TEXAS WATER COMMISSION

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INVESTIGATION OF GROUND-WATER RESOURCES NEAR FREDERICKSBURG, TEXAS

By

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INVESTIGATION OF GROUND-WATER RESOURCES NEAR FREDERICKSBURG, TEXAS

ABSTRACT

The Fredericksburg area, located in central Gillespie County, comprises an area of approximately 180 square miles. Altitudes range from less than 1,500 feet to greater than 2,150 feet. The economy is based on agriculture and related industries. The climate is mild, with an average temperature of 65° F and an average annual rainfall of nearly 28 inches.

Almost all rocks appearing at the surface are of Cretaceous age and exhibit a gentle easterly dip. Rock older than Cretaceous are dissected by numerous faults.

Principal water-bearing units are the Edwards and Comanche Peak Limestones and the Hensell Sand Member, of Cretaceous age; the Ellenburger Group, of Ordovician age; and the Hickory Sandstone Member, of Cambrian age. It is estimated that at least 5,000 acre-feet per year of ground water could be developed from these units.

Rocks of the Ellenburger Group furnish most of Fredericksburg's water and appear to have the greatest potential for future development of large amounts of ground water.

INVESTIGATION OF GROUND-WATER RESOURCES NEAR FREDERICKSBURG, TEXAS

INTRODUCTION

Purpose and Scope

The city of Fredericksburg has always obtained an adequate supply of water from underground sources, but because of complicated geologic and hydrologic conditions, the city has recently experienced difficulty in obtaining large-capacity water wells to meet increasing demands on their water system and requested assistance from the Texas Water Commission. The Commission agreed to make a special study for the city which would consist of a review of available data and the collection of data in the field, and to furnish the city a memorandum-type report, containing basic hydrologic data, a discussion of ground-water conditions, and recommendations, to assist them in locating future water wells and in determining the adequacy of ground-water resources available to them.

Fieldwork began in October 1962 and continued intermittently through March 1963. Measurements of the depths to water in selected wells were made by personnel of the Fredericksburg Water Department from May 1962 through September 1962 and by personnel of the Texas Water Commission during the field study. The work performed during the field study consisted of inventorying wells and springs, conducting pumping tests of wells, determining altitudes of wells and springs, and collecting pumpage, precipitation, and water-level data. The well inventory was made to obtain measurements of depths to water, or water levels, to collect samples of water for chemical analysis, and to obtain yields and pumping capacities of wells. Chemical analyses of water samples were made by the Texas State Department of Health. Altitudes for most of the wells were determined by field stadia surveying, but some altitudes were determined with an altimeter. In addition to the work performed in the field, samples of cuttings from some wells were examined and described with the aid of a binocular microscope.

The data collected during the study are presented in tables and illustrations at the end of this report. These include data on hydrology, geology, water wells, pumping tests, and water quality, as well as hydrographs, geologic maps, and a cross-section.

Location and Physical Features

The area of study, designated in this report as the Fredericksburg area, comprises approximately 180 square miles in central Gillespie County. (See Figure 1.) The area is located principally in the Texas hill country; however, it also lies partly within the eastward margin of the Edwards Plateau. The area is south of the Central Mineral or Llano region.

The area is almost entirely within the drainage basin of the Pedernales River, a major tributary to the Colorado River. The Pedernales River flows in an easterly direction through the southern part of the area. Important tributaries entering the Pedernales from the north are Live Oak Creek, Barons Creek, and Palo Alto Creek. Wolf, Bear, and Meusebach Creeks flow into the Pedernales from the south. The locations of these streams are shown on Figure 2. The streams derive their base flow from springs and seeps and generally flow throughout the year. During the summer months, however, irrigation from the streams and high rates of evaporation and plant transpiration cause many streams to become dry in some reaches.

Topographic coverage of the area includes the 30-minute Fredericksburg and Kerrville topographic sheets published in 1894 by the U. S. Geological Survey, and the Llano topographic sheet, NH 14-5 Series V502, published in 1954 by the Army Map Service of the Corps of Engineers. Because geology is a controlling factor in physiographic development, a general indication of the topography in the Fredericksburg area can be obtained by examining the geologic map (Figure 2) and the geologic section (Figure 3).

Topographic relief in the Fredericksburg area is greater than 650 feet. Altitudes range from less than 1,500 feet in the eastern part of the area along the Pedernales River to greater than 2,150 feet in the north-central part of the area. Areas of gentle and pronounced relief occur, and the transition between the two types of relief is abrupt.

Bordering the Pedernales River and its tributaries and situated at altitudes of generally less than 1,800 feet are areas of gentle to moderate relief with deep sandy soils. Encouraged by these favorable soil conditions, numerous farms have developed. Where not cleared for agricultural purposes, the land is densely vegetated with live oak and mesquite.

At altitudes generally higher than 1,800 feet, a rather abrupt change in relief occurs because of differences in the type of bedrock upon which the surface is formed. Hard limestones in the higher altitudes have produced a rugged topography consisting of steep slopes and escarpments. These conditions favor the development of a thin, stony soil which is unsuitable for farming but often supports a generous growth of various species of oak.

The population in the Fredericksburg area is mostly urban. Fredericksburg, the county seat of Gillespie County, is the only community in the study area. The population of Gillespie County increased from 1,240 in 1850 to 11,020 in 1930, and has since declined to 10,048 in 1960. Conversely, the population of Fredericksburg has increased from 2,416 in 1930 to 3,544 in 1940, to 3,854 in 1950, and to 4,629 in 1960. In the Fredericksburg area, most of the rural population is concentrated in the regions of low relief, which are more suitable for farming than the higher and more rugged regions.

The economy of the Fredericksburg area is based on agriculture and related industries. In general, crops are grown only in the lower altitudes. Principal crops include peaches, corn, wheat, grain sorghum, and peanuts. In the higher and more rugged parts of the area the land is generally not suited for farming and is used mostly for the grazing of sheep and goats. Cattle are raised in the lower parts, mostly for the production of beef but also for dairying purposes. Turkeys and hogs are also raised in the area. Among the supporting industries located in Fredericksburg are a turkey processing plant, a peanut processing plant, grain storage warehouses, and dairies. The local economy is boosted through game leases, as Gillespie County abounds with deer. Because of the scenic beauty and recreational facilities, the Fredericksburg area is, to many individuals, a desirable location for retirement.

Climate

The climate of the Fredericksburg area is subhumid, and temperatures are usually mild. The average temperature is 65° F; the average January temperature is 49° F and the average July temperature is 81° F. The mean annual net lake-surface evaporation is about 45 inches. The growing season averages 241 days.

Rainfall in Fredericksburg from 1877 to 1963, exclusive of periods of no record (1883 through 1888 and 1915 through 1938), averaged nearly 28 inches per year. During the period of record, there have been 9 years with more than 35 inches of rainfall and 9 years with less than 20 inches. Most of the rainfall occurs during the spring and fall months. The monthly precipitation for the period of record is presented in Table 7; monthly precipitation for the period 1948-63 is illustrated on Figure 5.

Previous Work

The first ground-water study in the Fredericksburg area was by Sellards (1930), who as a result of a 1-day field investigation collected several drillers' logs of wells within the city and designated possible water-bearing units in the area. As a project of the Works Progress Administration, Shields (1937) inventoried water wells and springs in Gillespie County. A brief description of the city of Fredericksburg's water supply is given in U. S. Geological Survey Water-Supply Paper 1069 (Sundstrom and others, 1949). Barnes (1952c, d, e, f) mapped in detail the geology of the four 7-1/2 minute quadrangles in which the Fredericksburg area is located, in addition to mapping adjacent quadrangles. Included with Barnes' maps are texts pertaining to geologic and ground-water conditions. In 1959-61 the ground-water resources of the Colorado River Basin, which includes the Fredericksburg area, were studied as part of a statewide ground-water reconnaissance investigation program (Mount and others, 1962).

Well-Numbering System

The numbers assigned to wells and springs in this report conform to the statewide well-numbering system adopted by the Texas Water Commission. This system is based on division of the State into quadrangles formed by degrees of latitude and longitude, and repeated division of these quadrangles into smaller ones as shown on the following page.

The largest quadrangle, a 1-degree quadrangle, is divided into sixty-four 7-1/2 minute quadrangles, each of which is further divided into nine 2-1/2 minute quadrangles. Each 1-degree quadrangle in the State has been assigned a number for identification. The 7-1/2 minute quadrangles are numbered consecutively from left to right beginning in the upper left hand corner of the 1-degree quadrangle, and the 2-1/2 minute quadrangles within the 7-1/2 minute quadrangle are similarly numbered. The first two numbers of a well number identify the 1-degree quadrangle; the third and fourth numbers identify the 7-1/2 minute quadrangle; the fifth number identifies the 2-1/2 minute quadrangle; and the last two numbers designate the order in which the well was inventoried within the 2-1/2 minute quadrangle.

The Fredericksburg area lies entirely within 1-degree quadrangle number 57, and the boundaries of this quadrangle are not shown on the illustrations in this report. However, the complete numbers of all wells and springs in this report begin with 57.

The points along the streams where flow measurements or observations were made do not conform to the statewide well-numbering system, but are numbered consecutively, and the numbers are preceded by the capital letter F.

Acknowledgements

Appreciation is expressed to Water Superintendent Walter Fuhrmann and to employees of the Fredericksburg Water Department for measuring depths to water in selected wells prior to commencement of fieldwork, for assistance in conducting pumping tests of wells, and for providing technical data from the Water Department's files. From his long experience with the Water Department, Herman Rusche was able to establish the location of many abandoned wells drilled by the city and furnish information on the performance of the wells. Local water well drillers Howard Cravens, Alvin Heimann, and Lonnie Itz furnished drillers' logs of wells, samples of cuttings from wells, and information on subsurface geology and ground-water conditions that were of considerable benefit in accomplishing the study. Appreciation is also expressed to local citizens for the cooperation and information they provided during the study.

GENERAL GEOLOGY

The Fredericksburg area is located on the southern flank of a large domal feature called the Llano uplift which covers several counties. The center of the Llano uplift is north of Gillespie County, in Llano County. After a period of uplifting which occurred toward the end of Paleozoic time (about 200 million years ago), the area was leveled by erosion. Later, during Cretaceous time (about 100 million years ago), sediments were deposited on this erosional surface. Sands and clays were the first to be laid down, and upon these were deposited a sequence of limestones. At a still later time, the incising of the Colorado River and its tributaries removed some of the Cretaceous rocks and in some localities exposed the older Paleozoic and Precambrian rocks. Cretaceous sands and clays now occupy the lower and more gentle terrain in the

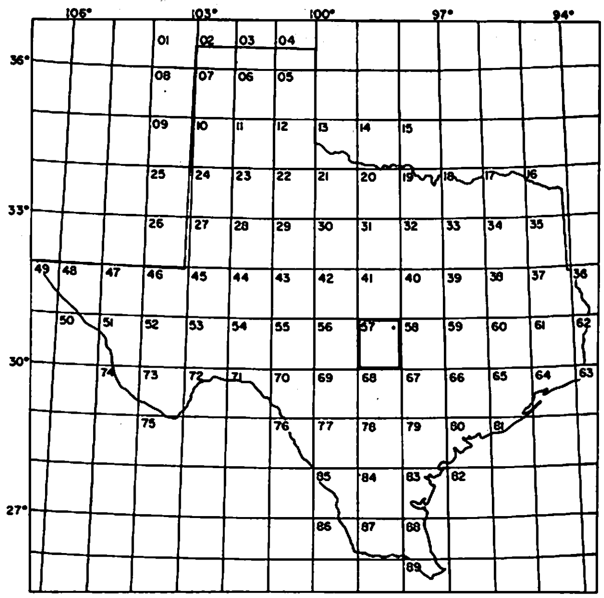
Location of Well 57-15-701

57 1-degree quadrangle

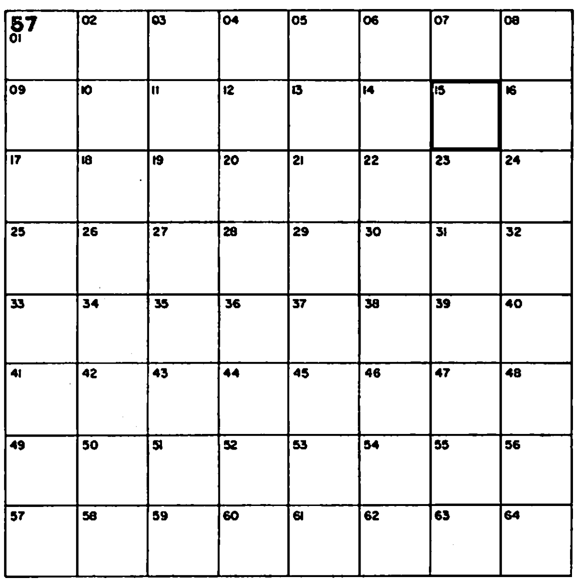
15 7 1/2 minute quadrangle

7 2 1/2 minute quadrangle

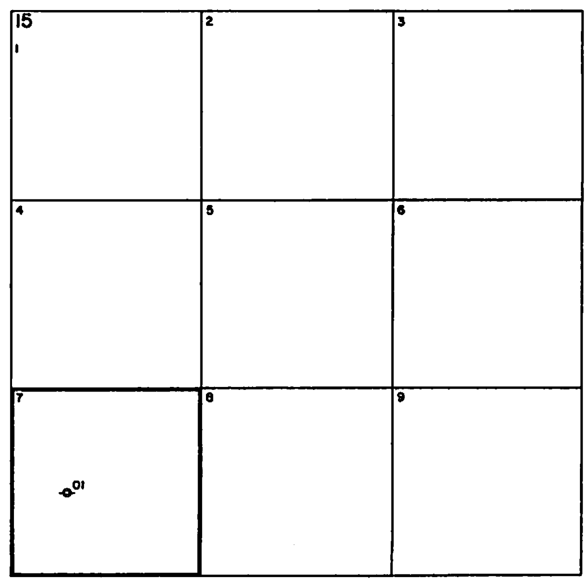
01 Well number within 2 1/2 minute quadrangle



I-degree Quadrangles



7 1/2-minute Quadrangles



2 1/2-minute Quadrangles

Fredericksburg area; Cretaceous limestones occur in the higher and more rugged parts of the area, the dissected eastern margin of the Edwards Plateau.

The geology of the Fredericksburg area was mapped by Barnes (1952c, d, e, f), but recently the names of some geologic units have been changed. In this report, names of geologic units conform to current usage (Barnes, 1956, and Wilson and others, 1959). Geologic units in the Fredericksburg area are listed in Table 1. Geologic units appearing at the surface are shown on the geologic map (Figure 2). Knowledge of geologic units in the subsurface was obtained from descriptions of cuttings from wells presented in Table 4.

Nearly all the rocks appearing at the surface in the Fredericksburg area are of Cretaceous age. The lowest Cretaceous rock unit is the Hensell Sand Member of the Shingle Hills Formation. The Hensell, which is predominantly red clay and sand, occurs at the surface in the lower parts of the area. Because the Hensell is easily eroded, it produces a gentle topography having deep soils. The successively higher rock units--Glen Rose Limestone, Walnut Clay, Comanche Peak Limestone, and Edwards Limestone--are mostly hard and resistant to erosion. They produce the rugged topography and thin stony soils in the higher parts of the area. Cretaceous rock units at one time covered the entire Fredericksburg area; their removal from parts of the area was accomplished through erosion by recent streams.

Rocks older than Cretaceous crop out in a few localities, mostly in the eastern part of the area. Many different geologic units are exposed, which suggests that the pattern of rocks beneath the Cretaceous is far from simple. Information afforded by well drilling is the only means of determining the identity of the rock units beneath the Cretaceous. A general indication of those rocks occurring below the Cretaceous is presented in the geologic section (Figure 3), which is necessarily oversimplified due to the scarcity of data.

The Cretaceous rocks dip to the east at a rate of about 5 feet per mile. This very gentle, regional dip is the only significant structural character exhibited by the Cretaceous rocks. However, important changes in thickness of the Cretaceous rocks occur because of the very uneven surface upon which the rocks were deposited.

As a result of the regional uplifting which occurred toward the end of Paleozoic time, the Paleozoic rocks in the area dip to the south, away from the Llano uplift. During the period of uplifting the rocks were subjected to stresses, and in some places where stresses were severe enough to cause fractures, the vertical movement of strata along fracture planes resulted in faults. The trend of the faults is probably in a northeast direction, but neither the trend nor the exact location of the faults can be verified because of their concealment by the covering of Cretaceous sediments. Outcrops of Paleozoic and Precambrian rocks and information afforded from well drilling furnish conclusive evidence that large displacements of rock occurred before Cretaceous time.

The geologic section on Figure 3 shows the probable location along the line of section of several important faults below the Cretaceous. In addition to those shown, many other faults are undoubtedly present. As illustrated in Figure 3, probably the greatest displacement is along a fault or system of faults passing just east of the Fredericksburg city limits, in which Paleozoic rocks on the east have been brought into contact with Precambrian rocks on the west.

The stratigraphic units which occur in the Fredericksburg area are listed and described in Table 1. Those exhibiting significant water-bearing properties, from youngest to oldest, are the Edwards and Comanche Peak Limestones, the Hensell Sand Member, the Ellenburger Group, and the Hickory Sandstone Member. These units are discussed in detail in another section of this report.

GENERAL GROUND-WATER HYDROLOGY

This section has been included to acquaint the reader with some of the basic fundamentals of ground-water hydrology and the terms used in this report.

Hydrologic Cycle

The hydrologic cycle is the sum total of the processes and movements of the earth's moisture from the sea through the atmosphere to the land, and eventually, with numerable delays en route, back to the sea. The cycle may be divided into three phases: (1) Evaporation and transpiration--water enters the atmosphere by evaporation from land and water surfaces and by transpiration from plants; (2) Precipitation--particles of moisture from the atmosphere fall on the earth, usually as rainfall or snow; and (3) Infiltration and runoff--precipitation is disposed of by evaporation back into the atmosphere, by infiltration and storage in the ground, and by runoff or overland flow into streams. All water occurring in the Fredericksburg area, whether surface water or ground water, is derived from precipitation.

Occurrence and General Hydraulics

Ground water is contained in the openings or pores of rock strata. In granular sediments, such as sand and gravel, ground water occurs in the openings between the grains. In limestones and dolomites, ground water occurs in solution-formed openings. These openings, once small fractures, partings, and joints in the rock, have been enlarged by the dissolving of rock material by percolating waters. Where there is free circulation of water through joints or other openings in limestone or dolomite, solution of the rock material may progress until the rock contains a network of caverns, some of which may be of great size. Igneous and metamorphic rocks in the Fredericksburg area possess negligible porosity; neither are they readily dissolved by water, nor are openings in them enlarged by solution. Hence, igneous and metamorphic rocks in the area contain little or no ground water.

Two rock characteristics of fundamental importance in the occurrence of ground water are porosity, the percentage of open space contained in the rock, and permeability, which expresses the ability of porous material to transmit water. The property of permeability is related to the size and nature of interconnected openings within the rock. Fine-grained sediments such as clay and silt commonly have high porosity, but owing to the small size of pores, they do not readily yield or transmit water.

Water falling on the land surface may take one of many courses in completing the hydrologic cycle. A large percentage of it is evaporated back to the atmosphere or taken up by plants and returned to the atmosphere by transpiration. Some of the water will run off the land surface into streams and thus return to the sea. A small percentage will percolate downward under the force of gravity to a zone in which all rock openings are saturated. This zone is known as the zone of saturation and the upper surface of the zone is called the water table. Water in the zone of saturation also moves in response to gravity to points of lower altitude where it is discharged naturally or artificially and is subjected to other phases of the hydrologic cycle. Occasionally a relatively impermeable layer above the water table will retard downward percolation of the water, creating a saturated zone above the main water table. This is known as perched water.

Ground water may occur under water-table or artesian conditions Under water-table conditions, the water surface is unconfined and open to the atmosphere. The hydraulic gradient in an unconfined aquifer is the slope of the water table. Under artesian conditions, water is confined under hydraulic pressure between relatively impermeable beds. Hence, the water is able to rise in a well to a level higher than that of the water-bearing strata. The higher the hydraulic pressure, the higher the water will rise in a well. Pressure head is expressed as the height of a column of water that can be supported by the pressure. Under artesian conditions, water moves in the direction of lower head, from points of recharge to points of discharge. Under these conditions the levels to which water rises in wells describes a surface, called the piezometric surface, which slopes in the direction of lower hydraulic pressures or points of discharge. Under artesian conditions, the hydraulic gradient is the slope of the piezometric surface. Water-table surfaces and piezometric surfaces generally slope in the same direction as the regional land surface.

The water-yielding capacity of a water-bearing unit, or aquifer, depends upon its ability to store and transmit water. Under artesian conditions, ground water is withdrawn from storage without draining the water-bearing rocks. As water is pumped from the artesian aquifer the hydrostatic pressure is lowered. The weight of the overlying sediments, which were partially supported by the hydrostatic pressure, compresses the water-bearing material and the confining beds, causing some water to be released from storage. The coefficient of storage is equal to the amount of water in cubic feet that will be released from or taken into storage by a vertical column of the aquifer having a base one foot square when the water level or hydrostatic pressure is lowered or raised one foot. The coefficient of transmissibility provides an index of an aquifer's ability to transmit water. It is defined as the amount of water in gallons per day which will pass through a vertical strip of the aquifer one foot wide under a hydraulic gradient of one foot per foot.

The coefficients of storage and transmissibility are generally determined from pumping tests of wells. Most pumping tests consist of pumping a well at a constant rate for a period of time and making periodic measurements of water levels in the pumping well and, if possible, in one or more observation wells. The recovery of the water level is also measured after pumping stops. From the data obtained, the coefficients of transmissibility and storage can be calculated by means of certain formulas. The coefficient of storage can be determined only if data are obtained from an observation well. The coefficients of transmissibility and storage may be used in computing the effects that pumping from a well will have on water levels in the aquifer at various times and at various distances from the pumped well. The coefficients can also be used in computing the quantity of water that will flow through an aquifer and in estimating the availability of water from storage.

A general indication of the hydraulic characteristics of an aquifer is provided by the specific capacity of a well. The specific capacity of a well is defined as the gallons per minute a well will yield for each foot of water-level drawdown that has occurred at the end of a period of time during which the well has been pumped at a constant rate. However, the type of well construction and the thoroughness of well development also have an effect on a well's specific capacity. Because of this, the specific capacity is not a direct indication of the aquifer's hydraulic characteristics.

Recharge, Discharge, and Movement

Recharge is the addition of water to an aquifer. The primary source of ground-water recharge in the Fredericksburg area is precipitation which falls on the land and infiltrates the aquifers. In addition, seepage from streams and interformational leakage are sources of recharge to particular aquifers.

Recharge is a limiting factor in the amount of water that can be developed on a perennial basis, as it must balance the discharge over a period of time or the water in storage in the aquifer will eventually be depleted. Among the factors which influence the amount of recharge received by an aquifer are: the amount and frequency of precipitation, the extent of the infiltration area, topography, type and amount of vegetation, the condition of the soil cover in the infiltration area, and the ability of the aquifer to accept recharge and transmit it to areas of discharge.

Discharge is the loss of water from an aquifer. The discharge may be either artificial or natural. In the Fredericksburg area, artificial discharge takes place from water wells. Natural discharge occurs as effluent seepage, springs, evaporation, transpiration, and leakage between aquifers through confining sediments.

Ground water generally moves from the areas of recharge to areas of natural discharge with the movement being in the direction of the hydraulic gradient. However, local anomalies develop in areas of pumping wells and some water moves toward these points of artificial discharge. The rate of ground-water movement in an aquifer is generally very slow, being in the magnitude of a few inches to a few feet per year; in limestones and dolomites containing connected solution openings the rate of movement is generally much greater.

Fluctuations of Water Levels

Changes in water levels are due to many causes. Some are of regional significance while others reflect local conditions. The more significant causes of water-level fluctuations are changes in recharge and discharge. When recharge is reduced as in the case of a drought, water discharged from the aquifer must be taken from storage and water levels decline. However, when adequate rainfall resumes, the volume of water drained from storage in the aquifer during the drought may be replaced, and water levels will rise accordingly.

When a water well is pumped, water levels in the vicinity are drawn down in the shape of an inverted cone with its apex at the pumped well. The development or growth of this cone of depression depends on the aquifer's coefficients of transmissibility and storage and on the rate of pumping. As pumping continues the cone expands both outward and downward, and continues to do so unless it intercepts some source of replenishment capable of supplying sufficient water to satisfy the pumping demand. If the quantity of water received from this source is sufficient to compensate for the water pumped, the expansion of the cone ceases and a balance between recharge and discharge is achieved. When the amount of water being pumped from an aquifer by wells is greater than the amount of recharge the aquifer is receiving, water is continuously removed from storage in the aquifer and water levels will continue to decline.

Where intensive development has taken place in ground-water reservoirs, each well superimposes its own individual cone of depression on that of neighboring wells. This results in the development of a regional cone of depression. When the cone of one well overlaps the cone of another, interference occurs and an additional lowering of water levels results as the wells compete for water by expanding their cones of depression. The amount or extent of interference between cones of depression depends on the rate of pumping from each well, the spacing between wells, and the hydraulic characteristics of the aquifer in which the wells are completed. In developing a ground-water supply, water-level declines in the vicinity of pumping wells are necessary to establish hydraulic gradients sufficient to permit a particular quantity of water to move to the wells.

Water levels in some wells, especially those completed in artesian aquifers, have been known to fluctuate in response to such phenomena as changes in barometric pressure, tidal pressure, and earthquakes. However, the magnitude of these fluctuations is usually small.

Chemical Quality

All ground water contains dissolved minerals; the kind and concentration of these depends upon many factors. Water has considerable solvent power and it dissolves mineral matter from the soil and the rocks of the aquifer as it passes through them. The amount that is dissolved depends, among other factors, on the solubility of the minerals which are present, the length of time the water is in contact with the rocks, and the amount of dissolved carbon dioxide contained in the water. The concentrations of dissolved minerals in water generally increase with depth and are greater in aquifers where ground-water circulation is restricted. Therefore, at some depth, highly mineralized water is encountered.

The principal mineral constituents found in ground water are silica, calcium, magnesium, sodium, potassium, iron, manganese, bicarbonate, sulfate, chloride, nitrate, fluoride, and boron. Water used for municipal supplies should be colorless, odorless, palatable, and where possible be within the limits set by the U. S. Public Health Service (1962) for drinking water used on interstate carriers. Some of these standards, in parts per million, are as follows:

Chloride (Cl)------------------250
Fluoride (F)-------------------(*)
Iron (Fe)---------------------- 0.3
Manganese (Mn)----------------- 0.05
Nitrate (NO_3)----------------- 45
Sulfate (SO_4)------------------250
Total dissolved solids----------500

* When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in the following table.

Annual average of maximum daily air temperatures (°F)	Recommended control limits (Fluoride concentrations in ppm)		
	Lower	Optimum	Upper
50.0 - 53.7	0.9	1.2	1.7
53.8 - 58.3	.8	1.1	1.5
58.4 - 63.8	.8	1.0	1.3
63.9 - 70.6	.7	.9	1.2
70.7 - 79.2	.7	.8	1.0
79.3 - 90.5	.6	.7	.8

The above limits are desirable for municipal use, but it is realized that many supplies which cannot meet these standards must be used in the absence of more suitable supplies. Many supplies failing to meet all of these standards have been in use for long periods of time without any apparent ill effects on the user.

Water having nitrate concentration exceeding 44 ppm (parts per million) may cause methemoglobinemia, or "blue baby" disease, and is regarded as unsafe for infant feeding (Maxey, 1950, p. 271). Water containing more than 0.3 ppm iron and manganese combined is likely to cause objectionable staining of laundered clothes and plumbing fixtures.

Hardness of water is an important factor in domestic, municipal, and industrial supplies. The principal constituents causing hardness of water are calcium and magnesium. Water hardness is expressed in parts per million as calcium carbonate. An increase in hardness causes an increase of soap consumption in washing and laundering processes and the formation of scale in boilers and other equipment. A generalized classification for hardness which is useful as an index is as follows: less than 60 ppm, soft; 61 to 120 ppm, moderately hard; 121 to 200 ppm, hard; and more than 200 ppm, very hard. Water in the Fredericksburg area is a calcium bicarbonate type and very hard; hence, a treatment process for hardness reduction may be desirable.

The tolerance in chemical quality of water for industrial use differs widely for different industries and different processes. One of the major items of concern to most industries is the use of water supplies which do not contain corrosive or scale-forming constituents that affect the efficiency of their boilers and cooling systems. Hardness, along with excessive amounts of silica and iron, cause scale deposits which clog lines and reduce the efficiency of heat-exchange apparatus.

There are a number of factors involved in determining the suitability of water for irrigation purposes. The type of soil, adequacy of drainage, types of crops, climatic conditions, and the quantity of water used all have an important bearing on the continued productivity of irrigated acreages. Characteristics of water which are important in determining its suitability for irrigation are: total concentration of soluble salts; relative proportion of sodium to magnesium, calcium, and potassium (sodium adsorption ratio); concentration of carbonate in excess of calcium and magnesium; and concentration of boron.

PRINCIPAL WATER-BEARING UNITS

Principal water-bearing units in the Fredericksburg area are, from youngest to oldest, the Edwards and Comanche Peak Limestones, the Hensell Sand Member of the Shingle Hills Formation, the Ellenburger Group, and the Hickory Sandstone Member of the Riley Formation. Because ground water moves from the topographically higher into the lower water-bearing units, discussions of these units are presented in order of youngest to oldest.

Edwards and Comanche Peak Limestones

Because the Edwards and Comanche Peak Limestones occur extensively only at considerable distances from Fredericksburg, they are not practical sources of water for the city. However, these rocks intercept precipitation over a large area both in and adjacent to the Fredericksburg area, and thereby supply water to streams and furnish recharge by downward leakage to other water-bearing units.

The Edwards Limestone is composed principally of limestone, but also contains dolomite and gypsum. A persistent zone of gypsum is found about 140 feet above the base of the formation. The Edwards occupies a large part of the northern and northwestern part of the Fredericksburg area, the highest and most rugged part of the area. Because the Edwards is exposed at the surface and is not overlain by younger formations, changes in its thickness are mostly related to topography. Maximum thickness of the Edwards in the Fredericksburg area is probably not much greater than 200 feet.

The Comanche Peak Limestone contains considerably more clay than the Edwards, especially in its lower part. Hence, it is generally softer and more easily eroded than the overlying Edwards and produces a steepened topography along its outcrop. The Comanche Peak is about 30 feet thick and is less permeable than the Edwards. The Comanche Peak is underlain by the Walnut Clay, a bed only a few feet thick composed of yellow clay grading upward into limestone. Clay beds of the Walnut and the Comanche Peak, because of very low permeability, largely prevent water in the Edwards and Comanche Peak from percolating downward into lower formations. These clays establish a perched water table, perhaps as high as 50 feet above the base of the Edwards.

The Edwards and Comanche Peak Limestones are recharged on their outcrop by precipitation which infiltrates downward through openings in the rocks to the regionally perched water table. Because the outcrops of the formations extend for considerable distances north and west of the Fredericksburg area, some of the water in the formations is derived from land outside this area. Studies to determine the amount of recharge to the aquifer in the Fredericksburg area have not been made. Investigations in Edwards County to the southwest (Long, 1962, p. 25) indicate that in northern Edwards County the Edwards and other limestone units are recharged at an average rate of 74 acre-feet per square mile per year. The estimate was based on the analysis of precipitation and streamflow records for the period 1923-54. Similarity of conditions in the outcrop of the formations in Gillespie and Edwards Counties suggests that the average recharge to the Edwards and Comanche Peak in the Fredericksburg area may be on the order of 2,500 acre-feet per year.

Most of the water in the Edwards and Comanche Peak moves through solution-formed openings toward surface drainageways and is discharged through springs and seeps. Minor quantities of water are discharged artificially through small-capacity wells used for domestic and livestock purposes. Although none of the springs discharge large amounts of water, they are reported, for the most part, to have sustained flow in droughts. Records of some of the wells and springs which derive water from the Edwards and Comanche Peak Limestones are given in Table 2.

Water in the Edwards and Comanche Peak is uniformly of good chemical quality. Analyses of water from springs 57-41-101, 57-41-203, 57-42-103, and 57-42-302 are shown in Table 3. These analyses indicate that concentrations of individual constituents are remarkably uniform over a large area.

Hensell Sand Member of the Shingle Hills Formation

The Hensell Sand Member of the Shingle Hills Formation is composed of poorly-sorted sand, silt, and clay. The upper part of the member is typically finer grained than the lower part, which commonly contains conglomerate and angular coarse sand. The member is red in color, becoming gray and less sandy in its upper part as it grades into the overlying Glen Rose Limestone Member. Limestone beds commonly occur in the Hensell in the subsurface.

With few exceptions, the Hensell is present throughout the Fredericksburg area. It crops out at the lower elevations, but at higher elevations the Hensell is covered by overlying strata. The Hensell is easily eroded to form gentle slopes with fertile soils.

Because the Hensell was deposited upon a very uneven erosional surface, its thickness varies considerably. A few miles west of Fredericksburg, its thickness is probably greatest, exceeding 300 feet. North of Fredericksburg, the Hensell pinches out against Bear Mountain, a granite mass which remained exposed at least until the Comanche Peak Limestone was deposited. A general indication of the variation in thickness of the Hensell may be obtained from examination of Figure 4 which is a map showing the altitude of the base of the Cretaceous strata in the Fredericksburg area. The contours are on the base of the Hensell where it is present. In areas where the Hensell is absent, as in grid 57-41-2, the contours represent the base of other Cretaceous strata, usually the Edwards or Comanche Peak Limestones. As indicated by comparison of Figure 4 with a topographic map, the thickest development of the Hensell is most likely to occur in the southwest part of the Fredericksburg area, particularly in an elongate area trending northwest and located south and west of Fredericksburg. Further knowledge of the general occurrence of the Hensell in the subsurface may be obtained from the geologic section on Figure 3.

Most of the recharge to the Hensell is derived from precipitation that falls on its outcrop area and easily infiltrates the deep sandy soils. Some recharge also occurs by infiltration from streams crossing the Hensell outcrop. Probably small amounts of water are contributed to the Hensell by downward leakage from the Edwards and Comanche Peak Limestones in the northern and western parts of the area.

Except in the upper few feet of the member, clay and sand beds of the Hensell are generally saturated with water, and as a unit the Hensell is considered a water-table aquifer. However, the more permeable, lower sands of the Hensell are overlain by relatively impervious layers of clay, and water in the lower sands is under artesian conditions. Water in the lower sands is derived by downward leakage from overlying strata. Because of the loss in hydrostatic head associated with vertical leakage, water in the lower part of the Hensell is under less head than water in the upper part. Consequently, the water levels in wells that penetrate the deeper sands are lower than the levels in nearby shallower wells.

Water also moves horizontally through the Hensell toward discharge areas, which are seeps along streams. The regional direction of movement is southeast, toward the Pedernales River. Movement of ground water toward and into the Pedernales River is shown by streamflow measurements (Texas Board Water Engineers, 1960), which are presented in Table 8. The locations at which the streamflow measurements were made are shown on Figure 2. These measurements show that increments of water are added to the Pedernales River where it flows over rocks of the Hensell Sand Member.

Water is discharged artificially from the Hensell through wells. Most of the large-capacity wells in the Fredericksburg area are completed in the Hensell, and nearly all the domestic and livestock wells in the area obtain water from the Hensell. Most of the large-capacity wells are used for irrigation purposes. Four wells were formerly used to supply water for Fredericksburg, but only one is presently being used. Only a small fraction of the city's water is obtained from the Hensell, and the amount supplied is unknown as only total pumpage figures are available.

Depths to water in wells that penetrate the Hensell range from less than 10 to more than 170 feet below the land surface. Variations in depth to water are mostly due to differences in altitudes of the land surface. However, in some instances, differences in water levels occur because the wells are completed in zones having different head, as for example in wells 57-41-903 and 56-41-904 which are located near the National Guard Armory 1 mile west of the city. These wells are completed in the lower and upper Hensell, respectively.

Large, regional changes in water levels in Hensell wells have not occurred. Several wells (57-41-402, 57-41-601, 57-42-402, and 57-42-704) in which water levels had been measured in 1936 were visited in 1961-62 and the depth to water remeasured. In each well the water level had risen. The average water-level rise was about 2.5 feet.

Water levels were measured repeatedly in two Hensell wells, 57-42-702 and 57-41-903, during the present study; records of the water levels are presented in Table 5. Well 57-42-702 (Fredericksburg's Henke no. 2 well) is located north of the city limits on the Llano highway and is situated a considerable distance from any pumping. Observed fluctuations in water levels were very small and were probably due to climatic conditions affecting rates of recharge and discharge. Well 57-41-903 is located near the municipal wells at the Armory, and fluctuations in water levels are large, mainly due to pumping of nearby wells. This well was also used for observation purposes during a pumping test of well 57-41-902, which is also completed in the Hensell.

Variations in thickness and composition of the Hensell suggest that its water-bearing properties may vary greatly. The coefficients of transmissibility and storage were determined for the lower sands in the Hensell from a pumping test of well 57-41-902 conducted January 8 through 10, 1963. Well 57-41-903, located 218.6 feet to the south, was used for observation purposes. Measurements of depth to water and pumping rate were recorded for 48 hours and water levels were measured for an additional 24 hours after pumping ceased. Pumping rates were measured with a 4" x 2-1/2" pipe orifice. It was not possible to maintain a steady rate of pumping during the test, and a mean rate of 65 gpm (gallons per minute) was selected for computations. Data obtained from the test, presented in Table 9 and illustrated on Figure 6, were used to compute the coefficient of transmissibility and storage and the specific capacity. The coefficient of transmissibility determined for the Hensell in the vicinity of the wells is small, about 600 gpd/ft. (gallons per day per foot). The coefficient of storage is likewise small, about 0.00007. However, because the wells are located in an area where the Hensell's thickness is greater than average, coefficients of transmissibility and storage obtained from the tests are probably higher than average for the lower sands of the Hensell in the Fredericksburg area. The specific capacity of well 57-41-902 for the first hour of pumping was about 0.9 gpm per foot of drawdown. Well 57-41-901, located nearby, could not be used for observation during the test because the water-bearing zone in the well was plugged owing to caving.

The city of Fredericksburg has drilled many water-well test holes in the Hensell Sand, but most of the wells were abandoned because they were unable to sustain large yields. Because of low coefficients of transmissibility, a multiple-well system consisting of a series of properly spaced, small-capacity wells may be necessary in developing large supplies of water from the Hensell.

In the Fredericksburg area, almost all of the small-capacity wells, used mostly for domestic and livestock purposes, obtain water from the Hensell. Eleven wells that penetrate the Hensell and are equipped with large-capacity turbine pumps were inventoried. Pumping capacities of these wells ranged from 30 to 200 gpm and averaged 75 gpm. Of the 11 large-capacity wells, 9 are used for irrigation and most of these are located in the north-central part of the Fredericksburg area. The other two wells, 57-41-901 and 57-41-902, are public-supply wells near the Armory. Well 57-41-901 reportedly produced 250 gpm when drilled, the highest known yield of any well completed in the Hensell in the Fredericksburg area. This well was removed from service during the latter part of 1962 because of caving. The well was completed with casing extending only down to or partly into the water-bearing strata.

Most of the large-capacity wells are completed with steel casing which extends from the top of the hole to the bottom and is perforated or slotted opposite the water-bearing strata. In some wells, a gravel envelope is placed between the outside of the casing and the wall of the hole. Well 57-41-902, a municipal well near the Armory, and well 57-50-104, a former municipal well 3 miles southeast of the city, were completed by setting commercial screens adjacent to water-bearing intervals.

Pumpage from the Hensell has increased in recent years, accompanying a more general availability of electric pumps and increasing water demands of modern times. The first known large-capacity wells, 57-50-103 and 57-50-104, located 3 miles southeast of Fredericksburg, supplied the city from 1935 until about 1940. Well 57-50-104 was later sold to the landowner for irrigation following the completion by the city of two Ellenburger wells in the vicinity. Thereafter, the Hensell was not used for the city's water supply until 1956. In 1956 and 1957 the city completed and placed in operation wells 57-41-901 and 57-41-902, near the Armory. Well 57-41-901 was abandoned in 1962 because of caving but another well is planned at the same general location.

The irrigation wells in the Fredericksburg area have been drilled since the early 1950's as a result of a prolonged drought. Wells used for irrigation generally are pumped only during the growing season and mostly during periods of inadequate rainfall. Annual pumpage from the Hensell by irrigation and municipal wells is not known. Probably more water is pumped annually from small-capacity wells used for domestic and livestock purposes than from the larger capacity municipal and irrigation wells. Pumpage from the Hensell may increase in the future, especially in locations where irrigation from water wells is economically feasible.

Water in the Hensell is, with some exceptions, of good chemical quality and satisfactory for public supply. Concentrations of individual constituents and dissolved solids show a large degree of variation from place to place. Chemical analyses show that most of the water is high in bicarbonate and iron. In some instances the nitrate and chloride concentrations are objectionably high. Analyses of water samples from 20 wells that penetrate the Hensell are presented in Table 3. The dissolved-solids concentration of the samples ranges from 531 to 1,371 ppm. A well in the south part of Fredericksburg is reported to have produced water containing 7,052 ppm dissolved solids. This well, 63 feet deep, was inventoried by Shields (1937) but was not located during the present study.

Water from well 57-41-901, a municipal well near the Armory, was chemically analyzed in 1956 and in 1960. Results of these chemical analyses, presented in Table 3, show that the chemical quality did not change appreciably for the 5-year period.

Ellenburger Group

In the Fredericksburg area, rocks of the Ellenburger Group occur principally in the subsurface below the Hensell Sand east and south of Fredericksburg.

Clues bearing on the presence of Ellenburger dolomite and limestone beneath the Hensell may be afforded by the occurrence of numerous closed surface depressions which are easily seen on aerial photographs. The depressions are thought to be the result of collapse of cavernous limestone and dolomite in the subsurface.

The total thickness of the Ellenburger rocks is not believed to be much greater than 1,000 feet. Ellenburger rocks are underlain by dolomite of the San Saba Member of the Wilberns Formation. The San Saba is about 400 feet thick. Although nothing is known of the water-bearing properties of the San Saba in the Fredericksburg area, the member furnishes large quantities of water to wells and springs in many places in Central Texas, and therefore the possible water-bearing potential of the San Saba should not be overlooked. The precise identification of Ellenburger and San Saba rocks in the subsurface is commonly difficult owing to the similarity of the rock units. Hence, in the Fredericksburg area, some of the wells which are thought to produce water from the Ellenburger may in fact obtain water from the San Saba

Water in the Ellenburger occurs in solution-formed openings in limestone and dolomite and is generally under artesian conditions. Recharge to the Ellenburger is by downward leakage from the overlying Hensell Sand. Regionally, water in the Ellenburger moves easterly toward the Pedernales River, but locally movement is toward pumped wells. Water is discharged naturally from the Ellenburger through small springs and seeps along the Pedernales River. Some water may move into overlying alluvial deposits or the Hensell Sand Member before reaching the Pedernales River.

A considerable amount of water moving through the Ellenburger probably is discharged into the Pedernales downstream from the Fredericksburg area. Streamflow measurements along the Pedernales River show an increase in flow where the river passes over outcrops of Ellenburger rocks (Texas Board Water Engineers, 1960). Some of the measurements made in the Fredericksburg area are presented in Table 8, and locations where flow measurements were made are shown on Figure 2.

Practically all of the water discharged artificially from the Ellenburger is from five large-capacity wells near the Pedernales River. Few small-capacity domestic and livestock wells obtain water from the Ellenburger.

Depths to water in the Ellenburger wells inventoried range from less than 15 to more than 65 feet below land surface. The water levels are somewhat deeper than water levels in nearby Hensell wells. Water-level records for well 57-50-102, a public-supply well 3 miles southeast of the city, have been maintained by the city of Fredericksburg since 1956. Some of the measurements are presented in Table 5 and are shown graphically on Figure 5. These measurements show that despite ever-increasing pumpage from the Ellenburger wells, appreciable water-level declines have not occured.

Because water in the Ellenburger occurs in solution-formed openings which are uniform neither in size nor in distribution, water-bearing characteristics are highly variable. Therefore, hydraulic properties determined at any locality cannot be considered representative of the water-bearing unit throughout its area of occurrence.

Pumping tests were conducted on wells 57-50-101 and 57-50-102 during the period January 19 through 21, 1963. The wells are spaced 16.5 feet apart and produce from hydraulically-connected cavernous zones at depths of about 260 and 240 feet, respectively. Measurements of depth to water and pumping rate were made and are presented in Table 10. Some of the test data are shown graphically on Figure 7. Pumping rates were measured with a flowmeter installed in the pipeline leading from the wells.

Tests were conducted with each well pumping independently and with both wells pumping simultaneously, but because the wells were being used by the city, long periods of pumping and recovery were not possible. Water-level measurements in well 57-50-101 during recovery periods are probably not reliable because of a rapid rise followed by a slow decline in water level. Well 57-50-102 exhibited only a rise in water levels during recovery periods which is to be expected. The reason for the peculiar behavior of water levels in well 57-50-101 is not known. However, water levels were measured with an electric line, and a thick oil-water emulsion overlies the water in the well. Errors in water-level measurements may have been introduced by disturbances of the emulsion-water interface during the first moments of recovery. From the test data, the coefficient of transmissibility was computed to be on the order of 75,000 to 100,000 gpd/ft.; the coefficient of storage was not determined. The 1-hour specific capacity of well 57-50-101 was about 50 gpm/ft. for a pumping rate of 510 gpm.

Chemical analyses of water from wells 57-50-101 and 57-50-102 are given in Table 3. The concentrations of mineral constituents are within the range recommended for public water supply.

Most wells producing from the Ellenburger in the Fredericksburg area are constructed with casing that extends from the surface to a few feet into the hard Ellenburger rock.

The earliest Ellenburger water wells in the area were drilled by the city in 1939 and 1944. The other large-capacity wells, used for irrigation, have been drilled since 1956. Pumpage from the Ellenburger by the irrigation wells is small compared to the amount of pumpage from the Ellenburger by the city's wells. Fredericksburg's monthly pumpage for the period 1948-63 is given in Table 6 and presented graphically on Figure 5. All the pumpage given in Table 6 was from the Ellenburger until 1956; since that time a small part of the total pumpage has been from the Hensell.

Because the principal occurrence of the Ellenburger is in the fertile Pedernales River Valley east of Fredericksburg, there exists a potential for ground-water development for irrigation as well as for public supply. Future increase in pumpage from the Ellenburger, therefore, may depend not only on the growth of Fredericksburg but also on agricultural economics which may encourage the use of ground water for irrigation.

The amount of water available from the Ellenburger is not known. However, the Ellenburger appears to be the best aquifer in the Fredericksburg area from the standpoint of developing large supplies of ground water. This is because it occurs over a large part of the Fredericksburg area, probably about 40 to 50 square miles, because it has very high transmissibilities, and because it derives recharge from the overlying Hensell Sand Member. The Hensell occurs at the surface throughout most of the Fredericksburg area and is capable of intercepting large amounts of rainfall and streamflow. Owing to its large extent and thickness, the Hensell is capable of storing large amounts of water. The storage aspect of the Hensell in connection with the high transmissibility of the Ellenburger increases the value of the Ellenburger as an aquifer.

Some difficulty may be encountered in finding permeable zones in the Ellenburger. It is believed from available data that the more permeable zones in the Ellenburger occur near the Pedernales River and near the closed topographic depressions formed on Hensell outcrops.

Hickory Sandstone Member of the Riley Formation

In the Fredericksburg area the Hickory Sandstone occurs only in the subsurface. Because of displacements due to faulting, the Hickory is present at various depths below the Cretaceous, but in some places, such as in the city of Fredericksburg, the Hickory is not present because it was removed by erosion prior to the deposition of the Hensell Sand. Although the Hickory is known to be water-bearing only in the north-central part of the area, it is believed capable of supplying water to wells throughout much of the northwestern and perhaps in some places in the northeastern part of the area.

The Hickory is principally a fine- to medium-grained sand or sandstone containing numerous beds of shale or clay. The shale or clay beds become more predominant in the upper part of the member. Conglomerate occurs at the base of the member in some places. Because the Hickory was deposited upon a very uneven Precambrian terrain, its thickness varies considerably. Available data show that the thickness of the Hickory is as great as 320 feet and that the most productive water sands are in the lower part of the member.

Little data are available on the processes of recharge, movement, and discharge of ground water in the Hickory. Where the Hickory furnishes water to wells in the northern part of the Fredericksburg area, altitudes of water levels are higher than altitudes in any Hickory outcrop area of significant size in Gillespie County. Hence, water in the Hickory probably is not obtained from these outcrop areas but is derived by downward vertical leakage from overlying water-bearing strata, namely the Edwards and Comanche Peak Limestones, as indicated by the similarity of chemical constituents of waters from the Edwards and Comanche Peak and from the Hickory.

Available data suggest that in the north-central part of the Fredericksburg area the movement of water through the Hickory is to the east, and that the hydraulic gradient is about 10 feet per mile. Movement of water through the Hickory probably takes place in a very complicated manner because of numerous faults which probably restrict movement of water.

The locations of natural discharge are not known; artificial discharge occurs from only a few wells. Six wells which obtain or have obtained water from the Hickory were inventoried during the present study. Two of the wells are equipped with large-capacity turbine pumps.

The depth to water in the wells ranges from less than 15 feet to more than 350 feet below land surface, depending primarily on the altitude of the land surface at the well. Because there has been very little development in the Hickory in the area, there have been no widespread water-level declines. However, approximately 12 feet of net water-level decline occurred in well 57-42-101 from January 1961 to November 1962. This well, located on the Achtzehn ranch north of Fredericksburg, produced about 5 million gallons during the spring, summer, and fall months of 1962. Water levels in well 57-41-604, located on the property of Richard Stehling, 4 miles northwest of the city, are presented in Table 5. The only significant fluctuation in water levels measured in this well was during temporary pumping of nearby well 57-41-301. Well 57-41-301 was recently completed by the city of Fredericksburg and was placed in operation during the summer of 1963. Future water-level declines will occur as a result of pumpage from this well.

A pumping test of well 57-41-301 was conducted by personnel of the Texas Water Commission from January 26 through February 1, 1963. Measurements of pumping rate and depth to water are presented in Table 11 and illustrated on Figure 8. The pumping rate, which averaged 190 gpm during the test, was measured with a 4" x 3" pipe orifice. Depths to water were measured in well 57-41-301, the pumped well, and in well 57-41-604, an observation well located 812.5 feet southwest of the pumped well. The test consisted of pumping for a 4-day period after which pumping was stopped. Measurements of the water-level recovery were then taken for 2 days. After pumping for 2 days, it was necessary to relocate the point of discharge from the well. The relocation was accomplished without discontinuing pumping. However, slight changes in pumping rate occurred and difficulty was experienced thereafter in measuring the pumping rate. Nevertheless, it is believed that the quantitative results obtained from the test were not appreciably affected.

Data from the test were used to determine the coefficient of transmissibility, coefficient of storage, and specific capacity. Values of the coefficient of transmissibility obtained ranged from about 4,000 to 6,500 gpd/ft. Data from the pumping test show that transmissibility becomes less with time of pumping. Also, lower values were obtained from the observation well than from the pumped well, and it is believed that transmissibility decreases southwest from the pumped well. Moreover, the Hickory is not present in the subsurface at well 57-41-603, 0.9 miles southwest of the pumped well, probably because of faulting between these wells. The coefficient of storage determined from the observation-well data was approximately 0.00004. The 1-hour specific capacity of well 57-41-301 was 6.3 gpm/ft. for an average pumping rate of 193 gpm.

Data from the pumping test and the driller's log of well 57-41-301 indicate that water levels during pumping could in the future decline below the top of water-bearing strata, at a depth of about 265 feet. This would cause reduction of aquifer transmissibility near the well and eventually cause a decrease in well yield. It is therefore recommended that pumping levels in the well be checked frequently and the pumping rate adjusted so that the water level in the well does not decline below 265 feet.

A pumping test was attempted on well 57-42-101 on November 20, 1962. The well has been used for crop irrigation for several years and was recently purchased by the city for future municipal use. The well was pumped at a rate of 195 gpm, and measurements of the depths to water were made for 26 minutes, after which the water level declined below an obstruction in the well making further water-level measurements impossible. Data obtained in this brief test indicate that coefficients of transmissibility greater than 4,000 gpd/ft. probably would not have been obtained from a longer test. The well is reported to have penetrated only part of the Hickory section, in which case the coefficient of transmissibility should be less than if the well were completed in the entire section. The specific capacity of the well was 6.2 gpm/ft. for a pumping rate of 195 gpm for 26 minutes. The coefficient of storage could not be determined, as no observation well was available. Data obtained from the pumping test of well 57-42-101 are not included in the tables in this report.

