GEOHYDROLOGY OF THE AQUIFER IN THE SANTA FE GROUP, NORTHERN WEST MESA OF THE MESILLA BASIN NEAR LAS CRUCES, NEW MEXICO

By Robert G. Myers and Brennon R. Orr

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4190

Prepared in cooperation with the

NEW MEXICO STATE ENGINEER OFFICE

and the CITY OF LAS CRUCES

Albuquerque, New Mexico

1985

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Water Resources Division
505 Marquette NW, Room 720
Albuquerque, New Mexico 87102

Copies of this report can
be purchased from:

Open-File Services Section
Branch of Distribution
U.S. Geological Survey, MS 306
Box 25425, Denver Federal Center
Denver, Colorado 80225
(303) 236-7476

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS - Concluded

TABLES

CONVERSION FACTORS

Figures for measurements in this report are given in inch-pound units only. The following table contains factors for converting to metric units.

Multiply inch-pound units	By	To obtain metric units
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
acre	4,047	square meter
square mile	2.590	square kilometer
foot per day	0.3048	meter per day
foot per mile	0.1894	meter per kilometer
foot squared per day	0.0929	meter squared per day
acre-foot	1,233	cubic meter
gallon per minute	0.631	liter per second

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 5/9(°F - 32).$$

GEOHYDROLOGY OF THE AQUIFER IN THE SANTA FE GROUP,

NORTHERN WEST MESA OF THE MESILLA BASIN NEAR LAS CRUCES, NEW MEXICO

by Robert G. Myers and Brennon R. Orr

ABSTRACT

The West Mesa of the Mesilla Basin in south-central New Mexico encompasses an undeveloