .5 | -- | 1,520 | 96 | 93 | 25 | 7.15 | 2,650 | 7.8 |
| 4/ 808 | 90 | June 22, 1938 | -- | -- | 108 | 25 | * 196 | -- | 329 | 45 | 340 | -- | -- | -- | 876 | 370 | -- | -- | -- | -- | -- |
| 833 | 65 | July 8, 1965 | 35 | -- | 84 | 16 | * 205 | -- | 322 | 38 | 295 | .3 | .8 | -- | 832 | 276 | 62 | 5.4 | .00 | 1,500 | 7.1 |
| 4/ 834 | 180 | June 24, 1938 | -- | -- | -- | -- | -- | -- | 329 | 28 | 230 | -- | -- | -- | 670 | -- | -- | -- | -- | -- | -- |
| 901 | 150 | July 8, 1965 | 25 | 0.12 | 55 | 13 | * 128 | -- | 278 | 9.4 | 160 | 1.7 | .2 | -- | 529 | 190 | 59 | 4.0 | .75 | 967 | 6.9 |
| 4/ 919 | 40 | June 26, 1938 | -- | -- | 65 | 5 | * 50 | -- | 256 | 5 | 54 | .1 | -- | -- | 305 | 183 | -- | -- | -- | -- | -- |
| 927 | 42 | July 8, 1965 | 28 | -- | 66 | 5.5 | * 50 | -- | 257 | 4.4 | 57 | .2 | .2 | -- | 337 | 187 | 37 | 1.6 | .47 | 586 | 7.4 |

* Sodium and potassium calculated as sodium (Na).
† Interval or depth tested.
a/ Includes the equivalent of any carbonate ($CO_3$) present.
1/ Analysis by Microbiology Service Laboratories, Houston, Texas.
2/ Analysis by Campbell Laboratories.
3/ Analysis by Curtis Laboratories.
4/ Analysis by personnel of the Work Projects Administration under supervision of Bureau of Industrial Chemistry of The University of Texas.
5/ Analysis by Texas A&M University.
6/ Analysis by Texas State Department of Health.