The water-bearing characteristics of the Hickory as determined from these pumping tests are applicable only to the immediate vicinity of the pumped wells. Because of faulting and large variations in thickness, the hydraulic conditions in the Hickory are very complicated. The hydraulic relationships can be better understood only from test drilling and pumping tests.

Large-capacity turbine pumps are installed on only two Hickory wells, 57-41-301 and 57-42-101. Both wells are located in the north-central part of the Fredericksburg area.

Well 57-41-301, located on the property of Richard Stehling, was drilled in 1948 as an oil test and subsequently abandoned. The hole was acquired by the city in 1962. The city completed the well by setting and cementing 16-inch steel casing to a depth of 254 feet, after which 10-inch casing with vertically slotted openings was set to a depth of 332 feet. A gravel envelope was poured around the 10-inch casing to prevent sand from entering the well. The well was first tested by the city and yielded 300 gpm for short periods, but prolonged pumping at this rate caused the water level to be drawn below the top of the water-bearing strata, which resulted in production of sand and air. Data from this test are presented in Table 11. A later test indicated that the well could be pumped at about 200 gpm for prolonged periods.

Well 57-42-101, located on the property of Fred Achtzehn, was drilled in 1953 for irrigation purposes and was recently acquired by the city for future public-supply use. It is reported that the well did not penetrate the entire Hickory section. Galvanized iron casing was reportedly set from the surface to the top of a resistant rock bed, and the remainder of the hole left open. The well is reported to have exhibited a 100-foot drawdown in water level at a pumping rate of 327 gpm during a 3-hour performance test. The electric-powered pump installed on the well yields 195 gpm, and on the basis of power-consumption data, pumpage from the well has probably never exceeded 10 million gallons per year. This well represents the only significant development of the Hickory in the Fredericksburg area. However, development of the Hickory will probably increase many fold in the future, as a result of pumpage from the recently completed public-supply well.

Well 57-41-604, completed in the Hickory but not equipped with a pump, is located 812.5 feet southwest of the recently completed public-supply well, 57-41-301. The well was drilled in 1955 for irrigation, but because of relatively high pumping costs the well was equipped only with a windmill and used for livestock purposes. The city has purchased the well for future use. The well is completed with 8-inch casing, vertically slotted opposite the water-bearing intervals. In 1962 the city conducted a performance test on this well. It yielded 150 gpm for 24 hours with a water-level drawdown of 80 feet. As a result of pumping the well at higher rates, sand and air were produced when the water level in the well declined below a depth of 208 feet, the top of the water-bearing zone. The well is reported to have penetrated the Hickory and entered granite at a depth of 257 feet.

Well 57-41-302, located in the north-central part of the Fredericksburg area on the property of Arthur Stehling, was drilled in 1962 for domestic and livestock purposes. The Hickory was encountered from about 405 to 520 feet and consisted mostly of loose, fine-grained sand. Casing was set from the surface to a depth of 50 feet and the remainder of the hole was left open. On a performance test, the well could not sustain a pumping rate greater than 45 gpm. It is presently pumped intermittently at 28 gpm.

The only other wells in the Fredericksburg area that are thought to obtain water from the Hickory are wells 57-41-401 and 57-42-502. These wells are equipped with small-capacity pumps. Data on these wells are included in Table 2, and chemical analyses of water obtained from them are presented in Table 3.

In the southern part of the Fredericksburg area, only two wells have penetrated the Hickory. Well 57-49-101, drilled as an oil test, is located on the property of Herman Usener in the southwestern part of the area. The well was abandoned and filled for lack of oil production; the water-bearing properties of the Hickory were not reported. Cuttings from this well were described by Barnes (1952e); the descriptions, included in Table 4 of this report, show that the Hickory was encountered at a depth of 300 feet, directly below the Hensell. Granite was reached at a depth of 620 feet. The Hickory may be water bearing at this locality, as it directly underlies the Hensell which is water bearing.

In 1955 the city drilled well 57-49-302. This well, located on the property of Gilbert Maurer (formerly the Wallendorf property) about 2 miles southwest of Fredericksburg, encountered Morgan Creek Limestone below the Hensell at about 165 feet. The well penetrated the top of the Hickory at about 960 feet and continued in Hickory until granite was reached at a depth of about 1,240 feet. Casing was set through the Hensell to a depth of 200 feet. When tested the well could not sustain a yield greater than 60 gpm without the water level being lowered below the base of the pump which was set at 350 feet. Because of the failure of this well to produce larger quantities of water, the well was awarded to the landowner and is now used for livestock purposes. It is possible that most, if not all, of the water obtained from the well is derived from the Welge Sandstone Member, as water reportedly was encountered when the Welge was penetrated during drilling operations.

Pumpage from the Hickory since 1953 has probably not exceeded 10 million gallons per year, practically all of which has been for irrigation purposes. Because the Hickory appears to be water bearing mostly in areas unsuitable for farming, future significant irrigation pumpage is not anticipated.

The amount of water that can be pumped from the Hickory over long periods cannot exceed the amount of water recharged to it. Available data suggest that the Hickory is recharged by downward vertical leakage from the Edwards and Comanche Peak Limestones; lowering of the hydraulic pressure in the Hickory by pumping should induce some additional recharge. On the basis of coefficients of transmissibility determined for the Hickory and the present hydraulic gradient, it is estimated that in the northern part of the Fredericksburg area water moves through the Hickory at a rate less than 200 acre-feet per year.

Although it is not known what amounts of water could be developed from the Hickory with a properly-spaced well system, it would be very optimistic to expect that long-term withdrawals greater than 500 acre-feet per year could be obtained. This corresponds to an average daily pumpage of about 1/2 million gallons.

Chemical analyses of water from the Hickory show it to be uniformly of good chemical quality, suitable for public supply. Water from the Hickory has a lower dissolved-solids content than water from the Ellenburger Group or Hensell Sand and is chemically similar to water obtained from the Edwards and Comanche Peak Limestones.

GROUND WATER AVAILABLE FOR DEVELOPMENT

Because of complicated geologic and hydrologic conditions, the amount of ground water available for development from each of the principal water-bearing units in the Fredericksburg area cannot be evaluated with available data. However, in this area the base flow of the Pedernales River is derived mostly from ground water in the principal water-bearing units, and therefore a lower limit for the magnitude of ground water moving through the area may be obtained from base-flow measurements of the river.

Streamflow measurements of the Pedernales River in the Fredericksburg area were made January 10-16, 1956 (Texas Board Water Engineers, 1960). Some of these measurements are presented in Table 8; locations of the measurements are shown on Figure 2. The discharge of the river was considerably less than its average winter low-flow when these measurements were made, as indicated by daily streamflow records since 1939 for the Pedernales River near Johnson City (30 miles downstream from the Fredericksburg area).

On the basis of these streamflow measurements in the Fredericksburg area, it appears that in 1956 at least 5,000 acre-feet of ground water could have been intercepted by wells. Moreover, available records of water-level measurements indicate that the amount of ground water in storage in the Fredericksburg area has never changed greatly. However, it is emphasized that this estimate of ground-water availability is correct only in its general order of magnitude and is subject to revision as future hydrologic data become available.

SUMMARY AND CONCLUSIONS

In the Fredericksburg area, stratigraphic units which appear to hold some promise for development of water supplies for municipal purposes are, in order of importance, the Ellenburger Group, the Hensell Sand Member of the Shingle Hills Formation, and the Hickory Sandstone Member of the Riley Formation.

Ellenburger Group

The Ellenburger Group, composed of limestone and dolomite, occurs mostly in the subsurface in a large area east and south of Fredericksburg. Recharge is readily derived by downward leakage from the Hensell Sand Member of the Shingle Hills Formation. Water in the Ellenburger moves through solution-formed openings in an easterly direction toward the Pedernales River. These openings are perhaps best developed in areas near streams and below closed topographic depressions. Water from the Ellenburger is suitable for public supply; however, it has a hardness of about 400 ppm.

The city of Fredericksburg obtains most of its water from two large-capacity wells that penetrate the Ellenburger Group. Additional Ellenburger development is from irrigation wells, whose annual pumpage is considerably less than the annual pumpage from the city's wells. Pumpage and water-level data from the city of Fredericksburg's wells indicate that the wells are capable of being pumped at higher rates.

Hensell Sand Member

The Hensell Sand Member of the Shingle Hills Formation occurs throughout most of the Fredericksburg area. Most irrigation wells and practically all wells used for domestic and livestock purposes obtain water from the Hensell. The city of Fredericksburg has produced water from four Hensell wells, but only one well is now being used.

Recharge occurs mostly by precipitation on the outcrop of the Hensell. Because of its large areal extent and saturated thickness, large quantities of ground water are contained in the Hensell, but its low transmissibility precludes the development of large-capacity wells. The best area for development from the Hensell appears to be to the west and south of Fredericksburg. Although the chemical quality of water from the Hensell is highly variable, obtaining water of suitable chemical quality does not appear to be a problem. In view of the favorable recharge conditions and because of low transmissibility, which limits the development of large-capacity wells, future pumpage from the Hensell probably will not exceed the amount of water recharged to it.

Hickory Sandstone Member

The Hickory Sandstone Member of the Riley Formation appears capable of supplying large amounts of water only in the northern part of the Fredericksburg area. Recharge to the Hickory is probably by downward leakage from the Edwards and Comanche Peak Limestones. Because recharge appears to be limited and because the Hickory is dissected by faults, which often restrict movement of water in sand strata, continuous withdrawals from the Hickory of more than 500 acre-feet per year probably are not feasible, even though greater rates of pumping may be possible for short periods.

Water from the Hickory is less mineralized than water from either the Ellenburger or Hensell. The Hickory has been penetrated by large-capacity wells only since 1953 and since then annual pumpage has probably not exceeded 10 million gallons. Greater quantities will be withdrawn from the Hickory in the future, principally from a well recently completed by the city.

RECOMMENDATIONS

A data-collection program would be of considerable future value, as an accurate determination of the quantity of ground water available for development cannot be made with present data owing to complex geologic and hydrologic conditions. Systematic monthly records of water levels and pumpage should be maintained in wells equipped with large-capacity turbine pumps. It would also be desirable to establish a system of water-level measurements in wells located adjacent to areas of development and completed in the water-bearing strata of interest. If possible, daily stream-gaging records in the Fredericksburg area should be obtained, but in order for streamflow records to be of value for determining the availability of ground water, they should be supplemented with an inventory of pumpage from the streams by irrigators.

Rocks of the Ellenburger Group appear to have the greatest potential for future development of large amounts of ground water; therefore, it is recommended that principal consideration be given this source in obtaining future water requirements. As interpretation of the Ellenburger's hydraulic properties requires a high degree of technical skill, it is suggested that the city obtain reputable professional assistance in planning a development program.

SELECTED REFERENCES

Barnes, V. E., 1952a, Geology of the Squaw Creek quadrangle, Gillespie and Mason Counties, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 1.

_______1952b, Geology of the Spring Creek quadrangle, Gillespie County, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 6.

_______1952c, Geology of the Live Oak Creek quadrangle, Gillespie County, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 7.

_______1952d, Geology of the Palo Alto Creek quadrangle, Gillespie County, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 8.

_______1952e, Geology of the Bear Creek quadrangle, Gillespie, Kerr, and Kendall Counties, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 12.

_______1952f, Geology of the Cain City quadrangle, Gillespie and Kendall Counties, Texas: Univ. Texas Bur. Econ. Geology Quadrangle Map No. 13.

_______1956, Resume of geology of eastern Llano uplift and road logs for first part of San Angelo Geological Society field trip, in San Angelo Geol. Soc. Guidebook, Four Provinces Field Trip, March 16-17, 1956: part I, p. 1-32.

Barnes, V. E., Cloud, P. E., Jr., Dixon, L. P., Folk, R. L., Jonas, E. C., Palmer, A. R., and Tynan, E. J., 1959, Stratigraphy of the pre-Simpson Paleozoic subsurface rocks of Texas and southeast New Mexico: Univ. Texas Pub. 5924, 836 p.

Cloud, P. E., Jr., and Barnes, V. E., 1946, The Ellenburger Group of central Texas: Univ. Texas pub. 4621, 473 p. [1948].

Long, A. T., 1962, Ground-Water Geology of Edwards County, Texas: Texas Water Commission Bull. 6208, 123 p.

Maxey, K. F., 1950, Report on the relation of nitrate concentrations in well waters to the occurrence of methemoglobinemia: Natl. Research Council, Bull. Sanitary Eng. and Environment, App. D., p. 265-271.

Mount, J. R., Rayner, F. A., Shamburger, V. M., Jr., and Peckham, R. C., 1962, Reconnaissance investigation of the ground-water resources of the Colorado River Basin, Texas: Texas Water Commission manuscript report [in files of Texas Water Commission prior to publication].

Sellards, E. H., 1930, Report on underground water conditions at Fredericksburg: Univ. Texas Bur. Econ. Geology open-file report [available at Austin, Texas], 5 p.

Shields, Elgean, 1937, Records of wells, drillers' logs, and water analyses in Gillespie County, Texas: State Board Water Engineers, 51 p.

Sundstrom, R. W., Broadhurst, W. L., and Dwyer, B. C., 1949, Public water supplies in central and north-central Texas: U. S. Geol. Survey Water-Supply Paper 1069, 128 p.

Texas Board Water Engineers, 1960, Channel gain and loss investigations, Texas streams, 1918-1958: Texas Board Water Engineers Bull. 5807-D, 270 p.

U. S. Public Health Service, 1962, Drinking water standards: Federal Register, Mar. 6, p. 2152-2155.

Wilson, Druid, Keroher, G. C., and Hansen, B. E., 1959, Index to the geologic names of North America: U. S. Geol. Survey Bull. 1056-B, 622 p.

Table 1.--Stratigraphic units in the Fredericksburg area

System	Series or Group	Formation	Member	Maximum thickness (ft.)	Description of rocks	Water-bearing characteristics
Quaternary				25	Alluvial deposits along streams.	Deposits are generally neither sufficiently thick nor extensive to provide a reliable major source of water.
Cretaceous	Comanche Series	Edwards Limestone		215	Limestone, hard, cherty, with beds of dolomite and gypsum. Permeable water-bearing zones occur near the base of the formation.	Formations supply water to springs and small-capacity wells in northern part of area.
		Comanche Peak Limestone		30	Shaly nodular limestone, and dolomite.	
		Walnut Clay		5	Yellow clay, silty, calcareous.	No water supply.
		Shingle Hills	Glen Rose Limestone	150	Alternating layers of limestone, dolomite, sand, and clay. Thins and disappears to the northeast.	Yields small quantities of water to seepage areas along stream banks.
			Hensell Sand	300	Beds and lenses of red clay, silt, sand, and conglomerate; gray in upper part. Limestone beds occur in subsurface.	Furnishes water for most wells in area; yields of more than 100 gpm are uncommon.
Ordovician	Ellenburger Group	Gorman		400±	Varicolored, cherty, fine-grained dolomite, and dolomitic limestone.	Permeable zones supply more than 500 gpm to large-capacity wells in eastern part of area.
		Tanyard	Staendebach	200±	Cherty, fine- to coarse-grained dolomite.	
			Threadgill	300±	Non-cherty, very fine-grained limestone and fine- to coarse-grained dolomite.	
Cambrian		Wilberns	San Saba	400±	Cherty, fine- to coarse-grained gray dolomite.	Water-bearing properties unknown in Fredericksburg area.
			Point Peak	150±	Grayish-green shale and limestone.	No water supply.
			Morgan Creek Limestone	130	Glauconitic limestone.	Do.
			Welge Sandstone	25	Sandstone, medium- to fine-grained.	Probably furnishes water to one well used for livestock purposes.
		Riley	Lion Mountain Sandstone	60	Glauconitic, fine- to medium-grained sandstone, silt, shale, and limestone.	No water supply.
			Cap Mountain Limestone	600	Glauconitic limestone, with sandy layers which become more predominant toward base of member.	Do.
			Hickory Sandstone	300	Fine- to medium-grained sand and sandstone.	Yields about 200 gpm to large-capacity wells in northwestern part of area.
Precambrian Rocks					Igneous and metamorphic rocks.	No water supply.

Table 2.--Records of wells and springs in the Fredericksburg area

Altitude of land surface: Altitudes determined from topographic sheet denoted by ±; altitudes determined by altimeter given in feet; altitudes determined by field surveying given in feet and tenths.
Method of lift and type of power: T, turbine; C, cylinder; S, submersible; J, jet; E, electric; G, gasoline; W, wind; N, none.
Use of water : D, domestic; S, stock; Irr, irrigation; P, public supply; N, none.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*57-41-101	--	--	--	--	--	--	Edwards	1,940	Flows	--	(Spring)	N	Estimated flow, 10 gpm.
57-41-201	Alvin Moellering	--	--	120	36 10	100 120	do	--	100+ (rept.)	--	C,W	D,S	Weak supply.
57-41-202	--	--	--	--	5 1/2	--	--	2,110	104	2/24/61	C,W	S	
*57-41-203	Fred Mathiesen	--	--	--	--	--	Edwards	2,000±	Flows	--	(Spring)	D,S, Irr	Estimated flow, 5 gpm.
*57-41-301	City of Fredericksburg	Ed Rips Fred E. Burkett	1948 1962	500	16 10	254	Hickory	1,984.7	193.97 195.9	5/ 2/62 11/ 8/62	S,E	P	City of Fredericksburg's Stehling No. 2 well; drilled as oil test in 1948; purchased by city and reamed to larger diameter. Casing vertically slotted 218-332 ft.; gravel envelope. Pump; 8-in., 14-stage, set at 300 ft. Motor, 30-hp. Top of water-bearing zone, 265± ft. See Table 11 for pumping-test data. See Table 4 for descriptions of cuttings. Cuttings transmitted to Well Sample Library, Bureau of Economic Geology, the University of Texas.
*57-41-302	Arthur Stehling	Lonnie Itz	1962	550	8	50	do	2,145.4	352.3	11/ 9/62	S,E	D,S	Motor, 10-hp. Pumping capacity 28 gpm, measured. See Table 4 for descriptions of cuttings.
57-41-303	do	Alvin Heimann	1962	295	12	3	Edwards	2,142.0	159.0	10/27/62	N	N	
*57-41-401	A. Hartman	Howard Cravens	1954	190	5 1/2	140	Hickory	1,874.6	60 (rept.)	1954 11/28/62	C,W	S	Hard rock at 140 ft.
*57-41-402	--	--	--	79	6	--	Hensell	1,819.2	31.0 27.50 28.78	2/19/36 2/24/61 12/13/62	N	N	Well No. 126 of Shields (1937).
57-41-601	Richard Stehling	--	--	49	36	--	do	1,853.4	36.5 33.11	2/28/36 2/23/61	C,W	D,S	Well No. 136 of Shields (1937).
*57-41-602	do	Douglas Clary	1956	175	10	175	do	1,835.1	19 (rept.)	1956	T,E	Irr	Used for supplemental irrigation. Motor, 3-hp. Pumping capacity 50 gpm, reported. Granite at 175 ft., reported.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing		Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
					Diameter (in.)	Depth (ft.)			Below land-surface datum (ft.)	Date of measurement			
57-41-603	Richard Stehling	Lonnie Itz	1961	250	8	187	Hensell	1,863.4	50.16	10/11/62	C,G	S	Granite at 187 ft.
*57-41-604	City of Fredericksburg	--Brandle	1955	257	8	--	Hickory	1,919.1	128.22	2/23/61	N	N	Location, 812.5 ft., N 44° E from well 57-41-301. City of Fredericksburg's Stehling No. 1 well. Casing slotted. Yielded 150 gpm with 80-ft. water-level drawdown after 24 hours of pumping. Top of water-bearing zone, 208 ft. See Table 5 for record of water-level measurements. See Table 11 for pumping-test data. Granite at 257 ft., reported.
57-41-606	Richard Stehling	--	1950	25	8	25	Hensell	--	6 (rept.)	1950	N	Irr	Water flows into sump excavated around casing. Casing slotted.
57-41-607	Alfred Crenwelge	Howard Cravens	1957	130	6	130	do	1,820	40 (rept.)	1957	T,E	Irr	Casing slotted 85-130 ft. Motor, 3-hp. Pumping capacity 35 gpm, measured. Pumps continuously. Reported yielded 80 gpm with 86-ft. water-level drawdown after 36 hours of pumping.
57-41-608	do	do	1954	365	5 1/2	235	do	1,790	45 (rept.)	1954	J,E	D,S	Reported yield, 140 gpm. Reported Precambrian rocks encountered below Hensell Sand Member.
57-41-701	A. O. Kneese	--	1890	180	5 1/2	180	do	1,877	174.0	1/24/63	C,E	D,S	Reported water level does not decline in drought.
57-41-801	do	--	1900	140	5 1/2	140	do	1,788	80.55	1/24/63	C,W	S	
*57-41-901	City of Fredericksburg	King Stokes	1956	400	8	247	do	1,762.0	90	3/ 3/62	T,E	N	City of Fredericksburg's Nat'l. Guard No. 1 well. Drilled to 400 ft., caved 275-400 ft. Pump; 6-in., 22-stage, set at 250 ft. Motor, 40-hp. Pumping capacity 200 gpm, reported. Electric log in files of Texas Water Commission.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*57-41-902	City of Fredericksburg	Texas Water Wells, Inc.	1957	397	26 10 3/4	100 105	Hensell	1,755.3	62 (rept.)	1/ /58	T,E	P	Location, 620.1 ft. N 78 1/4°E from well 57-41-901. City of Fredericksburg's Hennig No.1 well. Plugged at 279 ft. Screen setting, 105-275 ft. Motor, 10-hp. See Table 9 for pumping-test data. Electric log in files of Texas Water Commission. See Table 4 for descriptions of cuttings. Cuttings from depth interval 105-396 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-29,538.
57-41-903	City of Fredericksburg	Layne-Texas Co.	1959	426	8 5/8	165	do	1,756.6	76 (rept.)	4/17/59	N	N	Location, 218.6 ft. S 4°W from well 57-41-902. City of Fredericksburg's Basse no. 1 well. Plugged at 352 ft. See Table 5 for record of water-level measurements. See Table 9 for pumping-test data. Electric log in files of Texas Water Commission. See Table 4 for descriptions of cuttings. Cuttings from depth interval 0-406 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-29,578.
57-41-904	U. S. Army	Grobe	--	107	--	--	do	1,759.7	37.57	1/ 7/63	J,E	D	Supplies National Guard Armory.
57-41-905	City of Fredericksburg	Layne-Texas Co.	1958	394	--	--	do	1,755.2	--	--	--	--	Filled and abandoned. Location, 16 ft. E from well 57-41-902. City of Fredericksburg's Hennig no. 2 well. Electric log in files of Texas Water Commission.
57-41-906	Henry Basse	Layne-Texas Co. Milton Vater	1953	537 700	--	--	do	1,724.7	--	--	--	--	Filled and abandoned. City of Fredericksburg's no. 6 well. See Table 4 for descriptions of cuttings. Cuttings from depth interval 20-405 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-23,399.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*57-42-101	City of Fredericksburg	Frank Scharper	1953	316	7	--	Hickory	1,791.8	25 (rept.) 23.37 35.85	8/13/53 1/20/61 11/14/62	T,E	Irr, D,S	City of Ferdericksburg's Achtzehn no. 1 well. Pump; 6-in., 12-stage, set at 150 ft. Motor 10-hp. Pumping capacity 197 gpm, measured. Yielded 327 gpm with 100-ft. water-level drawdown after 3 hours of pumping. Main water-bearing zone 300-316 ft., reported. See Table 4 for descriptions of cuttings.
*57-42-102	Frederick Cross	do	1956	150	--	--	Hensell	1,873.7	60 (rept.)	1956	T,E	Irr	Motor, 7.5 hp. Pumping capacity 100± gpm, estimated. Granite at 150 ft., reported.
*57-42-103	Liston Manor	--	--	--	--	--	Comanche Peak	1,900±	Flows	--	(Spring)	Irr	
57-42-201	Andrew Fritz	Howard Cravens	1956	134	6	134	Hensell	--	24 (rept.)	1956	T,E	Irr	Pump; 4 5/8-in., 9-stage, set at 123 ft. Motor, 3-hp. Pumping capacity 55 gpm, measured.
*57-42-302	Texas State Highway Department	--	--	--	--	--	Edwards	1,890	Flows	--	(Spring)	S	Spring no. 339 of Shields (1937). Known as "Marshall Spring". Spring opening, originally on west side of highway, grouted in and tapped by 3/4-in. pipe to divert discharge to east side of highway. Measured flow 4 gpm, 2-20-36. Measured flow 2 gpm, 12-27-62. Flow reportedly never ceases.
*57-42-401	Werner Klein	Howard Cravens	1954	175	5 1/2	175	Hensell	1,826	125.0	12/ 2/60	J,E	D,S	
*57-42-402	Erwin Itz	--	--	49	60	--	do	1,713	42 40.99	4/11/36 1/30/61	C,E	D,S	Well no. 139 of Shields (1937).
*57-42-501	Perry Schumacher	Lonnie Itz	1961	120	7	120	do	1,708.2	36.6	11/14/62	T,E	Irr	Casing slotted 20-40 ft. and 60-120 ft. Pump; 6-in, 9-stage, set at 115 ft. Motor, 3-hp. Measured pumping capacity 60 gpm with 72-ft water-level drawdown after 10 min. of pumping.
*57-42-502	L. R. Segner	Wehmeyer	1957	265	6	75	Hickory	1,665.8	21 (rept.) 13.9	1959 12/20/62	J,E	D,S	Granite at 264 ft., reported.
*57-42-503	Arthur Grobe	Howard Cravens	1960	120	6	120	Hensell	1,692.1	23 (rept.)	1960	T,E	Irr	Motor, 3-hp. Pumping capacity 30 gpm, measured. Gravel 0-100 ft., and fine sand 100-120 ft., reported.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing		Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
					Diameter (in.)	Depth (ft.)			Below land-surface datum (ft.)	Date of measurement			
57-42-601	Otto Mangleberger	--	1870	60	36	--	Hensell	1,654	52.17	1/28/63	C,W	D,S	Well has never been deepened to furnish adequate supply of water.
57-42-602	do	Alvin Heimann	1960	154	5 1/2	154	do	1,719	145 (rept.)	1960	N	N	
57-42-701	Mrs. Richard Henke	Howard Cravens	1960	180	--	--	do	1,716.5	--	--	--	--	Filled and abandoned. Location 336 ft. SW from well 57-42-702. City of Fredericksburg's Henke no. 1 well. See Table 4 for descriptions of cuttings. Cuttings from depth interval 30-180 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-30,781.
57-42-702	City of Fredericksburg	do	1961	300+	8	150	do	1,725.0	42.5	1/27/61	N	N	City of Fredericksburg's Henke no. 2 well. See Table 5 for record of water-level measurements. Cuttings transmitted to Well Sample Library, Bureau of Economic Geology, The University of Texas.
*57-42-703	Felix H. Heimann	W. R. Bruison	1948	223	--	--	do	1,701.3	--	--	N	N	Filled and abandoned. City of Fredericksburg's no. 5 well ("Lochte Storage Well"). Yielded 100 gpm., reported. See Table 4 for descriptions of cuttings. Cuttings from depth interval 0-223 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-19,148.
*57-42-704	Evers Ice and Storage Co.	Charles Leyendecker	1919	211	8	211	do	1,692	24.2 20.74	2/13/36 10/30/62	C,E	N	Well no. 164 of Shields (1937). Casing perforated 111-211 ft. Formerly used for condenser cooling and for cleaning.
*57-42-705	Mrs. Frank Grothe	Howard Cravens	1954	106	5 1/2	106	do	--	38 (rept.)	1954	J,E	D	
*57-42-711	Fredericksburg Public School	-- Leyendecker	--	418	6	--	do	1,718	32.8	2/14/36	N	N	Filled and abandoned. Well no. 161 of Shields (1937). Formerly owned by Louis Kott. Granite at 168 ft. (Sellards, 1930).
57-42-713	--	--	--	60+	5 1/2	--	do	1,728.6	37.6	12/28/62	C,W	S	

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
57-42-901	Mrs. Joel Taylor	--	1919	180	--	--	Hensell	1,618	68.90	1/28/63	C,W	D,S	
57-49-101	Herman Usener	B. L. Raborn	--	632	--	--	--	1,809.0	--	--	N	N	Oil test. Filled and abandoned. See Table 4 for descriptions of cuttings. Cuttings from depth interval 30-630 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-17,461.
*57-49-102	T. A. Immel	--	--	80	5 1/2	--	Hensell	--	30 (rept.)	--	T,E	Irr	Motor, 5-hp. Pumping capacity 100± gpm, estimated.
*57-49-103	do	Howard Cravens	1957	115	6	115	do	--	--	--	T,E	Irr	Pumping capacity 50 gpm, estimated.
57-49-104	do	--	--	--	--	--	do	1,698.2	32.6	11/13/62	C,W	S	
*57-49-201	Ben Hagel	Milton Vater	1956	537	8	180	Ellenburger(?)	1,651.0	40 (rept.)	1956	T,E	Irr	Measured pumping rate 80 gpm. Motor, 7-1/2 hp.
*57-49-301	August Apelt	A and B Kothman	1929	800±	12	--	Ellenburger	1,645.5	55.4	11/26/62	C,E	D,S	Drilled as oil test--no. 1 F. W. Arhelger (formerly no. 1 Becker). Reported plugged at 550 ft. Yield greater than 200 gpm reported. See Table 4 for descriptions of cuttings. Cuttings from depths 200, 250, and 580 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. 31.
*57-49-302	Gilbert Maurer	Howard Cravens; Antlers Drilling Co.	1955	1,250	10	200	Welge(?)	1,711.6	64.09 63.28 64.34	1/30/61 5/ 3/62 10/27/62	C,W	S	City of Fredericksburg's Wallendorf no. 1 well. Yielded 60 gpm with 285-ft. water-level drawdown after 8 hours of pumping. See Table 4 for descriptions of cuttings. Cuttings from depth interval 45-1,250 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no's. R-26,485 and R-30,784.
57-49-303	Felix Boos	--	1929	151	8	--	Hensell	1,655.8	16.1	11/27/62	C,W	N	See Table 4 for descriptions of of cuttings. Cuttings from depth interval 130-151 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. 1756.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*57-49-304	Felix Boos	Werner Wehmeymer	1958	214	6	214	Hensell	1,638.5	45 (rept.) 51.05	1958 11/27/62	J,E	D,S	Bottom of well in hard, white rock.
*57-49-305	Gilbert Maurer	--	--	--	--	--	do	--	--	--	J,E	D,S	
*57-50-101	City of Fredericksburg	Layne-Texas Co.	1939	260	15 12	40 96	Ellen-burger	1,582.4	--	--	T,E	P	City of Fredericksburg's well no. 3. Pump; 10-in., 5-stage, set at 120 ft. Motor 40-hp. See Table 10 for pumping-test data. See Table 4 for description of cuttings.
*57-50-102	do	do	1944	240	16 12 3/4	40 99	do	1,582.4	45.7 44.27	11/ 8/44 4/17/46	T,E	P	Location, 16.5 ft. north from well 57-50-101. City of Fredericksburg's well no. 3. Pump; 10-in., 7-stage, set at 120 ft. Motor, 40 hp. See Table 5 for record of water-level measurements. See Table 10 for pumping-test data. See Table 4 for descriptions of cuttings.
*57-50-103	do	do	1935	39	40 8	39 --	Hensell	1,583.0	28 (rept.) 28.41	1935 1/21/63	N	N	Location, 16.5 ft. SW from well 57-50-102. City of Fredericksburg's well no. 2. Well no. 236 of Shields (1937). Formerly used for public supply.
*57-50-104	Charles Boerner	do do	1935 1939	80 210	40 16	20 79	Hensell and Ellen-burger	1,580.6	20 (rept.) 42 (rept.) 31.1	6/10/35 4/ 4/39 11/27/62	T,E	Irr	Location, 560 ft. N45°W from well 57-50-102. City of Fredericksburg's well no. 1. Well no. 237 of Shields (1937). Screen settings; 28-33 ft., 69-79 ft. Drilled to 80 ft. in 1935; yielded 72 gpm with 49-ft. water-level drawdown after an un-specified pumping period. Drilled to 210 ft. in 1939; interval 124-210 ft. yielded 145 gpm with 23-ft. water-level drawdown after 25 minutes of pumping. Pump; 8-in., 8-stage, set at 49 ft. Motor, 7 1/2-hp. Pumping capacity 86 gpm. Not used since 1959. See Table 4 for descriptions of cuttings.

* See footnote at end of table.

Table 2.--Records of wells and springs in the Fredericksburg area--Continued

Well	Owner	Driller	Date com-plet-	Depth of well (ft.)	Casing		Water-bearing unit	Altitude of land surface (ft.)	Water level		Method of lift	Use of water	Remarks
					Diam-eter (in.)	Depth (ft.)			Below land-surface datum (ft.)	Date of measure-ment			
57-50-201	Henry Mogford Est.	E. L. Nixon	1935	1,100	8	150±	Ellen-burger	1,597.7	68.32	10/25/62	C,E	N	Drilled as oil test. See Table 4 for descriptions of cuttings. Cuttings from depth interval 65-611 ft. filed at Well Sample Library, Bureau of Economic Geology, The University of Texas, catalog no. R-19,263.
*57-50-301	Hilmar Weinheimer	--	--	61	48	--	Hensell	1,561.4	52.5 45.98 46.92	4/ 7/36 2/ 3/61 12/19/62	N	N	Well no. 373 of Shields (1937) Reported to have failed in droughts.
*57-50-302	do	Howard Cravens	1959	146	10	--	Ellen-burger	1,543.9	40 (rept.) 34.72 34.40	1959 10/16/62 1/ 9/63	T,E	Irr	Pump setting, 120 ft. Motor, 15-hp. Pumping capacity, 200 gpm, estimated.
*57-50-303	do	do	1956	163	10	--	do	--	12 (rept.)	1956	T,E	Irr	Motor, 5-hp. Pumping capacity, 57 gpm, measured. Pumps continuously.
57-50-304	do	do	1959	268	8	--	do	1,561.1	49.40	12/19/62	S,E	D	Reported yield, 60 gpm.

* See Table 3 for chemical analysis of the water.

Table 3.--Chemical analyses of water from wells and springs in the Fredericksburg area

(Analyses are in parts per million except specific conductance and pH)

Analyses by Texas State Department of Health except where indicated as follows: (*) United States Geological Survey, (†) Works Progress Administration, and (‡) Microbiology Service Laboratories, Houston, Texas.

Well or spring	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)		Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids (Sum)	Total Hardness as $CaCO_3$	Specific Conductance (Micromhos at 25°C.)	pH
57-41-101	--	--	3-27-63	13	--	66	36	12	--	361	10	22	0.4	<0.4	520	314	601	8.1
57-41-203	Fred Mathiesen	--	do	14	--	75	28	18	--	336	12	33	.2	7	523	303	633	7.4
57-41-301	City of Fredericksburg	500	8- 2-62	--	1.82	72	30	7	--	332	34	10	.2	< .4	--	303	565	7.5
Do.	do	500	1-30-63	12	--	65	27	7	--	295	30	11	.2	< .4	447	273	530	7.9
57-41-302	Arthur Stehling	550	11- 9-62	14	--	56	34	8	--	305	38	10	.4	2.4	468	281	504	7.6
57-41-401	A. Hartmann	190	11-27-62	19	1.25	74	63	46		444	44	54	1.2	74.5	821	443	986	7.4
†57-41-402	--	79	2-19-36	--	--	52	52	4		366	26	19	--	--	--	346	--	--
57-41-602	Richard Stehling	175	11- 9-62	14	--	57	49	16	--	365	24	33	.6	27.0	586	344	616	7.6
57-41-604	City of Fredericksburg	257	10-27-61	--	.34	76	26	8	--	321	31	12	.1	.9	--	300	578	7.2
57-41-901	do	400	5-25-56	--	.58	58	42	19	--	384	25	28	.5	2.7	--	320	--	7.8
*57-41-901	do	400	12- 1-60	12	--	62	39	18		342	20	34	.3	3.8	531	315	657	7.0
‡57-41-902	do	397	1-17-58	9	.26	88	45	21		356	18	100	--	--	--	405	860	6.9
57-41-902	do	397	4- 9-58	--	.80	78	43	18	--	381	20	61	.6	5.8	--	375	720	7.4
57-42-101	do	316	10-23-62	13	--	75	37	8	--	336	58	16	.1	< .4	543	343	617	7.4
57-42-102	Frederick Cross	150	11-14-62	18	--	119	66	36	--	423	63	113	.2	114.5	953	565	1,086	7.1
57-42-103	Liston Manor	--	do	12	.02	85	43	9	--	443	16	13	.1	17.5	639	388	719	7.6
†57-42-302	Texas Highway Department	--	2-20-36	--	--	--	--	--	--	207	<10	30	--	--	--	--	--	--
57-42-302	do	--	12-27-62	12	--	88	41	8	--	436	28	20	.1	8.0	641	390	730	7.4
*57-42-401	Werner Klein	175	12- 2-60	16	--	65	39	13		378	11	18	.5	2.8	543	322	633	7.0
†57-42-402	Erwin Itz	49	4-11-36	--	--	82	44	40		390	20	92	--	--	--	384	--	--
*57-42-402	do	49	6-12-61	23	--	111	40	65		408	45	94	.4	84.0	870	442	1,100	6.8
57-42-501	Perry Schumacher	120	11-14-62	32	.96	71	119	124	--	709	75	191	.8	18.5	1,341	664	1,520	7.4
57-42-502	L. R. Segner	265	11-27-62	14	.04	76	30	9	--	345	11	29	.2	2.2	516	311	620	7.3
57-42-503	Arthur Grobe	120	11-14-62	18	.66	66	40	13	--	389	10	22	.2	4.2	563	330	595	7.4
57-42-703	Felix Heimann	223	10- 7-48	80	7.0	64	42	54		409	29	60	.7	1.8	748	332	--	7.8
†57-42-704	Evers Ice and Storage Co.	211	2-13-36	--	--	12	72	65		256	16	174	--	--	--	329	--	--

Table 3.--Chemical analyses of water from wells and springs in the Fredericksburg area--Continued

Well or spring	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)		Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids (Sum)	Total Hardness as $CaCO_3$	Specific Conductance (Micromhos at 25°C.)	pH
57-42-704	Evers Ice and Storage Co.	211	7-31-50	23	1.20	117	79	160		464	84	334	0.5	31.0	1,294	617	--	7.2
57-42-705	Mrs. Frank Grothe	106	3-26-54	33	.05	69	46	152		519	57	124	1.1	38.0	1,039	366	--	7.2
Do.	do	106	11-27-62	54	.16	48	51	86	--	506	25	47	1.2	17.0	835	329	926	7.7
†57-42-711	Fredericksburg Public School	418	2-14-36	--	--	8	65	47		232	< 10	142	--	--	--	288	--	--
57-49-102	T. A. Immel	80	11-13-62	19	--	94	48	48	--	412	31	110	.2	10.5	773	431	906	7.2
57-49-103	do	115	do	23	--	146	58	196	--	426	104	378	.2	39.5	1,371	603	1,690	7.2
57-49-201	Ben Hagel	537	11- 7-62	18	--	72	37	45	--	353	33	82	.6	< .4	641	332	752	7.4
57-49-301	August Apelt	800±	9-29-54	22	.4	54	40	52		372	35	50	.9	< .4	626	299	--	7.5
do	do	800±	11-26-62	14	--	56	42	30	--	366	25	47	.9	< .4	581	312	710	7.4
57-49-302	Gilbert Maurer	1,250	10-27-62	12	--	52	44	59	--	354	43	80	1.1	< .4	645	310	814	7.6
57-49-304	Felix Boos	214	11-27-62	20	.27	80	66	45	--	398	47	132	.7	19.0	808	470	1,095	7.4
57-49-305	Gilbert Maurer	--	do	37	--	70	19	78		303	46	88	.2	19.5	661	252	828	7.5
*57-50-101	City of Fredericksburg	260	5-17-46	17	2.3	121	55	66	10	412	53	192	.0	25.0	953	528	--	7.0
57-50-101	do	260	9-18-50	12	.1	84	49	46		348	44	124	.4	6.0	714	411	--	7.7
do	do	260	11-18-52	18	.04	71	43	55		348	39	99	.5	8.0	682	354	--	8.0
do	do	260	3-27-54	18	.24	78	45	57		348	44	114	.5	13.0	718	380	--	7.6
*57-50-101	do	260	8-15-60	16	--	78	42	49		354	35	96	.4	13.0	683	367	901	6.8
57-50-102	do	240	8-20-47	17	.22	80	45	53		354	37	114	.3	14.0	715	385	--	7.7
do	do	240	9-18-50	14	.09	87	48	45		354	44	124	.4	8.0	724	420	--	7.7
do	do	240	7-13-51	17	.27	90	19	35		336	32	50	.1	4.0	583	303	--	7.7
do	do	240	8-20-51	18	.10	82	48	44		348	40	117	.3	7.0	704	402	--	7.6
do	do	240	11-18-52	20	.03	76	45	48		342	39	120	.4	11.0	701	375	--	7.8
do	do	240	3-27-54	19	.02	78	45	57		342	46	117	.4	13.0	717	380	--	7.8
57-50-103	do	39	1936	--	--	51	48	57		268	10	158	--	--	--	328	--	--
†57-50-103	do	39	5-19-39	14	.02	126	65	110		348	67	328	.4	5.3	1,064	583	--	7.3
*57-50-103	do	39	5-17-46	15	.12	96	47	32	7.4	357	36	120	.2	15.0	726	433	--	7.4
†57-50-104	Charles Boerner	210	3-27-36	--	--	--	--	--	--	195	210	250	--	--	--	--	--	--
57-50-104	do	210	5-19-39	20	.08	133	56	109		378	56	305	< .4	< .4	1,057	563	--	7.3
*57-50-104	do	210	5-17-46	14	.88	92	47	35	7.8	358	36	117	.4	14.0	722	423	--	7.7
57-50-104	do	210	7-29-50	14	.08	79	45	58		354	41	124	.3	5.0	720	382	--	7.6
†57-50-301	Hilmar Weinheimer	61	4- 7-36	--	--	--	--	--	--	232	74	500	--	--	--	--	--	--
57-50-302	do	146	11-16-62	19	.22	77	37	46	--	365	35	74	.2	11.0	664	344	758	7.3
57-50-303	do	163	11-15-62	20	.02	105	51	98	--	437	66	178	.2	17.0	972	468	1,135	7.1

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area

Description	Depth (feet)
Well 57-41-301	
Cuttings described by driller, Fred E. Burkett of San Antonio*	
Rock	0-3
Blank (20-in. bit did not touch)	3-17
Rock, water trickling in at 60 feet	17-60
Rock	60-95
Marl	95-112
Rock	112-118
Marl	118-120
Rock	120-121
Marl	121-124
Rocky marl	124-138
Solid rock	138-147
Red clay and sand	147-150
Rock	150-153
Red clay	153-155
Rock	155-157
Blank (20-in. bit did not touch)	157-160
Blue marl	160-165
Rock	165-169
Marl	169-181
Very hard rock	181-220
Rock and red clay	220-235

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-41-301--Continued	
Rocky, sandy red clay	235-240
Sandstone	240-243
Hard rock and sandstone	243-253
Hard rock	253-254
Rock	254-262
Blank (15-in. bit did not touch)	262-267
Sand	267-283
Abrasive white and brown sandstone	283-295
Reddish sandstone, very abrasive	295-301
Pink sand and sandstone	301-319
Yellow sand and sandstone	319-320
Red sandstone (like granite)	320-325
Conglomerate of sandstone, sand, and granite	325-330
Granite, pink	330-359
Granite, grey, solid	359-400

* Cuttings were obtained while drilling an existing hole to a larger diameter. Fragments of glauconitic limestone in the cuttings dump near the well were found by personnel of the Texas Water Commission.

Well 57-41-302

Cuttings* described by Driller, Lonnie Itz, Willow City.

Limestone	0-200
Yellow and light red sand and sandstone; good drilling.	200-400
Red clay	400-405

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-41-302--Continued	
Sandstone, fine, hard in upper part	405-520
Red granite	520-550

* Fragments of glauconitic limestone in the cuttings dump near the well were found by personnel of the Texas Water Commission.

Well 57-41-902

Cuttings described by driller, Texas Water Wells, Inc.

Rotary table to ground	0-3
Surface clay	3-9
Red clay and caliche	9-30
Sand and fine gravel	30-55
Red clay and sand	55-105
Sand streaks and rock	105-115
Soft rock streaks and red clay	115-164
Hard rock	164-183
Hard sand	183-251
Sand streaks and shale	251-295
Shale and hard rock	295-394
Very hard rock	394-397

Well 57-41-902

Cuttings described by personnel of the Texas Water Commission.

Sand, clean pink, medium-grained, well-rounded; large (2 millimeters) fragments of gray fine-grained limestone; and scattered lumps of red clay	105-115

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-41-902--Continued	
Limestone, gray, fine-grained; and lumps of silt and clay	115-135
Limestone, gray, fine-grained; and sand, coarse, well-rounded	135-183
Sand, clean, fine, white	183-199
Sand, fine to medium, well-rounded; and lumps of red clay	200-220
Sand, quartz, coarse, clean; and scattered grains of pink feldspar	220-240
Siltstone and shale, red; and sand, fine to coarse	240-257
Schist, red, micaceous (precambrian rock)	257-276

Well 57-41-903

Cuttings described by driller, Layne-Texas Co.

Surface soil	0-3
Red clay	3-23
Sandy clay	23-48
Sand	48-59
Hard lime and clay	59-146
Hard lime and sandstone	146-166
Hard sand	166-241
Hard shale (black)	241-286
Hard shale (black)	286-316
Hard shale (blue)	316-333
Hard shale (blue)	333-390
Hard shale (blue)	390-426

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-41-903	
Cuttings described by personnel of the Texas Water Commission.	
Sand, fine; and schist	240-260
Schist (precambrian rock)	260-280
Well 57-41-906	
Cuttings described by personnel of the Texas Water Commission.	
Sand, coarse; and silt and clay.	20-25
Clay, red, silty	25-65
Limestone, gray, fine-grained	65-85
Limestone, gray, fine-grained; and sand, silt, and clay	85-95
Sand, medium to coarse; and red clay	95-105
Pebbles (5-10 millimeters) of rounded quartz and angular feldspar	105-115
Sand, medium to fine; and clay	115-125
Silty red clay, and medium-grained sand	125-135
Gray silty clay	135-145
Coarse conglomeratic sand composed of rounded grains of quartz and feldspar	145-155
Conglomerate of quartz, feldspar, and glauconitic limestone	155-165
Coarse conglomeratic sand, and clay	165-175
Sand, medium, well-rounded; and red clay	175-185
Conglomerate of quartz, feldspar, and diorite	185-205
Diorite (precambrian rock)	205-215

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 47-42-101	
Cuttings described by William Rossman, Fredericksburg.	
Rock	65-75
Clay, brown, blue, and yellow	75-125
Sand, white	125-300
Well 57-42-701	
Cuttings described by personnel of the Texas Water Commission.	
Sand, coarse; and red and gray clay	30-40
Conglomerate and sand; pebbles and fragments of quartz and feldspar as large as 5 millimeters	40-50
Red, sandy clay	50-60
Conglomerate and sand; pebbles of quartz, feldspar, and limestone	60-70
Sand, well-sorted, coarse, predominantly feldspar	70-100
Sand, coarse, composed of quartz and feldspar; and red clay	100-120
Sand, fine-to medium-grained; and red clay	120-140
Sand composed of coarse angular fragments of weathered feldspar	140-160
Diorite (precambrian rock)	180
Well 57-42-703	
Cuttings described by driller, W. R. Bruison.	
Red clay and gravel	0-17
Sand	17-24
Red clay	24-31
Red beds, gravel	31-48

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-42-703--Continued	
Sandstone	48-53
Sandstone	53-60
Sandstone	60-70
Sandstone	70-85
Sandstone	85-100
Limestone	100-110
Limestone	110-120
Red sandstone	120-128
Red sandstone	128-135
Red sandstone	135-138
Red sand, limestone	138-140
Red clay, limestone	140-145
Limestone, red	145-150
Limestone	150-155
Limestone and clay	155-160
Limestone	160-167
Limestone, yellow	167-170
Limestone	170-180
Limestone, yellow	180-182
Yellow limestone	182-185
Yellow limestone	185-190
Brown sand, lime	190-195

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-42-703--Continued	
Brown sand, lime	195-200
Brown sand, lime	200-205
Brown sand, lime	205-212
Brown sand, lime	212-216
Brown sand, lime	216-220

Well 47-42-703

Cuttings described by personnel of the U. S. Geological Survey.

(Sample no.)	
1 Red (iron stained) sandy clay with caliche (20%) and large subangular subrounded sand grains. Some large angular feldspar fragments noted. Unsorted sand.	0-17
2 Sand--Large angular grains with some red clay binder lighter in color than the preceding sample. Small amount of caliche present. Coarseness, angularity and lack of sorting, chemical or mechanical, very noticeable.	17-24
3 Sand--Lighter in color than preceding sample and with less clay binder but otherwise very similar.	24-31
4 Sand and gravel--Small amount of clay. Sample completely unsorted with angular fragments of sand and gravel size. No sorting evident - fragments include mineral and rock samples. Some caliche fragments present. Twenty-five percent gravel.	-
5 Sand and gravel. Less gravel than No. 4 and more fine sand. Less ferruginous cement.	-
6 Sand and gravel. Lighter in color and more uniform size. Larger fragments lacking but smaller gravel size more numerous. Some angular limestone(?) fragments noted. Fragments very angular and completely unsorted chemically.	-48

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

	Description	Depth (feet)
	Well 47-42-703--Continued	
7	Ferruginous sandstone. Angular, unsorted sand with ferruginous cement. Light reddish brown color.	48-53
8	Sandstone--Slight decrease in overall size of grains. Otherwise similar to No. 7.	53-60
9	Sandstone--Lighter in color and higher percent ferruginous cement. Some white limestone(?) fragments noted.	60-70
10	Sand--Buff; unsorted, angular sand with some (15%) gravel. Lack of cement or binder and freshness and angularity of grains noted. A very small amount of binder present.	70-85
11	Sandstone--Reddish brown ferruginous sandstone similar to sample number 8 with less gravel size fragments.	85-100
12	Limestone--Light grayish brown to buff. Hard, angular chips in cuttings.	100-110
13	Sandstone--Light brown unsorted sand and gravel. Angular fragments with some ferruginous cement.	110-120
14	Sandstone--Same as sample number 13 only less gravel size fragments.	120-128
15	Sandstone--Light tan unsorted sand and gravel. Smaller sand sizes lacking and grains more nearly uniform than in any previous sample. Some slight rounding noted. Calcareous binder.	128-135
16	Sandstone--Light tan unsorted sand. Few fragments of gravel size, much fine material. Angular grains--Calcareous binder.	135-138
17	Wash(?)--Mixture of unsorted sand and large angular limestone fragments with a ferruginous binder. Reddish brown in color.	138-140
18	Sandstone--Dark reddish brown unsorted angular sand with a ferruginous binder. No fragments of gravel size noted. Some angular limestone fragments present.	140-145

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 47-42-703--Continued	
19 Limestone--Light reddish brown. Some calcite crystals present.	145-150
20 Limestone--Buff, crystalline limestone. Some intermixed sand probably from up the hole.	150-155
21 Wash--Intermixed reddish brown angular, unsorted sand and angular light gray limestone fragments. Sand with ferruginous binder.	155-160
22 Wash--Intermixed sand and dark gray angular limestone fragments. Sand with some calcareous binder and composed of angular, unsorted grains.	160-167
23 Limestone--Light gray noncrystalline limestone, hard, occurring in small angular chips.	167-170
24 Limestone--Buff noncrystalline limestone.	170-180
25 Limestone--As sample number 24.	180-182
26 Limestone--As sample number 24, more tan color.	182-190
27 Limestone--As sample number 26, color becoming darker.	190-195
28 Sandstone--Dark reddish brown, unsorted, subangular to subrounded sand with ferruginous binder.	195-200
29 Sandstone--Same as sample number 28 becoming less reddish.	200-205
30 Sandstone--Greenish brown glauconitic sandstone with a ferruginous cement. Subangular to subrounded very fine to coarse sand. Some limestone.	205-208
31 Sandy limestone--Reddish brown sandy limestone with angular sand grains, and fresh feldspar fragments.	208-212
32 Sandstone--Greenish brown glauconitic sand with calcareous cement. Angular sand grains and fresh feldspars.	212-216
33 Sandstone--Same as sample number 32.	216-220
34 Granite--Angular granite fragments with preponderance of black minerals.	-

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-49-101	
Cuttings described by V. E. Barnes (1952e).*	
Sand--Coarse to fine, poorly sorted, mostly quartz but containing some microcline. The grains are well rounded to angular, most have rough surfaces, and some are stained reddish brown. A few cuttings present in the sample are composed of silt-sand mixtures cemented by calcium carbonate, which may be secondary.	30-45
Sand--Coarse to medium grained, poorly sorted, mostly quartz, some microcline, grains mostly angular, some well rounded, surfaces rough and mostly stained light brown.	120-125
Sand--Similar to that from 120 to 125 feet, except that microcline may be more abundant, and a few limestone cuttings that may be caliche cavings are present.	185-190
Caliche(?) and sand--Mostly caliche-like material containing silt and sand and grayish orange to light brown. The sand is similar to that from 120 to 125 feet.	245-250
Sand and caliche(?)--Sand is similar to that from 120 to 125 feet. The caliche-like material is highly silty, somewhat sandy, and mostly grayish pink.	270-275
Sand and sandstone--Sand is similar to that from 120 to 125 feet. The sandstone is fine grained, light gray, friable, glauconitic, silty, and argillaceous.	320-325
Clay and sand--Sample is a balled-up mass of pale red clay containing fine to very fine sand which in part is very well rounded. A few grains of glauconite are present.	335-340
Sand and sandstone--Sand in part is coarse-grained material from the Cretaceous and the rest is coarse-grained material from the Cambrian. The sandstone is very fine grained to fine grained, silty, and argillaceous. A few loose spheres are iron-oxide coated sand grains, some of which have a bronzy luster. All of the material in this sample ranges from moderate yellowish brown to dark yellowish brown.	365-370
Sand and sandstone--Sand is coarse grained, mostly from the Cretaceous with some from the Cambrian. The sandstone is medium grained, yellowish gray, poorly sorted, and white to yellowish gray.	390-395

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-49-101--Continued	
Sand and sandstone--The two are equally divided. The sand is mostly Cambrian but some is Cretaceous. The sandstone is similar to that from 390 to 395 feet.	415-420
Sand and sandstone--Similar to that from 415 to 420 feet except that mica is common in the sandstone.	420-425
Sand and sandstone--Mostly yellowish gray sand and only a small amount of sandstone.	425-430
Sand and sandstone--Similar to that from 425 to 430 feet except that some of the sandstone has a brownish tinge, and the sand contains considerable Cretaceous cavings.	435-440
Sand and sandstone--Considerable Cretaceous sand and the rest is is white to yellowish gray Cambrian sand. The sandstone forms a minor portion of the sample and is very fine grained, silty, micaceous, and grayish orange.	440-455
Sand--Mostly white to yellowish gray, coarse grained sand from the Cambrian but containing a variable percentage of pinkish Cretaceous sand. The sample from 560 to 570 feet contains some very fine grained moderate brown, micaceous sandstone (13 samples).	470-580
Sand--Coarse grained, white, poorly sorted, well rounded to angular, and mostly from the Cambrian (2 samples).	580-600
Sand--Similar to that from 580 to 600 feet except that it has a brownish tint.	600-615
Quartz and feldspar--Quartz is clear and angular. The feldspar is pale reddish brown microcline with kaolin present in recesses. Some green mica in the sample indicates that it is from a disintegrated granite.	620-625
Quartz, feldspar, and biotite--The overall color is moderate or orange pink. Both plagioclase and microcline are present, and the rock is probably Town Mountain granite.	630-632

* Barnes' interpretation of rock units and depths at which they occur are as follows: "Hensell sand, from surface to 300 feet; Hickory sandstone, 300 to 620 feet; and Town Mountain granite, 620 to 632 feet."

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)

Well 57-49-301

Cuttings described by V. E. Barnes (1953e)*.

Dolomite--Very fine grained to fine grained and pale yellowish brown.	200 and 250
Limestone and dolomite--Limestone is sublithographic and white to yellowish gray. The dolomite, subordinate in amount, is coarse grained and light gray. A few pieces of greenish gray shale in the sample are of unknown affinity.	550
Dolomite--Coarse grained and white to light yellowish gray.	580

* Barnes states, "the samples can be interpreted in the following three way ways, arranged in order of possibility:

	200 and 250 feet	550 and 580 feet
(1)	Staendebach Member	Threadgill Member
(2)	Gorman Member	Staendebach Member
(3)	Staendebach Member	Pedernales dolomite and San Saba limestone"

Well 57-49-302

Cuttings described by personnel of the Texas Water Commission.

Sand composed of quartz and feldspar, coarse	45-65
Sand, coarse, red clay and limestone	65-75
Limestone, white, fine-grained, sandy	75-95
Limestone, pink and white, fine-grained	95-105
Sand, coarse	115-135
Sandstone, hard, tan to brown, glauconitic, medium- to fine-grained, calcareous	135-165
Fine sand and clay, glauconite, and white glauconitic fine-gra grained limestone. (Base of Hensell Sand Member; top of Morgan Creek Limestone Member)	165-170
Limestone, gray, medium-grained, glauconitic, sandy	170-185

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-49-302--Continued	
Glauconitic silt and clay, calcareous	185-190
Limestone, white, glauconitic, fine-grained	195-200
Silt, glauconitic, calcareous	200-205
Limestone, medium- to coarse-grained, white, glauconitic	205-210
Limestone, fine- to medium-grained, gray, sandy, glauconitic	210-220
Limestone, brown and white, medium- to coarse-grained, glauconitic	220-235
Limestone, brown, coarse-grained, sandy, glauconitic	240-285
Sand, fine, glauconitic (Top of Welge Sandstone Member)	285-290
Sandstone, white, medium-grained, glauconitic, calcareous	290-295
Sand, quartzose, glauconitic, fine-grained, slightly calcareous	295-300
Sandstone, white, fine-grained, calcareous	300-308
Sandstone, medium-grained, rounded, tan, noncalcareous, glauconitic (Top of Lion Mountain Sandstone Member)	308-312
Sandstone, medium-grained, rounded, gray, well-cemented, calcareous, glauconitic	312-326
Highly glauconitic sand, medium-grained; and red, glauconitic, sandy clay	326-336
Glauconitic silt and clay, calcareous	336-356
Limestone, medium-grained, glauconitic (Top of Cap Mountain Limestone Member)	356-376
Limestone, fine-grained, white, slightly glauconitic	376-381
Gray shale, silty, glauconitic	381-396
Limestone, shaly, sparingly glauconitic	396-420

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-49-302--Continued	
Shale, gray, calcareous, sparingly glauconitic	420-430
Limestone, glauconitic, medium- to coarse-grained	430-480
Shale, silty, glauconitic	480-510
Limestone, medium- to coarse-grained, glauconitic	510-520
Shale, silty, glauconitic	520-550
Limestone, sparingly glauconitic	550-570
Shale, gray, glauconitic	570-590
Nonglauconitic gray limestone and shale	590-640
Limestone, medium-grained, gray, glauconitic, shaly in part	640-680
Fine sand, no glauconite	680-690
Nonglauconitic limestone	690-700
Siltstone, shaly, calcareous, slightly glauconitic	710-750
Sandstone, fine- to medium-grained, shaly, glauconitic in part, calcareous	750-830
Limestone, sandy, glauconitic	830-840
Sand, fine-grained, glauconitic	840-870
Clay, silty, glauconitic	870-880
Limestone, silty, argillaceous, glauconitic	880-890
Sand, fine-grained, glauconitic, limonitic in upper part	890-930
Sandstone, fine-grained, glauconitic, shaly, calcareous	930-940
Sand, medium-grained, rounded, quartzose, sparingly glauconitic, noncalcareous (Top of Hickory Sandstone Member)	940-950
Sand, fine, white, glauconitic, noncalcareous	950-960

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-49-302--Continued	
Sand, medium-grained, hematite-stained, noncalcareous, nonglauconitic	960-970
Sand and sandstone, fine- to medium-grained, nonglauconitic, partly limonitic	970-1,210
Sandstone, tan, fine-grained, angular	1,210-1,240
Granite (precambrian rock)	1,240-1,250

Well 57-49-303

Cuttings described by driller (Sellards, 1937, p. 4).

Soil	0-2
Pack sand	2-13
Sandy red clay	13-25
Water sand	25-30
Red clay	100
Gravel, dry	110
Red clay with boulders	130
Little water show	135
Hard white rock	130-151

Well 57-49-303

Cuttings described by personnel of the Texas Water Commission.

Mixture of coarse sand, red clay and silt, chert, and dolomite. The chert has the appearance of white unglazed china. The dolomite is of various colors, ranging from white to tan to light green; texture is medium-grained; scattered pinpoint porosity is faintly visible; dolomite rhombs are not clearly distinguishable. (Probably Ellenburger Group)	130-151

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-50-101	
Cuttings described by driller, Layne-Texas Co.	
Soil and gravel	0-6
Sand	6-18
Gravel	18-39
Red clay	39-65
Red clay	65-70
Red clay	70-85
Boulder and gravel	85-90
Hard lime rock	90-96
Gray lime	96-100
Yellow lime	100-110
Gray lime	110-127
Yellow lime	127-155
Pink rock	155-185
Gray lime	185-188
Yellow lime	188-235
Gray lime	235-239
Pink lime rock	239-255
Honeycomb rock	255-260
Well 57-50-102	
Cuttings described by driller, Layne-Texas Co.	
Surface soil	0-6

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-50-102--Continued	
Sand	6-18
Gravel	18-40
Red clay	40-84
Boulders and gravel	84-90
Hard yellow lime	90-93
Yellow and gray lime	93-102
Gray lime	102-127
Yellow lime	127-157
Pink rock	157-175
Gray lime	175-183
Yellow lime	183-230
Gray lime	230-235
Pink rock	235-236
Crevice	236-240
Well 57-50-104	
Cuttings described by driller, Layne-Texas Co.	
Soil	0-3
Clay	3-22
Sand and gravel	22-33
Red clay	33-44
Muddy sand	44-47
Rock	47-48

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-50-104--Continued	
Clay with streaks of sand	48-67
Coarse sand (muddy)	67-79
Rock	79-80
Gravel making	80-85
Lime making	85-92
Yellow lime making	92-120
Yellow rock making	120-138
Gray and yellow rock making	138-157
Yellow rock	157-162
Blue rock	162-170
Yellow and blue lime	170-175
Gray and yellow lime	175-180
Yellow sand rock	180-205
Blue rock	205-210
Well 57-50-201	
Cuttings described by V. E. Barnes (1952f).*	
Sand--Composed of coarse-grained quartz and containing microcline fragments up to half an inch in size	65
Sand--Medium to coarse and admixed with some red clay	75
Sand--Medium to coarse. Caliche present probably as cavings	85
Sand--Medium to coarse and some pebbles. Caliche present probably as cavings	95

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Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-50-201--Continued	
Sand, glauconitic limestone, and sandy limestone--conglomerate(?)	102-116
Sand, chert, and conglomerate	121
Sand--Medium to coarse, with much chert and considerable yellow clay	129
Sand--Medium to coarse and considerable chert	132
Dolomite--Fine grained and light gray, some sand	133
Dolomite--Fine grained to very fine grained and microgranular, and pink with some chips near white. Some limestone	133-140
Dolomite--Microgranular and beige	140-145
Dolomite--Microgranular, rose, beige, and other colors. Rare chips contain fine-grained sand	145-150
Dolomite--Fine grained, light to medium gray and red	160-162
Dolomite--Fine grained	170-174
Dolomite--Medium to fine grained, some microgranular, and white to beige	174-179
Dolomite--Microgranular, some medium grained	179-181
Dolomite--Coarse grained, light gray, and chert subgranular to porcellaneous	290-320
Dolomite--Fine to medium grained, light gray, and chert subgranular to porcellaneous ranging from dolomoldic to interstitial	330-340
Chert--Porcellaneous to subgranular, white, and with some quartz and fine- to medium-grained dolomite	340-350
Dolomite--Fine grained, light gray, and chert scarce	360-370
Dolomite--Very fine grained to fine grained	370-385

(Continued on next page)

Table 4.--Descriptions of cuttings from wells in the Fredericksburg area--Continued

Description	Depth (feet)
Well 57-50-201--Continued	
Dolomite--Medium grained and with very abundant chert porcellaneous to subgranular and quartzose and ranging from dolomoldic to interstitial	380-390
Sand (cavings)	592
Dolomite--Very fine grained to microgranular and greenish gray	594
Dolomite--Very fine grained and greenish gray	596
Dolomite--Very fine grained and medium gray	610-611

* Samples were not submitted for several depth intervals, but according to Barnes, rock units represented by samples from this well are interpreted as follows: Hensell Sand Member, surface to 133 ft.; dolomitic facies of the Gorman Formation, 133-181 ft.; dolomitic facies of the Staendebach Member, 290-390 ft.; dolomitic facies of the Staendebach Member or upper part of Threadgill Member, 594-611 ft.

Table 5.--Depths to water in selected wells in the Fredericksburg area

(Depths in feet below land-surface datum)

Well 57-41-604[a]

Date	Depth to water	Date	Depth to water	Date	Depth to water
Feb. 23, 1961	128.22	July 28, 1962	[b] 157.5	Oct. 11, 1962	129.23
May 2, 1962	129.84	July 30, 1962	131.9	Oct. 30, 1962	130.84
May 19, 1962	128.8	Aug. 18, 1962	129.4	Nov. 8, 1962	129.9
June 2, 1962	128.7	Sept. 1, 1962	129.0	Dec. 14, 1962	129.42
June 16, 1962	128.6	Sept. 15, 1962	129.5	Dec. 28, 1962	129.20
June 30, 1962	128.8	Sept. 29, 1962	129.3	Jan. 17, 1963	129.16
July 14, 1962	128.9				

[a] Measurements for January 26 through February 1, 1963, are given in Table 11.
[b] Nearby well 57-41-301 had been pumping for 24 hours at time of measurement.

Well 57-41-903[a]

Date	Depth to water	Date	Depth to water	Date	Depth to water
April 17, 1959	[b] 75	July 14, 1962	[c] [d] 144.5	Sept. 29, 1962	[c] 114.7
June 22, 1961	[c] [d] 149.65	July 28, 1962	[c] [d] 148.0	Dec. 14, 1962	[d] 142.22
May 19, 1962	[c] [d] 154.1	Aug. 18, 1962	[c] [d] 149.2	Dec. 28, 1962	[d] 143.87
June 2, 1962	[d] 140.7	Sept. 1, 1962	[c] [d] 149.1	Jan. 17, 1963	81.67
June 16, 1962	79.6	Sept. 15, 1962	[c] [d] 150.3	Feb. 19, 1963	[d] 146.8
June 30, 1962	[d] 141.0				

[a] Measurements for January 7 through 11, 1963, are given in Table 9.
[b] Reported depth to water.
[c] Nearby well 57-41-901 pumping at time of measurement.
[d] Nearby well 57-41-902 pumping at time of measurement.

Well 57-42-702

Date	Depth to water	Date	Depth to water	Date	Depth to water
Jan. 27, 1961	[a] 43.0	June 2, 1962	45.5	June 30, 1962	45.5
May 19, 1962	45.6	June 16, 1962	45.3	July 14, 1962	45.9

(Continued on next page)

Table 5.--Depths to water in selected wells in the Fredericksburg area--Continued

Date	Depth to water	Date	Depth to water	Date	Depth to water
Well 57-42-702--Continued					
Aug. 18, 1962	47.4	Oct. 30, 1962	48.07	Jan. 17, 1963	47.9
Sept. 1, 1962	47.4	Nov. 12, 1962	47.65	Feb. 1, 1963	48.02
Sept. 15, 1962	47.5	Dec. 14, 1962	48.15	Feb. 19, 1963	48.0
Sept. 29, 1962	47.5	Dec. 28, 1962	48.02	Mar. 27, 1963	48.5
Oct. 11, 1962	47.99				

[a] Well was being drilled and had not attained total depth at time of measurement.

Well 57-50-102[a]

Date	Depth to water	Date	Depth to water	Date	Depth to water
Nov. 8, 1944	45.7	Mar. 1, 1958	49.0	May 1, 1960	54.5
April 17, 1946	44.27	Mar. 29, 1958	51.0	June 5, 1960	69.0
June 8, 1956	76.0	April 26, 1958	50.5	July 3, 1960	64.0
July 7, 1956	72.5	May 24, 1958	59.5	Aug. 7, 1960	60.0
Aug. 4, 1956	70.5	June 14, 1958	57.0	Sept. 6, 1960	44.0
Sept. 8, 1956	69.0	July 28, 1958	54.5	Oct. 2, 1960	44.0
Oct. 13, 1956	71.0	Aug. 2, 1958	59.5	Nov. 6, 1960	48.5
Feb. 9, 1957	60.0	Mar. 1, 1959	43.0	Dec. 4, 1960	49.5
May 4, 1957	51.5	June 19, 1959	60.0	Jan. 29, 1961	49.0
July 4, 1957	69.0	Sept. 18, 1959	61.0	Feb. 12, 1961	49.0
Aug. 3, 1957	68.5	Oct. 2, 1959	51.0	Mar. 4, 1961	49.0
Sept. 7, 1957	62.5	Nov. 8, 1959	45.5	April 16, 1961	52.0
Oct. 6, 1957	54.0	Dec. 5, 1959	45.0	May 14, 1961	64.0
Nov. 2, 1957	52.0	Feb. 14, 1960	51.0	June 2, 1961	72.0

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Table 5.--Depths to water in selected wells in the Fredericksburg area--Continued

Date	Depth to water	Date	Depth to water	Date	Depth to water
Well 57-50-102[a]--Continued					
July 9, 1961	64.0	June 9, 1962	52.0	Sept. 14, 1962	75.5
Aug. 6, 1961	62.0	June 17, 1962	46.0	Sept. 16, 1962	77.0
Sept. 8, 1961	55.0	June 24, 1962	71.0	Sept. 22, 1962	74.0
Oct. 8, 1961	52.0	July 14, 1962	73.0	Sept. 29, 1962	65.0
Nov. 5, 1961	51.0	July 22, 1962	74.0	Oct. 13, 1962	64.0
Dec. 3, 1961	50.0	July 28, 1962	77.0	Oct. 27, 1962	61.0
Jan. 7, 1962	49.0	July 31, 1962	77.0	Nov. 4, 1962	61.0
Mar. 23, 1962	54.0	Aug. 4, 1962	77.5	Nov. 11, 1962	59.0
May 6, 1962	70.5	Aug. 11, 1962	77.5	Nov. 25, 1962	57.0
May 11, 1962	70.5	Aug. 19, 1962	75.0	Dec. 2, 1962	57.0
May 19, 1962	71.5	Aug. 25, 1962	77.5	Mar. 28, 1963	54.0
May 27, 1962	72.0	Sept. 8, 1962	53.0		

[a] Depths to water are given from land-surface datum to top of oil layer overlying the water in the well. Data on pumping rates at times of measurement are not available. Measurements for January 19 through 21, 1963, are given in Table 10.

Table 6.--Monthly municipal pumpage at Fredericksburg

(Pumpage in thousands of Gallons)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1948	6,324	6,264	--	--	--	--	--	--	10,314	11,935	11,961	9,486	--
1949	7,750	7,112	9,083	9,288	10,788	11,670	13,826	13,702	11,310	9,641	9,240	8,091	121,501
1950	7,688	6,636	7,874	9,720	10,540	15,180	17,360	--	--	--	--	--	--
1951	--	--	--	13,456	12,793	16,034	27,636	25,200	16,009	15,675	10,254	9,678	--
1952	11,420	13,784	11,244	10,591	14,094	18,166	20,369	28,722	17,334	--	--	10,076	--
1953	8,903	9,351	12,119	10,460	13,669	22,420	21,371	28,823	--	--	--	--	--
1954	--	--	--	--	--	24,295	28,622	28,399	21,669	14,876	10,765	11,296	--
1955	8,211	7,595	4,862	14,217	14,620	24,844	21,941	18,842	17,595	15,096	12,279	10,821	170,923
1956	11,274	10,027	16,405	19,391	22,286	28,191	33,455	31,684	24,336	19,853	11,032	12,768	240,702
1957	10,909	10,801	11,977	12,600	10,700	14,259	34,108	36,509	19,183	10,929	10,208	11,088	193,271
1958	10,972	9,675	11,314	12,779	17,762	24,783	29,680	28,087	14,947	15,655	15,570	15,731	206,955
1959	16,554	10,157	19,469	18,430	18,740	25,834	24,851	26,226	29,636	19,561	17,310	16,430	243,198
1960	15,748	13,195	15,686	19,800	21,483	37,560	29,109	26,164	27,000	22,010	17,550	16,120	261,425
1961	15,500	12,460	19,375	27,510	33,294	27,499	28,024	40,083	28,440	20,641	17,323	18,962	289,111
1962	17,750	17,986	20,766	19,188	31,802	24,070	40,461	42,349	33,473	24,400	19,275	16,776	308,296
1963	17,819	12,242	22,638	--	--	--	--	--	--	--	--	--	--

Table 7.--Monthly precipitation at Fredericksburg

(Precipitation in inches)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1877	--	--	--	2.30	3.69	2.63	1.36	0.19	1.09	3.93	1.50	4.79	--
1878	0.59	2.15	0.79	5.13	3.66	3.89	1.81	1.34	.38	.50	2.09	.45	22.78
1879	.08	.82	2.27	5.20	.61	2.30	.55	2.90	1.45	1.50	.38	.21	18.27
1880	1.15	2.27	1.08	3.33	5.46	2.64	5.40	4.55	12.25	2.69	5.09	1.32	47.23
1881	.23	.59	1.13	2.13	6.30	.00	4.28	1.53	2.14	3.38	1.68	.72	24.11
1882	3.54	2.20	2.01	.78	5.57	.30	4.28	3.16	5.06	2.26	2.40	.90	32.46
1883	.51	.87	--	--	--	--	--	--	--	--	--	--	--
1889	--	--	--	1.61	.90	5.17	1.43	.73	5.84	1.61	3.58	.04	--
1890	1.24	3.58	.41	4.00	3.42	3.30	.20	3.30	4.59	4.13	1.85	1.82	31.84
1891	5.01	.81	.84	2.88	4.48	2.73	.98	2.50	2.06	.99	.58	5.32	29.18
1892	1.34	.53	2.74	.64	3.30	1.26	.76	8.01	.57	2.51	.66	3.53	25.85
1893	.24	.46	1.45	1.95	3.47	1.54	.28	1.52	.10	.12	3.99	1.10	16.22
1894	2.50	1.28	.97	10.34	3.37	1.45	1.16	5.11	4.20	1.43	.00	.19	32.00
1895	1.30	3.62	1.85	1.63	8.64	3.40	Trace	2.50	2.46	1.56	4.74	1.51	33.21
1896	3.08	2.67	1.36	5.07	.06	1.43	2.56	1.53	7.99	4.29	.41	1.92	32.37
1897	1.65	.05	1.79	3.00	2.04	2.10	1.14	4.14	2.20	3.37	.20	1.42	23.10
1898	1.03	.54	2.05	3.68	1.22	5.85	1.68	1.93	1.61	Trace	2.24	1.75	23.58
1899	.36	.27	Trace	2.84	3.40	10.03	1.65	.29	1.41	2.95	2.02	4.15	29.37
1900	2.38	.24	4.29	7.42	6.22	.38	6.59	1.94	2.86	2.45	5.31	.97	41.05
1901	.88	1.13	.76	1.47	2.25	.69	3.31	1.50	2.17	.17	.83	.67	15.83
1902	.84	.42	3.02	1.74	4.97	.06	4.10	.00	.83	3.30	11.72	1.77	32.77
1903	3.06	6.55	2.21	1.13	3.03	4.19	2.58	3.53	1.59	2.30	.00	1.17	31.34
1904	.07	2.16	1.37	2.55	4.31	2.44	2.44	2.30	5.62	2.89	.37	1.66	28.18
1905	1.01	.88	3.63	9.48	2.56	1.05	2.56	1.61	4.18	2.88	1.07	2.21	33.12
1906	.52	.75	.80	2.63	1.73	1.32	3.53	3.71	2.71	.78	1.80	1.30	21.58
1907	.47	.13	.63	1.83	7.19	.41	3.89	.29	4.09	4.32	6.37	.27	29.89
1908	.69	2.08	2.25	3.36	3.86	.10	1.16	1.74	1.86	1.51	2.48	.65	21.74
1909	.21	.11	1.49	3.18	2.89	1.45	6.71	1.76	.15	.78	2.19	.94	21.86
1910	.19	1.23	5.68	2.66	2.12	1.11	.33	.17	2.20	3.61	.96	2.35	22.61
1911	.43	1.94	2.35	6.78	.39	.35	1.28	1.43	.52	1.39	1.47	2.03	20.36
1912	.16	2.03	1.56	2.34	.51	3.16	1.19	.84	1.22	4.80	1.90	.87	20.58
1913	1.86	1.27	1.49	2.87	2.96	4.51	.15	1.17	3.06	6.71	5.16	7.27	38.48
1914	.32	.55	1.13	3.87	4.93	.85	1.35	6.13	2.16	3.52	1.57	1.55	27.93
1915	2.40	1.38	1.53	5.27	--	--	--	--	--	--	--	--	--
1939	--	2.26	--	1.14	2.98	2.05	5.34	2.63	1.25	3.88	2.41	1.30	--
1940	.82	3.90	2.88	4.47	2.31	6.68	1.45	1.69	1.23	3.53	4.01	5.57	38.54
1941	1.56	3.28	3.42	6.69	2.64	2.61	1.43	.29	4.67	5.43	1.13	.58	33.73
1942	.14	.83	.73	3.88	1.79	2.24	.94	7.77	1.77	6.05	.47	1.13	27.74
1943	.66	.09	3.10	1.09	2.76	4.77	3.96	.42	3.70	.59	1.09	1.57	23.80
1944	2.87	3.01	1.04	.18	9.39	1.69	.35	13.15	3.49	1.97	2.43	2.73	42.30
1945	2.29	2.64	4.48	2.90	.47	2.79	1.20	2.93	--	4.71	.15	1.42	--
1946	2.86	1.26	.75	7.53	5.57	1.16	.07	1.02	5.58	4.85	3.00	1.77	35.42
1947	3.91	.28	1.98	2.84	1.57	1.41	.45	2.62	.11	.73	2.28	1.18	19.36
1948	.13	2.24	1.53	4.17	2.18	2.94	1.54	--	1.78	.74	.49	1.28	--
1949	2.67	3.20	1.70	2.86	1.55	3.03	2.22	3.13	2.71	3.53	.00	2.01	28.61
1950	.70	2.47	.21	2.57	3.88	2.45	2.54	5.97	2.66	.44	.33	.00	24.22
1951	.03	1.91	2.38	1.01	3.64	3.22	.15	.89	1.79	.54	.35	.35	16.26
1952	.18	1.42	2.94	5.33	6.24	3.76	.53	.00	16.48	.00	2.42	4.74	44.04
1953	.73	.38	2.36	2.01	.99	.47	.67	2.66	1.62	4.74	.18	.77	17.58
1954	.42	.08	.46	2.42	1.77	1.46	.15	1.29	.59	2.99	1.00	.14	12.77
1955	2.30	1.97	.49	.25	5.02	2.73	4.24	3.47	4.49	.55	.39	.78	26.68
1956	.60	.94	.05	.22	1.35	1.50	.49	1.77	.57	.76	1.56	1.48	11.29
1957	.77	1.84	3.30	8.03	6.62	4.13	.69	.13	4.49	6.08	4.54	.46	41.08
1958	2.90	3.36	1.81	1.95	2.21	7.52	.78	4.21	6.81	4.72	.57	.87	37.71
1959	.55	2.24	.01	3.93	1.71	5.99	2.78	1.59	2.29	9.19	1.46	2.93	34.67
1960	.97	1.92	2.17	.66	1.20	1.82	4.23	5.37	.91	6.61	2.46	3.59	31.91
1961	.84	2.88	.54	.30	.33	7.11	2.28	.62	1.97	1.22	1.38	.47	19.94
1962	.25	.39	.65	4.77	2.40	4.16	.46	.54	1.64	2.30	1.26	1.46	20.28
1963	.11	1.25	.05	--	--	--	--	--	--	--	--	--	--
Mean	1.26	1.64	1.76	3.24	3.23	2.65	1.98	2.54	2.99	2.77	2.01	1.71	27.78

Table 8.--Pedernales River flow measurements in the Fredericksburg area

(Data from Texas Board Water Engineers, 1960, p. 54-55. Locations of flow measurements are shown on Figure 2.)

Flow measurement no.	Date in 1956	Stream	Location	River miles	Discharge (cubic feet per second) Main stream	Tributary	Diversion	Remarks
F- 1	Jan. 10	Pedernales River	1.0 mile above State Highway 16	20.6	0.4	--	--	Estimated. Gravel streambed.
F- 2	10	5-in. pump	On right bank	21.3	--	--	1.0	Estimated. Irrigating winter grain.
F- 3	10	Pedernales River	0.1 mile above State Highway 16	21.4	.1	--	--	Estimated. Gravel streambed.
F- 4	16	Wolf Creek	At mouth	21.5	0	--	--	Gravel streambed.
F- 5	10	Pedernales River	0.3 mile above Bear Creek	23.5	.2	--	--	Estimated. Gravel streambed.
F- 6	10	Bear Creek	At mouth	23.8	--	0	--	Do.
F- 7	10	Tributary	From left bank	25.0	--	.02	--	Estimated. Sand streambed.
F- 8	10	Pedernales River	2.0 miles above Live Oak Creek	25.1	.3	--	--	Estimated. Gravel streambed.
F- 9	10	Tributary	From left bank	25.2	--	.01	--	Estimated. Sand streambed.
F-10	10	Pedernales River	1.0 mile above Live Oak Creek	26.0	.6	--	--	Gravel streambed.
F-11	10	Live Oak Creek	At mouth	27.0	--	.56	--	Sand streambed.
F-12	10	Pedernales River	500 feet below Live Oak Creek	27.1	1.10	--	--	Gravel streambed.
F-13	10	Pedernales River	0.4 mile above U. S. Highway 87	28.8	1.24	--	--	Sand and gravel streambed.
F-14	11	do	0.2 mile above Muesebach Creek	31.0	1.0	--	--	Estimated. Gravel streambed.
F-15	11	Muesebach Creek	At mouth	31.2	--	0	--	Gravel streambed.
F-16	11	4-in. pump	On Barons Creek; 1 mile above mouth	--	--	--	1	Estimated. From pool behind temporary dirt dam.
F-17	11	Barons Creek	At mouth	32.0	--	.5	--	Estimated. Sand streambed.
F-18	11	Pedernales River	0.3 mile below Barons Creek	32.3	.96	--	--	Gravel streambed.
F-19	11	Pedernales River	200 feet above U. S. Highway 290	34.4	.90	--	--	Do.
F-20	11	Pedernales River	--	36.6	1.31	--	--	Do.
F-21	11	do	2 miles north of Rocky Hill School	38.4	1.36	--	--	Rock streambed.
F-22	12	6-in. pump	On left bank; 0.3 mile above Palo Alto Creek	39.1	--	--	1	Estimated. From pool behind 4-ft. dam.
F-23	12	Palo Alto Creek	At mouth	39.4	--	.02	--	Estimated. Sand streambed.
F-24	12	Pedernales River	0.6 mile below Palo Alto Creek	40.0	1.98	--	--	Rock streambed.

Table 9.--Pumping-test data for well 57-41-902

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 7 through January 8, 1958				
(Pumping test conducted by personnel of Texas Water Wells, Incorporated)				
				Depth to water before pumping started was 62 ft. Pumping rate measured with 6" x 3" pipe orifice.
1- 7-58	8:25 a. m.	198	99	
Do.	8:40	201	99	
Do.	8:55	204	96	
Do.	9:10	206	96	
Do.	9:25	207	94	
Do.	9:40	208	94	
Do.	9:55	210	94	
Do.	10:10	210	94	
Do.	10:25	211	94	
Do.	10:40	218	96	
Do.	10:55	219	94	
Do.	11:10	219	94	
Do.	11:25	219	94	
Do.	11:40	219	94	
Do.	11:55	229	102	
Do.	12:10 p. m.	242	99	
Do.	12:25	243	99	
Do.	12:40	244	99	
Do.	12:55	244	99	
Do.	1:10	246	94	
Do.	1:25	246	94	
Do.	1:40	247	94	
Do.	1:55	247	94	
Do.	2:10	247	94	
Do.	2:25	247	94	
Do.	2:40	247	94	
Do.	2:55	247	94	
Do.	3:10	247	94	
Do.	3:25	247	94	
Do.	3:40	247	94	
Do.	3:55	247	94	
Do.	4:10	247	91	
Do.	4:25	248	91	
Do.	4:40	248	91	
Do.	4:55	248	91	
Do.	5:10	248	91	
Do.	5:25	248	91	

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 7 through January 8, 1958--Continued				
1- 7-58	5:40 p. m.	248	91	
Do.	6:00	248	91	Pumping stopped.
Do.	6:01	179		
Do.	6:02	175		
Do.	6:03	170		
Do.	6:04	167		
Do.	6:05	163		
Do.	6:06	160		
Do.	6:07	157		
Do.	6:08	154		
Do.	6:09	152		
Do.	6:10	149		
Do.	6:15	140		
Do.	6:20	134		
Do.	6:25	129		
Do.	6:30	124		
1- 8-58	7:35 a. m.	78		

Pumping test from January 8 through January 11, 1963

(Pumping test conducted by personnel of the Texas Water Commission)

Pumped well 57-41-902

1- 7-63	9:45 a. m.	96.78		Well had not been pumped since 11:30 a. m., 1-4-63. Water-level measurements referenced to base of pump housing which is 1.0 ft. above land-surface datum.
Do.	11:00	96.55		
Do.	1:15 p. m.	96.11		
Do.	2:45	95.84		
Do.	5:30	95.38		
1- 8-63	12:01 a. m.	94.48		
Do.	6:02	93.51		
Do.	12:15 p. m.	92.52		
Do.	12.59	92.61		
Do.	1:00			Pumping started. Pumping rate measured with 4" x 2-1/2" pipe orifice.
Do.	1:01	106.66		
Do.	1:02	114.46		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Pumped well 57-41-902--Continued				
1- 8-63	1:03 p. m.	120.06	95	
Do.	1:04	125.02		
Do.	1:05	129.16		
Do.	1:06	133.49		
Do.	1:07	136.53	83	
Do.	1:08	139.34	83	
Do.	1:09	141.72		
Do.	1:10	143.94	78	
Do.	1:11	145.96		
Do.	1:12	148.07		
Do.	1:13	149.71		
Do.	1:14	151.18	78	
Do.	1:15	152.68	78	
Do.	1:16	154.31	78	
Do.	1:17	155.71	78	
Do.	1:18	156.90	78	
Do.	1:19	158.08	75	
Do.	1:20	159.05	75	
Do.	1:21	159.05	75	
Do.	1:22	160.97	74	
Do.	1:23	161.78	74	
Do.	1:24	162.49	74	
Do.	1:25	163.27	72	
Do.	1:28	165.20	71	
Do.	1:29	165.83	71	
Do.	1:30	166.40	71	
Do.	1:32	167.55	70	
Do.	1:34	168.48	70	
Do.	1:36	169.36	70	
Do.	1:38	170.08	68	
Do.	1:40	170.71	70	
Do.	1:42	171.36	70	
Do.	1:45	172.18	70	
Do.	1:48	172.95		
Do.	1:51	173.65	70	
Do.	1:54	174.26	69	
Do.	1:57	174.80	69	
Do.	2:00	175.30	68	
Do.	2:05	176.24	68	
Do.	2:10	177.02	68	
Do.	2:15	177.60	68	

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Pumped well 57-41-902--Continued				
1- 8-63	2:20 p. m.	178.19	67	
Do.	2:25	178.73	67	
Do.	2:30	179.17	67	
Do.	2:35	179.63	66	
Do.	2:40	180.05	66	
Do.	2:45	180.45	66	
Do.	2:50	180.86	65	
Do.	2:55	181.23	65	
Do.	3:00	181.56	65	
Do.	3:10	182.20	65	
Do.	3:20	182.76	65	
Do.	3:30	183.30	65	
Do.	3:40	183.84	65	
Do.	3:50	184.33	65	
Do.	4:00	184.79	65	
Do.	4:15	185.37	64	
Do.	4:30	185.94	64	
Do.	4:45	186.48	64	
Do.	5:00	186.92	64	
Do.	5:30	187.90	64	
Do.	6:00	188.72	64	
Do.	6:30	189.52	63	
Do.	7:00	190.22	63	
Do.	7:35	190.94	63	
Do.	8:00	191.39	63	
Do.	8:29	191.94	63	
Do.	9:02	192.47	63	
Do.	9:58	193.23	63	
Do.	10:58	194.00	62	
Do.	11:59	194.64	62	
1- 9-63	12:58 a. m.	195.19	62	
Do.	1:59	195.77	62	
Do.	2:59	196.27	62	
Do.	3:59	196.68	61	
Do.	5:05	197.11	61	
Do.	6:01	197.53	61	
Do.	6:59	197.91	61	
Do.	9:07	198.61	60	
Do.	11:00	199.19	60	
Do.	1:00 p. m.	199.63	60	
Do.	3:00	200.10	60	

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Pumping test from January 8 through January 11, 1963--Continued		
		Pumped well 57-41-902--Continued		
1- 9-63	7:00 p. m.	201.17	60	
Do.	11:00	202.03	59	
1-10-63	3:01 a. m.	202.78	59	
Do.	7:00	203.46	59	
Do.	12:55 p. m.	204.05	58	
Do.	1:00	--		Pumping stopped.
Do.	1:01	195.86		
Do.	1:02	190.09		
Do.	1:03	185.11		
Do.	1:04	181.45		
Do.	1:05	178.52		
Do.	1:06	175.57		
Do.	1:07	173.04		
Do.	1:08	170.84		
Do.	1:09	168.72		
Do.	1:10	166.42		
Do.	1:11	164.73		
Do.	1:12	163.18		
Do.	1:13	161.83		
Do.	1:14	160.39		
Do.	1:15	159.16		
Do.	1:16	157.87		
Do.	1:17	156.75		
Do.	1:18	155.76		
Do.	1:19	154.54		
Do.	1:20	153.51		
Do.	1:21	152.62		
Do.	1:22	151.87		
Do.	1:23	151.06		
Do.	1:24	150.38		
Do.	1:25	149.64		
Do.	1:26	148.98		
Do.	1:27	148.23		
Do.	1:28	147.55		
Do.	1:29	146.92		
Do.	1:30	146.34		
Do.	1:32	145.15		
Do.	1:34	144.16		
Do.	1:36	143.20		
Do.	1:38	142.22		
Do.	1:40	141.35		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Pumped well 57-41-902--Continued				
1-10-63	1:42 p. m.	140.39		
Do.	1:44	139.68		
Do.	1:46	138.92		
Do.	1:48	138.19		
Do.	1:50	137.55		
Do.	1:52	136.79		
Do.	1:54	136.32		
Do.	1:56	135.77		
Do.	1:58	135.22		
Do.	2:00	134.72		
Do.	2:05	133.43		
Do.	2:10	132.47		
Do.	2:15	131.57		
Do.	2:20	130.67		
Do.	2:25	129.92		
Do.	2:30	129.14		
Do.	2:40	127.86		
Do.	2:50	126.73		
Do.	3:00	125.77		
Do.	3:10	124.90		
Do.	3:20	124.12		
Do.	3:30	123.40		
Do.	3:45	122.30		
Do.	4:00	121.35		
Do.	4:15	120.49		
Do.	4:30	119.71		
Do.	5:00	118.27		
Do.	5:30	116.95		
Do.	6:00	115.87		
Do.	7:00	113.84		
Do.	8:00	112.26		
Do.	8:58	110.91		
Do.	10:00	109.65		
Do.	10:59	108.64		
Do.	11:57	107.75		
1-11-63	12:59	106.85		
Do.	1:59	106.14		
Do.	2:58 a. m.	105.42		
Do.	3:58	104.68		
Do.	4:57	104.09		
Do.	6:04	103.42		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Pumped well 57-41-902--Continued				
1-11-63	7:56 a. m.	102.48		
Do.	9:59	101.53		
Do.	1:00 p. m.	100.31		
Observation well 57-41-903				
1- 7-63	8:45 a. m.	97.78		
Do.	9:50	97.62		
Do.	10:00	97.49		
Do.	11:05	97.31		
Do.	1:10 p. m.	96.94		
Do.	2:53	96.64		
Do.	6:00	96.17		
1- 8-63	12:06 a. m.	95.36		
Do.	6:07	94.41		
Do.	12:20 p. m.	93.65		
Do.	1:00	93.53		Pumping started in well 57-41-902.
Do.	1:01	93.53		
Do.	1:02	93.53		
Do.	1:03	93.60		
Do.	1:04	93.68		
Do.	1:05	93.80		
Do.	1:06	93.93		
Do.	1:07	94.11		
Do.	1:08	94.31		
Do.	1:09	94.50		
Do.	1:10	94.79		
Do.	1:11	95.00		
Do.	1:12	95.22		
Do.	1:13	95.45		
Do.	1:14	95.72		
Do.	1:15	95.97		
Do.	1:16	96.22		
Do.	1:17	96.48		
Do.	1:18	96.73		
Do.	1:19	96.99		
Do.	1:20	--		
Do.	1:21	97.59		
Do.	1:22	97.75		
Do.	1:23	97.02		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
				Pumping test from January 8 through January 11, 1963--Continued
				Observation well 57-41-903--Continued
1- 8-63	1:24 p. m.	97.27		
Do.	1:25	98.52		
Do.	1:26	98.75		
Do.	1:27	98.98		
Do.	1:28	99.22		
Do.	1:29	99.47		
Do.	1:30	99.68		
Do.	1:31	99.92		
Do.	1:32	100.13		
Do.	1:33	100.36		
Do.	1:34	100.58		
Do.	1:35	100.78		
Do.	1:36	101.00		
Do.	1:37	101.21		
Do.	1:38	101.40		
Do.	1:39	101.60		
Do.	1:40	101.79		
Do.	1:41	101.97		
Do.	1:42	102.17		
Do.	1:43	102.35		
Do.	1:44	102.53		
Do.	1:45	102.72		
Do.	1:46	102.89		
Do.	1:47	103.07		
Do.	1:48	103.23		
Do.	1:49	103.40		
Do.	1:50	103.58		
Do.	1:51	103.72		
Do.	1:52	103.88		
Do.	1:53	104.05		
Do.	1:54	104.20		
Do.	1:55	104.34		
Do.	1:56	104.50		
Do.	1:57	104.64		
Do.	1:58	104.78		
Do.	1:59	104.93		
Do.	2:00	105.03		
Do.	2:01	105.23		
Do.	2:02	105.37		
Do.	2:03	105.50		
Do.	2:04	105.63		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Observation well 57-41-903--Continued				
1- 8-63	2:05 p. m.	105.79		
Do.	2:10	106.40		
Do.	2:15	107.00		
Do.	2:20	107.55		
Do.	2:25	108.03		
Do.	2:30	108.59		
Do.	2:35	109.07		
Do.	2:40	109.52		
Do.	2:45	109.95		
Do.	2:50	110.40		
Do.	2:55	110.79		
Do.	3:00	111.16		
Do.	3:10	111.87		
Do.	3:20	112.57		
Do.	3:30	113.22		
Do.	3:40	114.42		
Do.	4:00	114.93		
Do.	4:15	115.69		
Do.	4:30	116.41		
Do.	4:45	117.05		
Do.	5:00	117.69		
Do.	5:15	118.27		
Do.	5:30	118.80		
Do.	6:00	119.81		
Do.	6:30	120.74		
Do.	7:00	121.58		
Do.	7:38	122.56		
Do.	8:02	123.12		
Do.	8:33	123.79		
Do.	8:57	124.31		
Do.	10:02	125.52		
Do.	11:07	126.58		
1- 9-63	12:03 a. m.	127.41		
Do.	1:02	128.13		
Do.	2:03	128.82		
Do.	3:02	129.41		
Do.	4:02	130.00		
Do.	4:59	130.52		
Do.	6:03	131.01		
Do.	7:03	131.48		
Do.	9:05	132.38		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Observation well 57-41-903--Continued				
1- 9-63	11:00 a. m.	133.16		
Do.	1:00 p. m.	133.79		
1-10-63	3:00	134.38		
Do.	7:03	135.50		
Do.	11:03	136.54		
Do.	3:05 a. m.	137.39		
Do.	7:04	138.09		
Do.	12:57 p. m.	139.03		
Do.	1:00	--		Pumping stopped.
Do.	1:01	139.04		
Do.	1:02	139.03		
Do.	1:03	138.99		
Do.	1:04	138.94		
Do.	1:05	138.89		
Do.	1:06	138.79		
Do.	1:07	138.68		
Do.	1:08	138.57		
Do.	1:09	138.43		
Do.	1:10	138.31		
Do.	1:11	138.15		
Do.	1:12	137.98		
Do.	1:13	137.83		
Do.	1:14	137.65		
Do.	1:15	137.48		
Do.	1:16	137.31		
Do.	1:17	137.14		
Do.	1:18	136.95		
Do.	1:19	136.78		
Do.	1:20	136.60		
Do.	1:21	136.41		
Do.	1:22	136.22		
Do.	1:23	136.03		
Do.	1:24	135.05		
Do.	1:25	135.67		
Do.	1:26	135.51		
Do.	1:27	135.31		
Do.	1:28	135.15		
Do.	1:29	134.96		
Do.	1:30	134.80		
Do.	1:31	134.62		
Do.	1:32	134.45		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Observation well 57-41-903--Continued				
1-10-63	1:33 p. m.	134.27		
Do.	1:34	134.11		
Do.	1:35	133.92		
Do.	1:36	133.76		
Do.	1:37	133.60		
Do.	1:38	133.44		
Do.	1:39	133.29		
Do.	1:40	133.13		
Do.	1:41	132.97		
Do.	1:42	132.82		
Do.	1:43	132.66		
Do.	1:44	132.52		
Do.	1:45	132.38		
Do.	1:46	132.22		
Do.	1:47	132.08		
Do.	1:48	131.92		
Do.	1:49	131.78		
Do.	1:50	131.62		
Do.	1:51	131.49		
Do.	1:52	131.35		
Do.	1:53	131.22		
Do.	1:54	131.09		
Do.	1:55	130.94		
Do.	1:56	130.83		
Do.	1:57	130.69		
Do.	1:58	130.56		
Do.	1:59	130.43		
Do.	2:00	130.29		
Do.	2:05	129.70		
Do.	2:10	129.10		
Do.	2:15	128.55		
Do.	2:20	128.03		
Do.	2:25	127.52		
Do.	2:30	127.05		
Do.	2:40	126.18		
Do.	2:50	125.35		
Do.	3:00	124.60		
Do.	3:10	123.89		
Do.	3:20	123.23		
Do.	3:30	122.60		
Do.	3:45	121.75		

(Continued on next page)

Table 9.--Pumping-test data for well 57-41-902--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 8 through January 11, 1963--Continued				
Observation well 57-41-903--Continued				
1-10-63	4:00 p. m.	120.96		
Do.	4:15	120.23		
Do.	4:30	119.52		
Do.	5:00	118.27		
Do.	5:30	117.14		
Do.	6:00	116.11		
Do.	7:04	114.20		
Do.	8:03	112.85		
Do.	9:04	111.56		
Do.	10:05	110.38		
Do.	11:04	109.60		
1-11-63	12:01 a. m.	108.74		
Do.	1:04	107.98		
Do.	2:01	107.24		
Do.	3:01	106.55		
Do.	4:02	105.88		
Do.	5:00	105.27		
Do.	6:06	104.59		
Do.	7:59	103.66		
Do.	10:02	102.41		
Do.	1:00	101.22		

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102

(Pumping test conducted by personnel of the Texas Water Commission from January 19 through January 21, 1963.)

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-101		
1-19-63	1:21 p.m.	56.76		Wells 57-50-101 and 57-50-102 have not been pumped since 5:00 a.m., 1-19-63. Depths to water referenced to land-surface datum. Water covered by layer of oil-water emulsion 5.19 ft. thick.
Do.	2:06	56.75		
Do.	2:12	--		Pumping started in well 57-50-101. Pumping rate measured with in-line, revolving vane-type flowmeter.
Do.	2:13	64.09		
Do.	2:14	64.82		
Do.	2:15	65.07		
Do.	2:16	65.26		
Do.	2:18	65.48		
Do.	2:19	65.59		
Do.	2:20	65.68		
Do.	2:21	65.78		
Do.	2:22	65.77		
Do.	2:23	65.93		
Do.	2:24	65.98		
Do.	2:25	66.03		
Do.	2:26	66.06		
Do.	2:27	66.10		
Do.	2:28	66.14		
Do.	2:29	66.19		
Do.	2:30	66.23		
Do.	2:31	66.29		
Do.	2:32	66.38		
Do.	2:35	66.43		
Do.	2:36	66.44		
Do.	2:37	66.46		
Do.	2:38	66.49		
Do.	2:39	66.53		
Do.	2:40	66.57		
Do.	2:41	66.57		
Do.	2:42	66.59		
Do.	2:43	66.60		
Do.	2:44	66.62		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-101--Continued		
1-19-63	2:45 p. m.	66.63		
Do.	2:50	66.73		
Do.	3:00	66.85		
Do.	3:15	67.03		
Do.	3:30	67.19		
Do.	3:45	67.29		
Do.	4:00	67.44		
Do.	4:15	67.49		
Do.	4:30	--	519	
Do.	4:45	67.52		
Do.	5:10	67.60		
Do.	5:12	--		Pumping stopped.
Do.	5:13	61.80		
Do.	5:15	55.09		
Do.	5:17	55.35		
Do.	5:18	55.45		
Do.	5:19	55.58		
Do.	5:21	55.63		
Do.	5:22	55.67		
Do.	5:23	55.75		
Do.	5:24	55.81		
Do.	5:25	55.85		
Do.	5:26	55.88		
Do.	5:27	55.90		
Do.	5:28	55.95		
Do.	5:30	55.95		
Do.	5:35	56.05		
Do.	5:40	56.10		
Do.	5:50	56.18		
Do.	6:00	56.20		
Do.	6:15	56.25		
Do.	6:42	56.30		
1-20-63	11:30 a. m.	55.00		
Do.	2:30 p. m.	--		Pumping started in well 57-50-101.
Do.	5:45	66.39		
Do.	6:34	66.69		
Do.	6:35	--		Pumping stopped.
Do.	6:38	54.17		
Do.	6:39	54.33		
Do.	6:40	54.34		
Do.	6:45	54.68		
Do.	6:50	54.86		
Do.	6:59	54.90		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-101--Continued		
1-20-63	7:01 p. m.	54.91		
Do.	7:04	54.91		
Do.	7:05	--		Pumping started in well 57-50-101.
1-21-63	3:00 a. m.	--		Pumping stopped.
Do.	8:00	55.24		
Do.	8:07	--		Pumping started in well 57-50-101.
Do.	8:08	62.69		
Do.	8:09	63.67		
Do.	8:11	64.00		
Do.	8:12	--		Pumping stopped.
Do.	8:13	57.89		
Do.	8:14	53.08		
Do.	8:15	53.14		
Do.	8:16	53.21		
Do.	8:17	53.49		
Do.	8:18	53.52		
Do.	8:19	53.65		
Do.	8:20	53.69		
Do.	8:21	53.78		
Do.	8:25	--		Pumping started in well 57-50-102.
Do.	8:26	61.06		
Do.	8:27	62.15		
Do.	8:28	62.38		
Do.	8:29	63.09		
Do.	8:33	62.69		
Do.	8:34	62.69		
Do.	8:35	62.89		
Do.	8:40	62.84		
Do.	8:45	62.88		
Do.	8:50	62.89		
Do.	8:55	62.99		
Do.	9:00	63.17		
Do.	9:10	63.27		
Do.	9:20	63.29		
Do.	9:30	63.39		
Do.	9:45	63.54		
Do.	10:00	63.56		
Do.	10:15	63.58		
Do.	10:25	--		Pumping stopped.
Do.	10:26	52.72		
Do.	10:27	52.98		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-101--Continued		
1-21-63	10:28 a. m.	54.06		
Do.	10:29	54.06		
Do.	10:30	54.09		
Do.	10:31	54.11		
Do.	10:35	54.44		
Do.	10:36	54.57		
Do.	10:37	54.74		
Do.	10:38	54.76		
Do.	10:39	54.81		
Do.	10:40	54.87		
Do.	10:45	54.94		
Do.	10:50	54.94		
Do.	10:55	54.96		
Do.	11:00	54.98		
Do.	11:10	55.17		
Do.	11:24	55.20		
Do.	11:25	--		Pumping started in well 57-50-101.
Do.	11:26	62.58		
Do.	11:27	64.12		
Do.	11:28	64.42		
Do.	11:30	64.81		
Do.	11:32	65.01		
Do.	11:34	65.01		
Do.	11:35	65.01		
Do.	11:40	65.29		
Do.	11:45	65.39		
Do.	11:50	65.54		
Do.	11:55	65.49		
Do.	12:00 noon	65.51		
Do.	12:10 p. m.	65.65		
Do.	12:20	65.85		
Do.	12:30	65.92		
Do.	12:40	66.06		
Do.	12:45	66.09		
Do.	1:00	66.17	510	
Do.	1:15	66.37		
Do.	1:30	66.46		
Do.	1:45	66.51		
Do.	2:00	66.58		
Do.	2:15	66.60		
Do.	2:24	66.62		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-101--Continued		
1-21-63	2:25 p. m.	--		Pumping started in well 57-50-102. Pumping continued in well 57-50-101.
Do.	2:26	72.24		
Do.	2:28	72.47		
Do.	2:30	71.64		
Do.	2:33	72.60		
Do.	2:35	71.74		
Do.	2:39	71.82		
Do.	2:41	71.88		
Do.	2:45	71.90		
Do.	2:50	71.98		
Do.	2:55	72.01		
Do.	3:00	72.05		
Do.	3:15	72.11	695	Pumping rate for both wells.
Do.	3:30	72.16		
Do.	4:00	72.30		
Do.	4:15	72.37		
Do.	4:30	72.43		
Do.	5:15	72.55		
		Well 57-50-102		
1-19-63	10:39 a. m.	57.76		Wells 57-50-101 and 57-50-102 have not been pumped since 5:00 a.m. 1-19-63. Depths to water referenced to land-surface datum. Water covered by layer of oil 6.50 ft. thick.
Do.	11:28	57.65		
Do.	11:44	57.52		
Do.	2:05 p. m.	57.33		
Do.	2:12	--		Pumping started in well 57-50-101.
Do.	2:13	64.47		
Do.	2:14	65.33		
Do.	2:15	65.62		
Do.	2:16	65.81		
Do.	2:17	65.86		
Do.	2:18	65.95		
Do.	2:19	66.07		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-102--Continued		
1-19-63	2:20 p. m.	66.10		
Do.	2:21	66.18		
Do.	2:22	66.29		
Do.	2:23	66.24		
Do.	2:24	66.42		
Do.	2:26	66.36		
Do.	2:27	66.56		
Do.	2:28	66.58		
Do.	2:30	66.58		
Do.	2:35	66.81		
Do.	2:40	66.86		
Do.	2:41	66.98		
Do.	2:42	66.92		
Do.	2:43	66.98		
Do.	2:45	67.03		
Do.	2:50	67.10		
Do.	3:00	67.27		
Do.	3:15	67.44		
Do.	3:30	67.57		
Do.	3:45	67.66		
Do.	4:00	67.82		
Do.	4:15	67.88		
Do.	4:45	67.97		
Do.	5:10	68.04		
Do.	5:12	--		Pumping stopped.
Do.	5:13	58.34		
Do.	5:14	58.29		
Do.	5:15	58.36		
Do.	5:16	58.30		
Do.	5:17	58.29		
Do.	5:19	58.25		
Do.	5:20	58.22		
Do.	5:22	58.22		
Do.	5:24	58.19		
Do.	5:25	58.17		
Do.	5:30	58.12		
Do.	5:40	57.99		
Do.	5:50	57.90		
Do.	6:00	57.85		
Do.	6:15	57.77		
Do.	6:30	57.71		
Do.	6:42	57.67		
1-20-63	11:30 a. m.	56.52		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-102--Continued		
1-20-63	2:30 p. m.	--		Pumping started in well 57-50-101.
Do.	5:45	67.84		
Do.	6:28	67.96		
Do.	6:35	--		Pumping stopped.
Do.	6:42	61.23		
Do.	6:55	57.69		
Do.	7:02	57.61		
Do.	7:05	--		Pumping started in well 57-50-101.
1-21-63	3:00 a. m.	--		Pumping stopped.
Do.	7:40	57.17		
Do.	7:53	57.15		
Do.	8:07	--		Pumping started in well 57-50-101.
Do.	8:08	64.41		
Do.	8:09	65.31		
Do.	8:10	65.59		
Do.	8:11	65.77		
Do.	8:12	65.92		
Do.	8:13	--		Pumping stopped.
Do.	8:14	58.63		
Do.	8:16	57.23		
Do.	8:18	57.23		
Do.	8:20	57.19		
Do.	8:22	57.18		
Do.	8:25	--		Pumping started in well 57-50-102.
Do.	8:26	62.88		
Do.	8:27	64.28		
Do.	8:28	64.43		
Do.	8:29	64.58		
Do.	8:30	64.73		
Do.	8:32	64.63		
Do.	8:33	64.68		
Do.	8:35	64.71		
Do.	8:40	64.79		
Do.	8:45	64.85		
Do.	8:50	64.90		
Do.	8:55	64.93		
Do.	9:00	64.98		
Do.	9:10	65.05		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-102--Continued		
1-21-63	9:20 a. m.	65.11		
Do.	9:30	65.15		
Do.	9:45	65.21		
Do.	10:00	65.27		
Do.	10:15	65.29		
Do.	10:20	65.30		
Do.	10:25	--		Pumping stopped.
Do.	10:26	57.73		
Do.	10:27	57.83		
Do.	10:28	57.81		
Do.	10:29	57.79		
Do.	10:30	57.75		
Do.	10:32	57.71		
Do.	10:35	57.66		
Do.	10:40	57.59		
Do.	10:45	57.53		
Do.	10:50	57.49		
Do.	10:55	57.45		
Do.	11:05	57.38		
Do.	11:22	57.31		
Do.	11:25	--		Pumping started in well 57-50-101.
Do.	11:26	65.03		
Do.	11:27	65.83		
Do.	11:28	66.03		
Do.	11:29	66.18		
Do.	11:30	66.30		
Do.	11:31	66.39		
Do.	11:32	66.45		
Do.	11:33	66.52		
Do.	11:34	66.56		
Do.	11:35	66.61		
Do.	11:36	66.63		
Do.	11:38	66.70		
Do.	11:40	66.76		
Do.	11:42	66.80		
Do.	11:45	66.88		
Do.	11:48	66.94		
Do.	11:51	66.98		
Do.	11:55	67.04		
Do.	12:00	67.10		
Do.	12:05 p. m.	67.17		
Do.	12:15	67.27		

(Continued on next page)

Table 10.--Pumping-test data for wells 57-50-101 and 57-50-102--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
		Well 57-50-102--Continued		
1-21-63	12:25 p. m.	67.39		
Do.	12:35	67.45		
Do.	12:45	67.51		
Do.	1:00	67.60		
Do.	1:15	67.70		
Do.	1:30	67.81		
Do.	1:45	67.87		
Do.	2:00	67.92		
Do.	2:15	67.95		
Do.	2:25	--		Pumping started in well 57-50-102. Pumping continued in well 57-50-101.
Do.	2:26	72.69		
Do.	2:27	73.23		
Do.	2:28	73.38		
Do.	2:29	73.44		
Do.	2:30	73.48		
Do.	2:31	73.52		
Do.	2:32	73.53		
Do.	2:33	73.54		
Do.	2:34	73.57		
Do.	2:35	73.60		
Do.	2:36	73.61		
Do.	2:37	73.62		
Do.	2:38	73.63		
Do.	2:39	73.64		
Do.	2:40	73.65		
Do.	2:42	73.67		
Do.	2:45	73.71		
Do.	2:48	73.74		
Do.	2:50	73.76		
Do.	2:55	73.80		
Do.	3:00	73.83		
Do.	3:15	73.93		
Do.	3:30	73.99		
Do.	4:00	74.10		
Do.	4:15	74.17		
Do.	4:30	74.22		
Do.	5:15	74.40		
Do.	6:00	74.45		

Table 11.--Pumping-test data for well 57-41-301

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
				Pumping test of July 31, 1962
				(Pumping test conducted by city of Fredericksburg Water Department)
				Depths to water measured with air line. Depth to water before pumping started was 205 ft. Bottom of pump intake pipe at 338 ft.
7-31-62	9:45 a. m.	274	375	
Do.	10:15	274	350	
Do	10:45	274	340	
Do.	11:15	274	340	
Do.	11:45	274	340	
Do.	12:15 p. m.	274	330	
Do.	12:45	274	325	
Do.	1:15	274	320	
Do.	1:45	295	300	
Do.	2:15	295	300	
Do.	2:45	295	320	
Do.	3:15	295	300	
Do.	3:45	297	300	
Do.	4:15	297	290	
Do.	4:45	297	290	
Do.	5:15	297	290	
Do.	5:45	274	290	
Do.	6:15	262	200	Pumping sand and water.
Do.	6:45	288	300	
Do.	7:15	297	300	
Do.	7:45	299	290	
Do.	8:15	299	290	
Do.	8:45	299	290	
Do.	9:15	299	290	
Do.	9:45	299	290	
				Pumping test from August 2 through August 3, 1962
				(Pumping test conducted by city of Fredericksburg Water Department)
				Depths to water obtained with air line. Depth to water before pumping began was 205 ft. Bottom of pump intake pipe at 338 ft.

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from August 2 through August 3, 1962--Continued				
8- 2-62	10:45 a. m.	205	300	
Do.	11:15	256	300	
Do.	11:45	262	300	
Do.	12:15 p. m.	262	300	
Do.	12:45	265	300	
Do.	1:15	265	300	
Do.	1:45	265	300	
Do.	2:15	265	300	
Do.	2:45	265	300	
Do.	3:15	265	300	
Do.	3:45	269	300	
Do.	4:15	269	300	
Do.	4:45	274	300	
Do.	5:15	274	300	
Do.	5:45	274	300	
Do.	6:15	274	300	
Do.	6:45	274	300	
Do.	7:15	274	300	
Do.	7:45	274	300	
Do.	8:15	279	300	Pumping sand and water.
Do.	8:45	297	250	
Do.	9:15	269	250	
Do.	9:45	269	250	
Do.	10:15	269	250	
Do.	10:45	265	250	
Do.	11:15	267	250	
Do.	11:45	269	300	
8- 3-62	12:15 a. m.	274	300	
Do.	12:45	297	300	Pumping sand and water.
Do.	1:15	288	250	
Do.	1:45	274	250	
Do.	2:15	274	250	
Do.	2:45	274	250	
Do.	3:15	274	250	
Do.	3:45	274	250	
Do.	4:15	274	250	
Do.	4:45	269	250	
Do.	5:15	269	250	
Do.	5:45	269	250	
Do.	6:15	269	250	
Do.	6:45	269	250	
Do.	7:15	267	250	
Do.	7:45	267	250	

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from August 2 through August 3, 1962--Continued				
8- 3-62	8:15 a. m.	267	250	
Do.	8:45	267	250	
Do.	9:15	269	250	
Do.	9:45	274	300	
Do.	10:15	274	300	
Do.	10:45	285	280	Pumping sand and water.
Do.	11:15	279	280	

Pumping test from January 26 through February 1, 1963

(Pumping test conducted by personnel of the Texas Water Commission)

Pumped well 57-41-301

				Depths to water referenced to top of plate over casing, which is 0.78 ft. above land-surface datum. Prior to pumping test, well had not been pumped since November 1962, except for short intervals between 4 p.m. 1-25-63 and 11 a.m. 1-26-63.
1-25-63	4:00 p. m.	196.22		
1-26-63	9:00 a. m.	196.30		
Do.	1:13 p. m.	199.10		
Do.	1:15	197.55		
Do.	3:03	197.01		
Do.	3:28	196.93		
Do.	3:30	--		Pumping started. Pumping rate measured with 4" x 3" pipe orifice.
Do.	3:31	209.20		
Do.	3:32	211.92	192	
Do.	3:33	214.42		
Do.	3:34	215.73		
Do.	3:35	216.73		
Do.	3:36	217.65	190	
Do.	3:37	218.58	195	
Do.	3:38	219.17	194	
Do.	3:39	219.68	192	

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Pumped well 57-41-301--Continued				
1-26-63	3:40 p. m.	220.15	192	
Do.	3:42	220.98	192	
Do.	3:44	221.56	191	
Do.	3:46	222.09	191	
Do.	3:48	222.58	190	
Do.	3:50	223.17	198	
Do.	3:52	223.73		
Do.	3:54	224.12	195	
Do.	3:56	224.45	195	
Do.	3:58	224.70	194	
Do.	4:00	224.96	194	
Do.	4:03	225.30	193	
Do.	4:06	225.58	193	
Do.	4:09	225.72	191	
Do.	4:12	225.92	190	
Do.	4:15	226.15	190	
Do.	4:20	226.64	192	
Do.	4:25	226.99	192	
Do.	4:30	227.29	192	
Do.	4:40	227.77	191	
Do.	4:45	228.58	198	
Do.	4:50	228.68	195	
Do.	5:00	228.78	192	
Do.	5:15	229.30	192	
Do.	5:30	229.74	192	
Do.	5:45	230.17	192	
Do.	6:00	230.48	192	
Do.	6:30	231.13	191	
Do.	7:00	231.59	191	
Do.	7:30	232.08	191	
Do.	8:00	232.47	191	
Do.	8:30	233.01	192	
Do.	9:00	233.40	191	
Do.	10:00	233.96	191	
Do.	11:00	235.09	195	
1-27-63	12:10 a. m.	235.66	194	
Do.	1:55	236.41	194	
Do.	3:55	237.09	194	
Do.	5:55	237.58	194	
Do.	8:55	238.36	195	
Do.	12:00	238.96	193	

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Pumped well 57-41-301--Continued				
1-27-63	4:00 p. m.	239.58	193	
Do.	8:05	240.15	192	
1-28-63	12:05 a. m.	240.61	192	
Do.	8:05	241.29	192	
Do.	6:30 p. m.	--	192	Changed location of discharge; pumping rate changed.
Do.	8:00	242.08	?	
1-29-63	8:35 a. m.	242.65	?	
Do.	7:20	243.63	?	
1-30-63	9:25	244.13	?	
Do.	2:00	--	187	Pumping rate measured with tank and stopwatch.
Do.	2:05	245.16		
Do.	3:26	245.21		
Do.	3:30	--		Pumping stopped.
Do.	3:31	228.93		
Do.	3:32	227.65		
Do.	3:33	226.59		
Do.	3:34 p. m.	225.48		
Do.	3:35	224.64		
Do.	3:36	223.55		
Do.	3:37	222.83		
Do.	3:38	222.08		
Do.	3:39	221.54		
Do.	3:40	221.03		
Do.	3:42	220.10		
Do.	3:44	219.40		
Do.	3:46	218.78		
Do.	3:48	218.27		
Do.	3:50	217.81		
Do.	3:52	217.39		
Do.	3:54	217.02		
Do.	3:56	216.69		
Do.	3:58	216.40		
Do.	4:00	216.10		
Do.	4:05	215.50		
Do.	4:10	215.00		
Do.	4:20	214.16		
Do.	4:30	213.49		
Do.	4:40	212.81		
Do.	4:50	212.46		
Do.	5:00	212.01		

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Pumped well 57-41-301--Continued				
1-30-63	5:15 p. m.	211.44		
Do.	5:30	210.96		
Do.	6:00	210.12		
Do.	6:30	209.48		
Do.	7:00	208.86		
Do.	8:00	207.90		
Do.	9:00	207.12		
Do.	10:00	206.47		
Do.	12:00	205.41		
1-31-63	1:55 a. m.	204.53		
Do.	4:00	203.80		
Do.	6:00	203.19		
Do.	10:00	202.20		
Do.	1:50 p. m.	201.37		
Do.	6:15	200.73		
Do.	11:50	200.02		
2- 1-63	5:50 a. m.	199.44		
Do.	12:00	198.93		
Observation well 57-41-604				
1-26-63	8:15 a. m.	130.25		Depths to water referenced to top of casing which is 1.0 ft. above land-surface datum.
Do.	3:10 p. m.	130.96		
Do.	3:28	130.93		
Do.	3:30	130.92		Pumping started in well 57-41-301.
Do.	3:31	130.92		
Do.	3:32	130.93		
Do.	3:33	130.96		
Do.	3:34	131.02		
Do.	3:35	131.10		
Do.	3:36	131.19		
Do.	3:37	131.27		
Do.	3:38	131.39		
Do.	3:39	131.50		
Do.	3:40	131.60		
Do.	3:41	131.71		
Do.	3:42	131.84		
Do.	3:43	131.95		

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Observation well 57-41-604--Continued				
1-26-63	3:44 p. m.	132.06		
Do.	3:45	132.16		
Do.	3:46	132.28		
Do.	3:47	132.37		
Do.	3:48	132.48		
Do.	3:49	132.57		
Do.	3:50	132.68		
Do.	3:51	132.77		
Do.	3:52	132.86		
Do.	3:53	132.96		
Do.	3:54	133.07		
Do.	3:55	133.16		
Do.	3:56	133.25		
Do.	3:57	133.35		
Do.	3:58	133.39		
Do.	3:59	133.48		
Do.	4:00	133.58		
Do.	4:02	133.74		
Do.	4:04	133.87		
Do.	4:06	134.03		
Do.	4:08	134.20		
Do.	4:10	134.30		
Do.	4:12	134.43		
Do.	4:14	134.57		
Do.	4:16	134.72		
Do.	4:18	134.79		
Do.	4:20	134.92		
Do.	4:22	135.02		
Do.	4:24	135.13		
Do.	4:26	135.24		
Do.	4:28	135.38		
Do.	4:30	135.44		
Do.	4:32	135.56		
Do.	4:34	135.63		
Do.	4:36	135.74		
Do.	4:38	135.82		
Do.	4:40	135.92		
Do.	4:42	136.00		
Do.	4:44	136.09		
Do.	4:46	136.18		
Do.	4:48	136.28		

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Observation well 57-41-604--Continued				
1-26-63	4:50 p. m.	136.34		
Do.	4:52	136.45		
Do.	4:54	136.53		
Do.	4:56	136.60		
Do.	4:58	136.68		
Do.	5:00	136.74		
Do.	5:05	136.94		
Do.	5:10	137.12		
Do.	5:15	137.30		
Do.	5:20	137.43		
Do.	5:25	137.59		
Do.	5:30	137.74		
Do.	5:35	137.88		
Do.	5:40	138.01		
Do.	5:45	138.15		
Do.	5:50	138.28		
Do.	5:55	138.42		
Do.	6:00	138.53		
Do.	6:05	138.66		
Do.	6:10	138.77		
Do.	6:15	138.88		
Do.	6:30	139.20		
Do.	6:50	139.62		
Do.	7:10	139.98		
Do.	7:40	140.50		
Do.	8:10	140.95		
Do.	8:40	141.39		
Do.	9:10	141.80		
Do.	10:00	142.42		
Do.	11:15	143.31		
Do.	12:00	143.79		
1-27-63	2:00 a. m.	144.79		
Do.	4:05	145.65		
Do.	6:05	146.28		
Do.	9:05	147.14		
Do.	12:05 p. m.	147.89		
Do.	4:10	148.66		
Do.	8:00	149.24		
Do.	12:00	149.85		
1-28-63	6:00 a. m.	150.60		
Do.	8:15 p. m.	151.40		

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Observation well 57-41-604--Continued				
1-29-63	8:45 a. m.	152.10		
Do.	7:10 p. m.	152.72		
1-30-63	8:45 a. m.	152.81		
Do.	2:45 p. m.	153.52		
Do.	3:29	153.59		
Do.	3:30	153.59		Pumping stopped.
Do.	3:31	153.58		
Do.	3:32	153.57		
Do.	3:33	153.54		
Do.	3:34	153.49		
Do.	3:35	153.41		
Do.	3:36	153.30		
Do.	3:37	153.19		
Do.	3:38	153.09		
Do.	3:39	153.00		
Do.	3:40	152.87		
Do.	3:42	152.60		
Do.	3:44	152.38		
Do.	3:46	152.14		
Do.	3:48	151.94		
Do.	3:50	151.75		
Do.	3:52	151.51		
Do.	3:54	151.33		
Do.	3:56	151.19		
Do.	3:58	150.99		
Do.	4:00	150.82		
Do.	4:05	150.42		
Do.	4:10	150.04		
Do.	4:15	149.70		
Do.	4:20	149.44		
Do.	4:25	149.12		
Do.	4:30	148.84		
Do.	4:35	148.60		
Do.	4:40	148.39		
Do.	4:45	148.13		
Do.	4:50	147.92		
Do.	4:55	147.69		
Do.	5:00	147.50		
Do.	5:15	146.92		
Do.	5:30	146.40		
Do.	5:45	145.99		

(Continued on next page)

Table 11.--Pumping-test data for well 57-41-301--Continued

Date	Time	Depth to water (ft.)	Pumping rate (gpm)	Remarks
Pumping test from January 26 through February 1, 1963--Continued				
Observation well 57-41-604--Continued				
1-30-63	6:00 p. m.	145.58		
Do.	7:00	144.87		
Do.	7:00	144.25		
Do.	8:10	143.07		
Do.	9:00	142.31		
Do.	10:00	141.57		
Do.	12:00	140.35		
Do.	2:00 a. m.	139.38		
1-31-63	4:00	138.57		
Do.	6:00	137.90		
Do.	10:00	136.73		
Do.	2:10 p. m.	135.75		
Do.	6:10	135.08		
2- 1-63	12:01 a. m.	134.27		
Do.	5:45	133.63		
Do.	11:50	133.07		

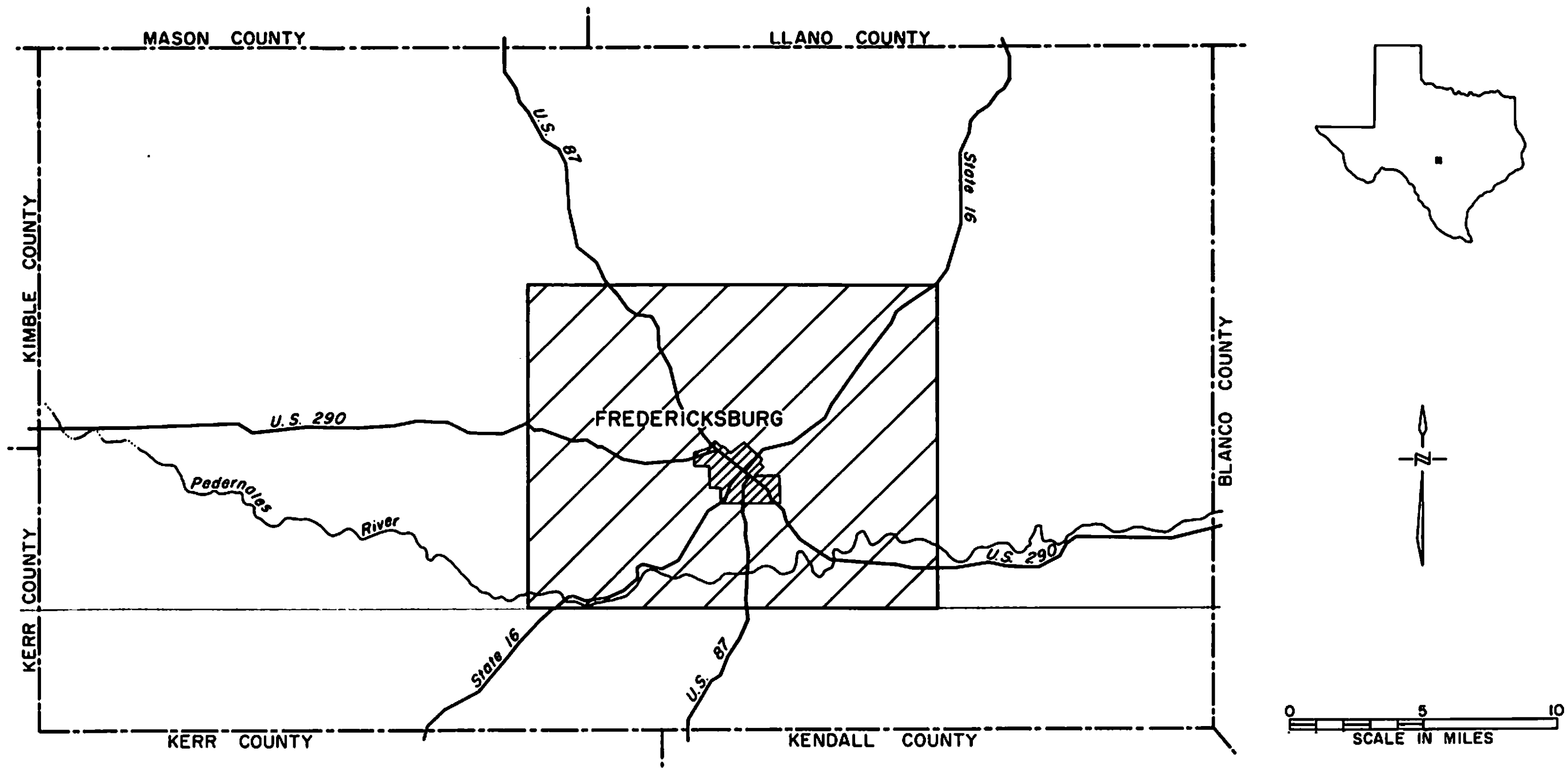

Figure I
Index Map of Gillespie County Showing Location of the Fredericksburg Area
Texas Water Commission

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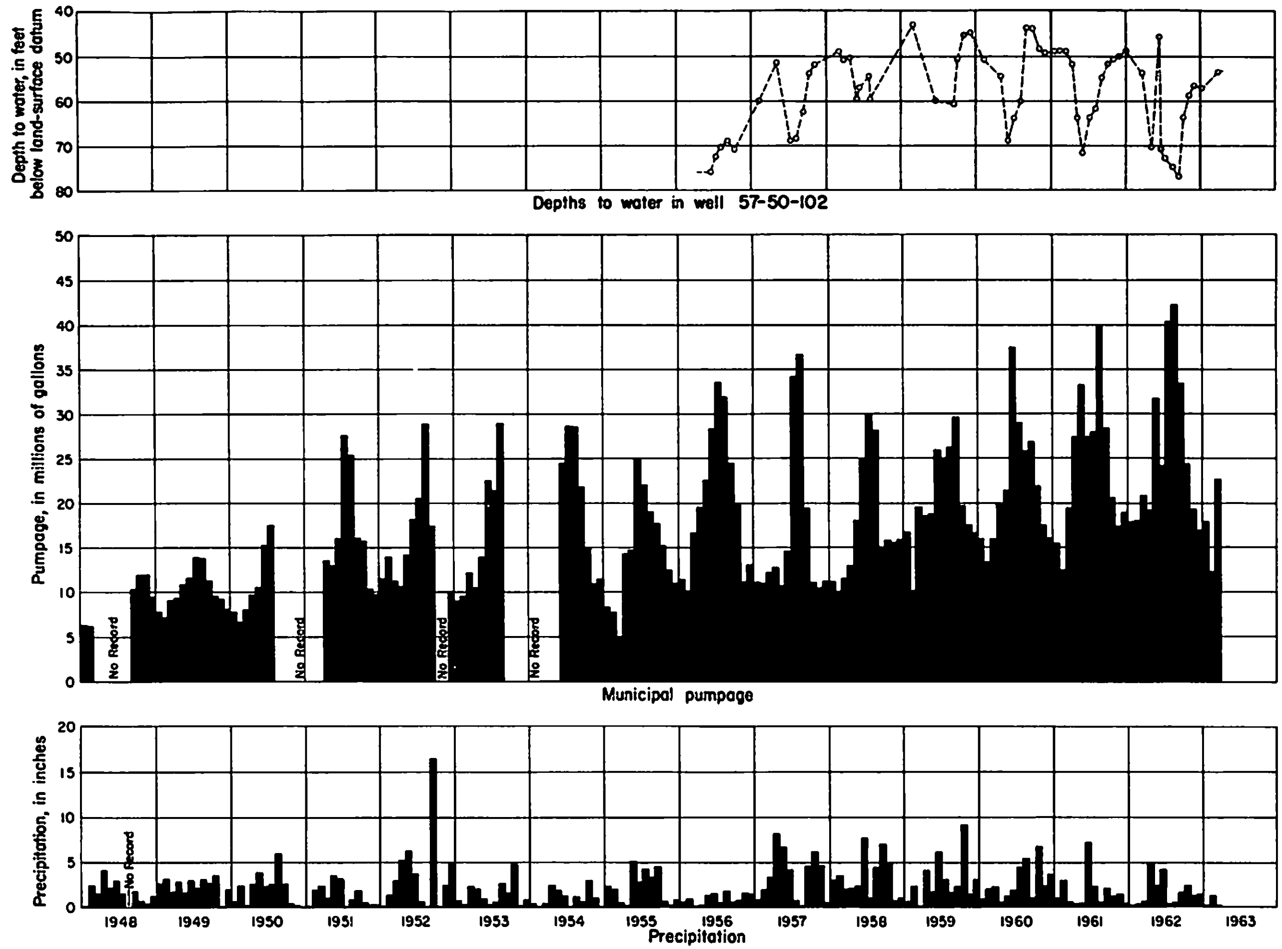

Figure 5

Depths to Water in Well 57-50-102, Monthly Municipal Pumpage, and Monthly Precipitation at Fredericksburg, 1948-63

Texas Water Commission

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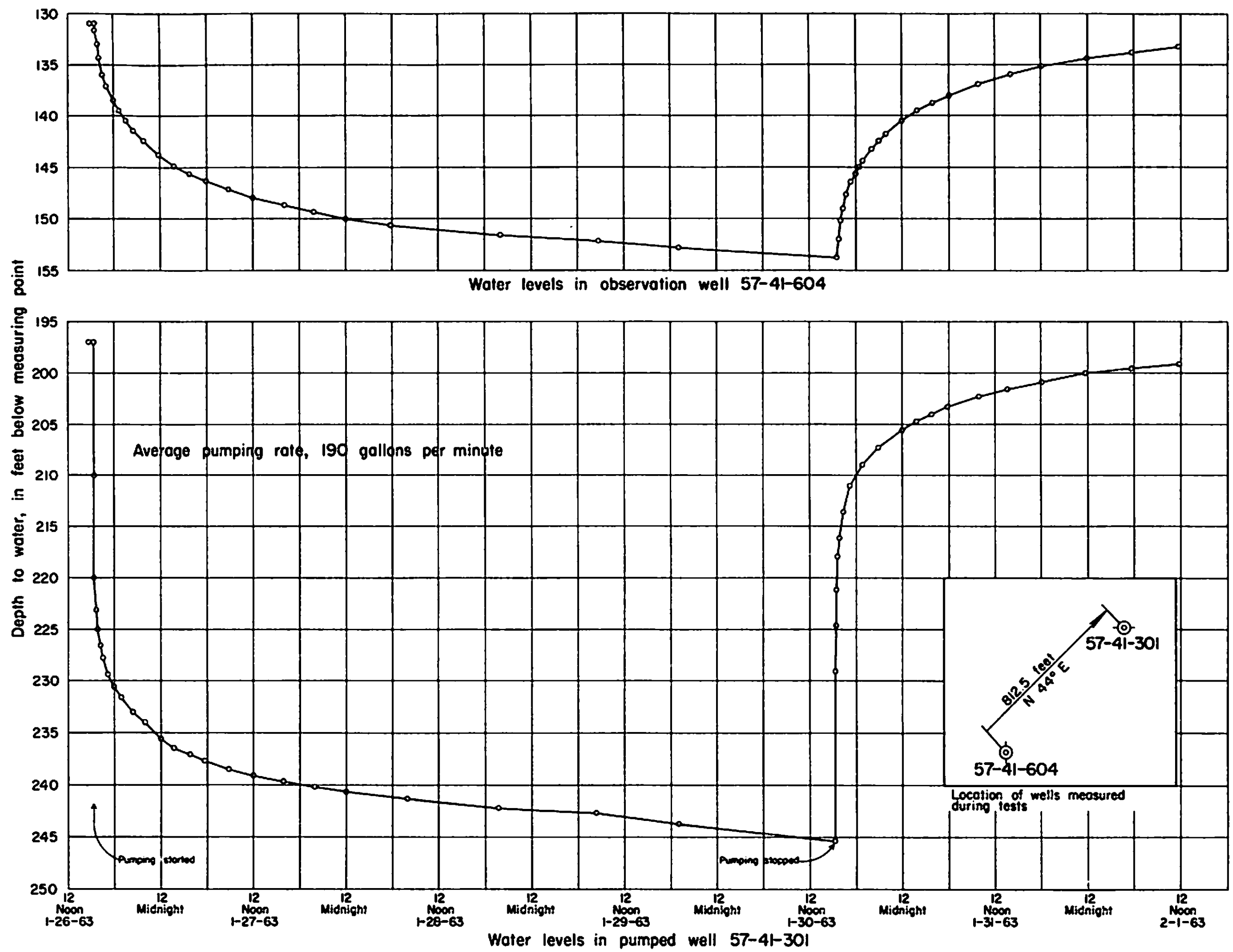

Figure 8

Pumping Test of Well 57-41-301

Texas Water Commission

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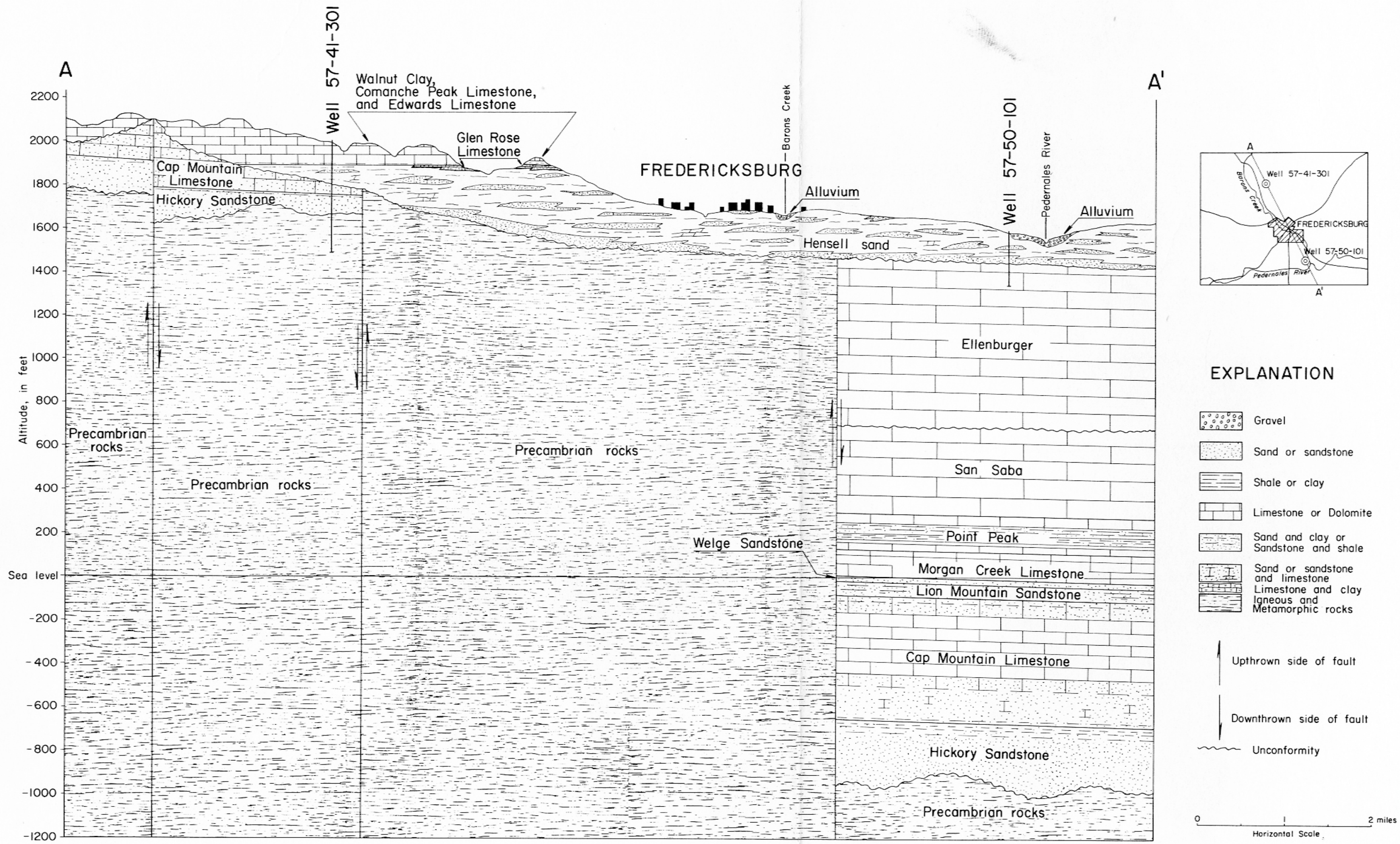

Figure 3

Generalized Geologic Section Through the Fredericksburg Area

Texas Water Commission

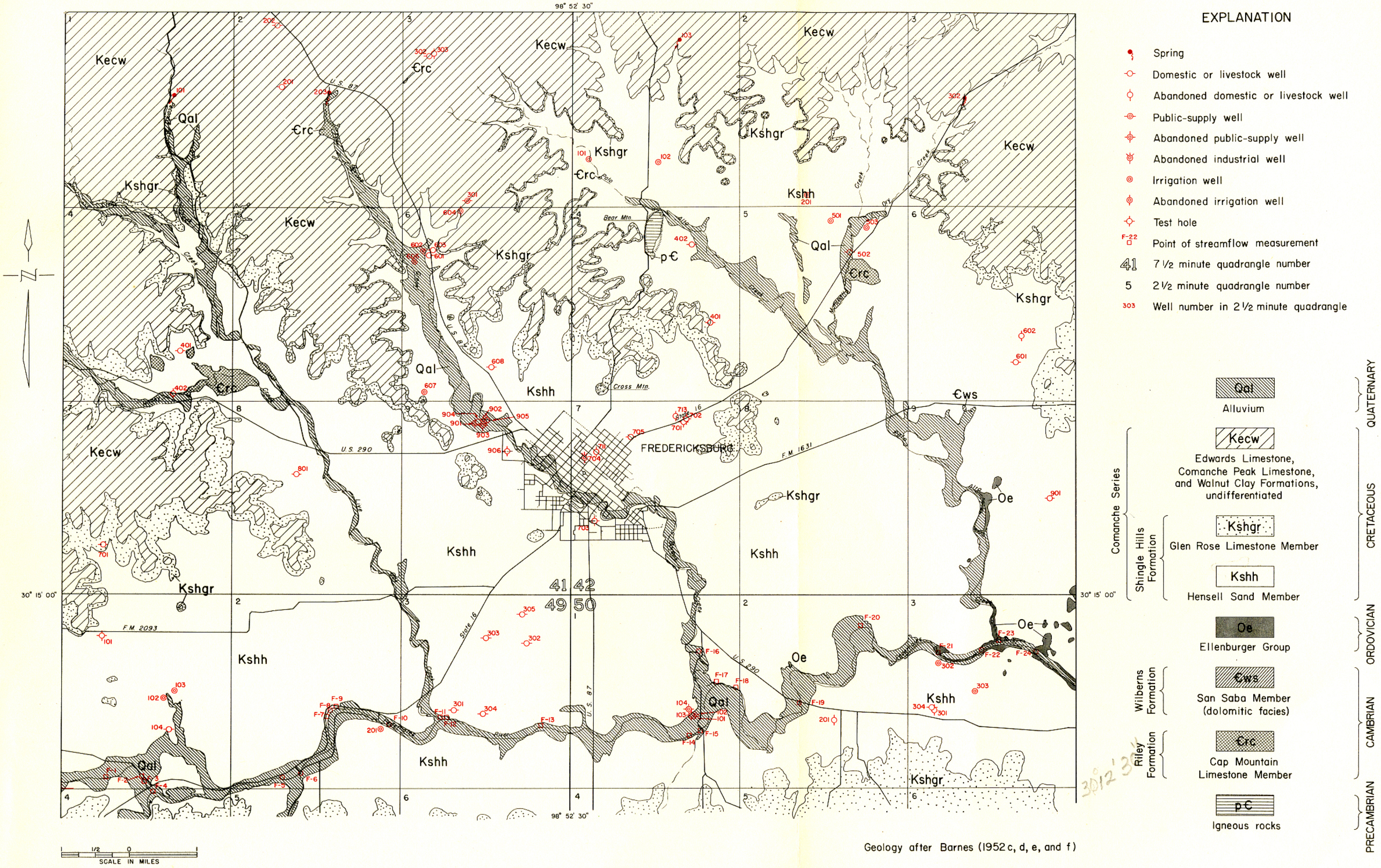

Figure 2

Geologic Map of the Fredericksburg Area Showing Locations of Data Points

Texas Water Commission

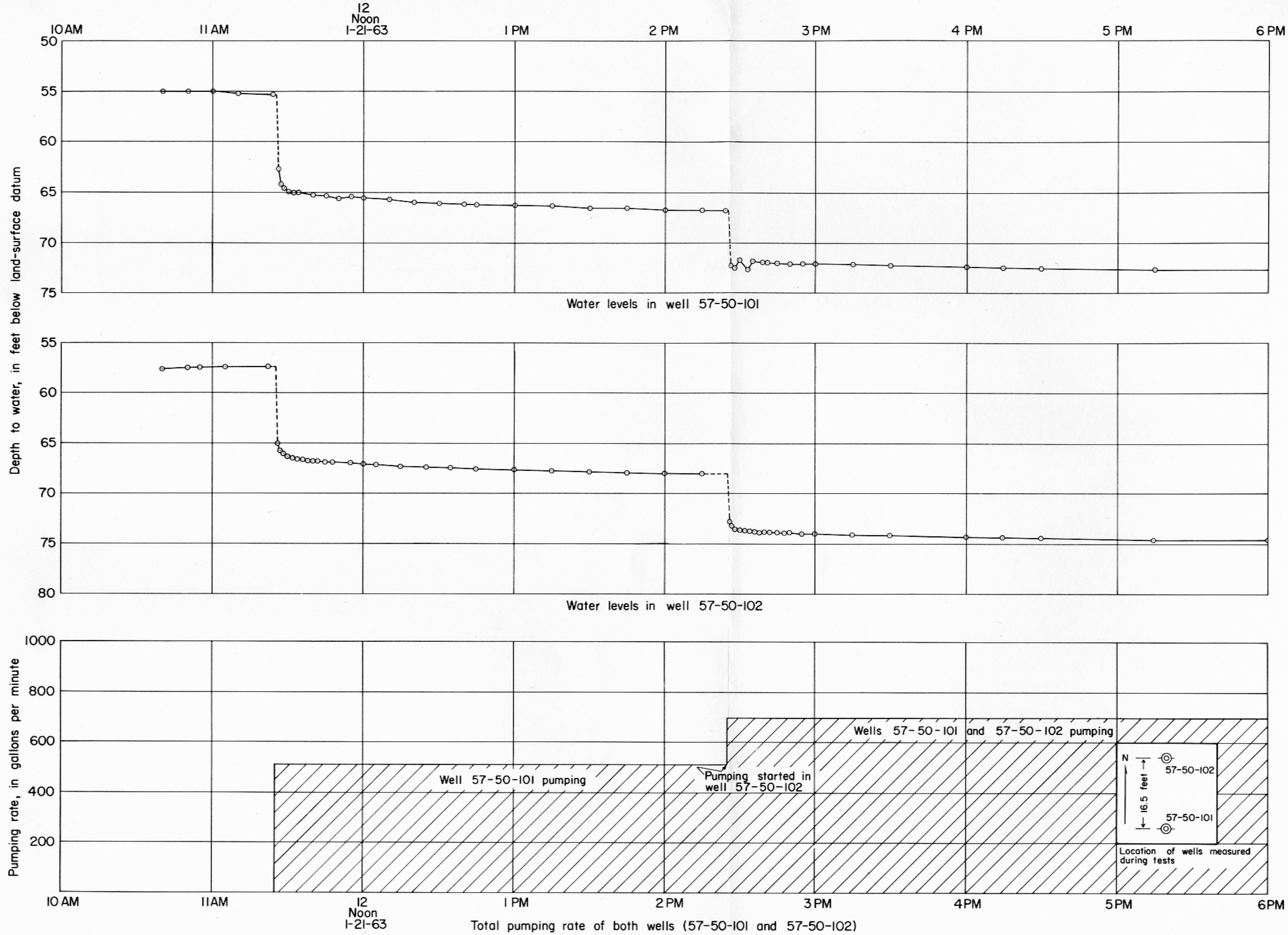

Figure 7

Pumping Test of Wells 57-50-101 and 57-50-102

Texas Water Commission

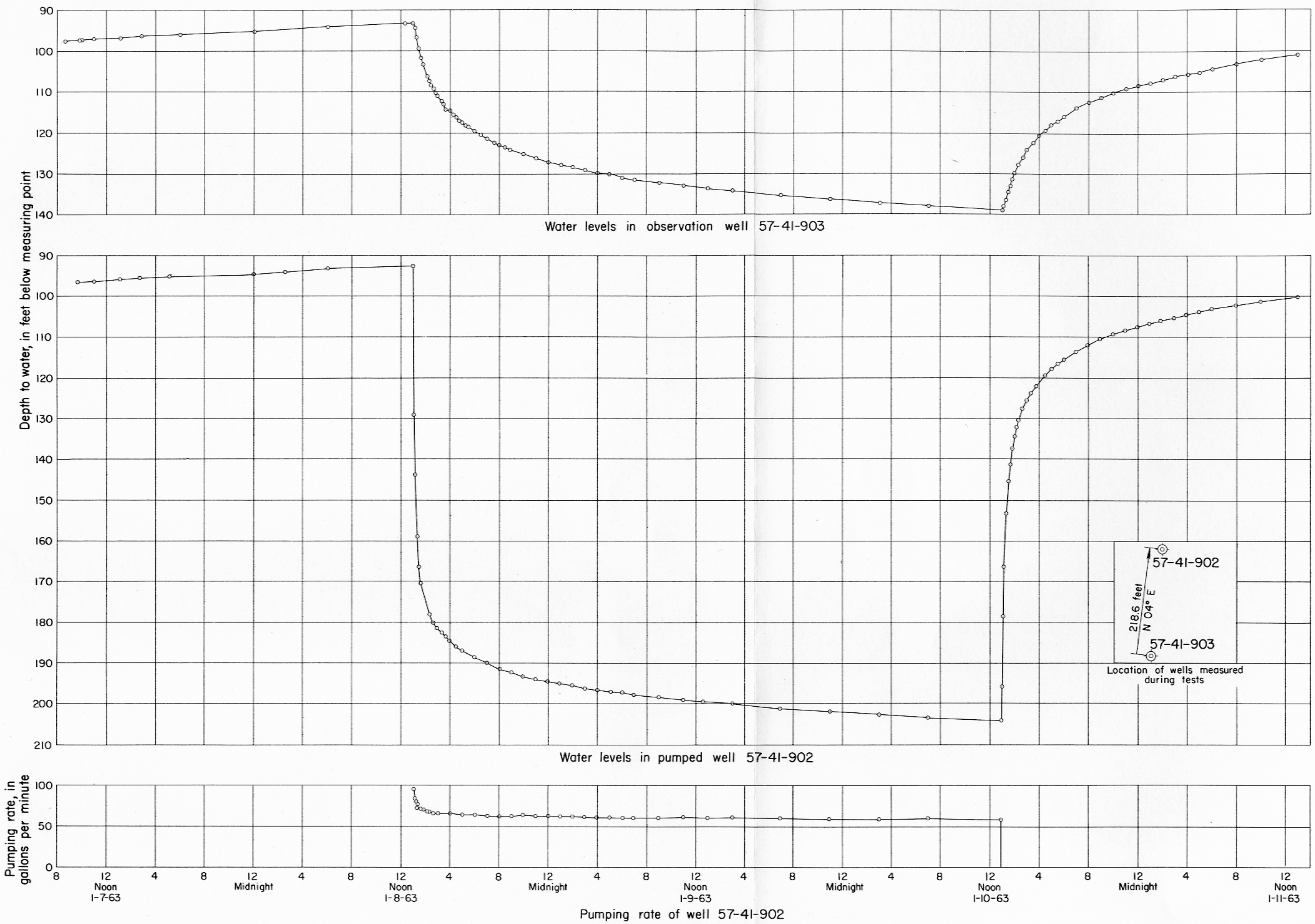

Figure 6

Pumping Test of Well 57-41-902

Texas Water Commission

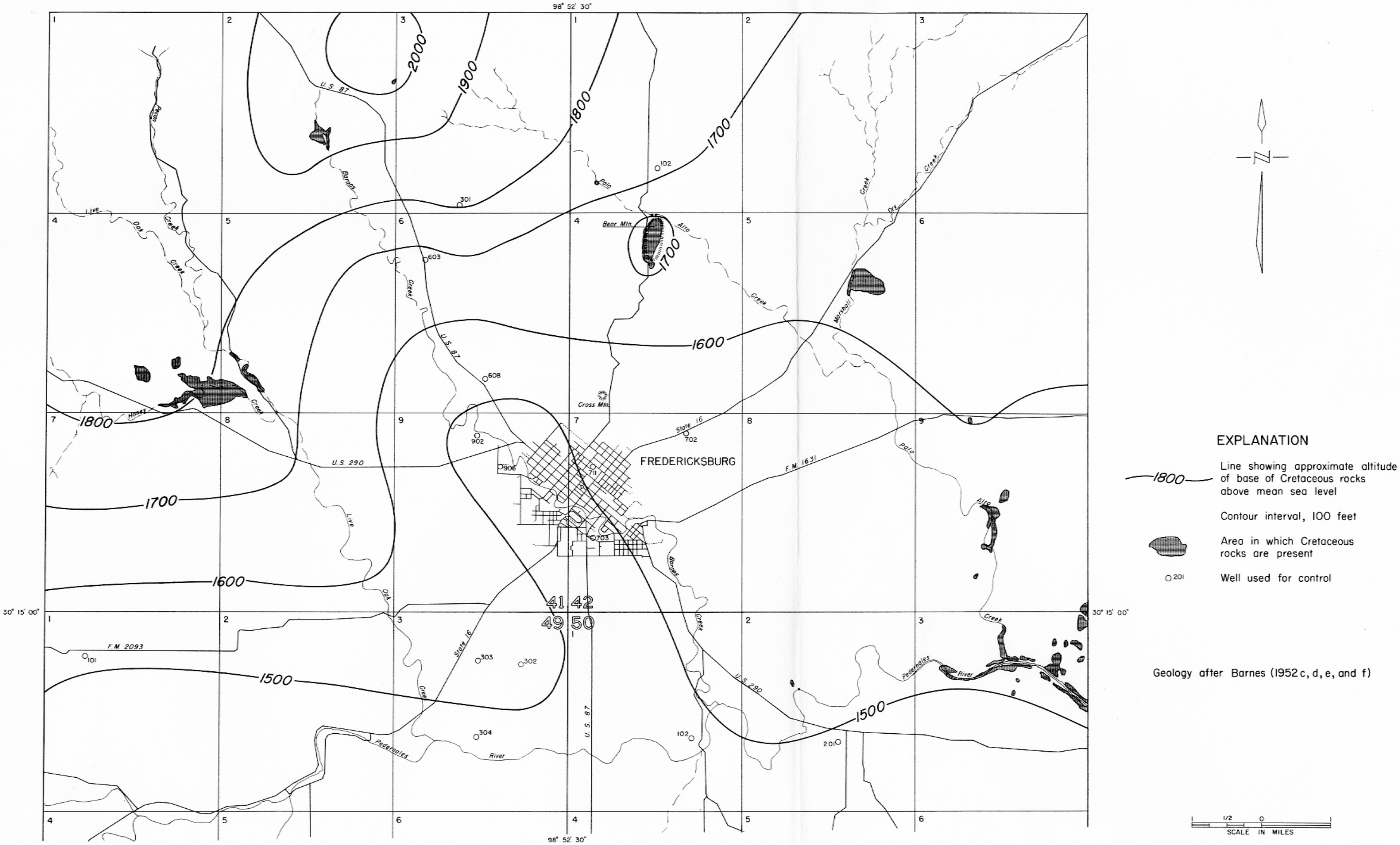

Figure 4

Approximate Altitude of the Base of Cretaceous Rocks, Fredericksburg Area

Texas Water Commission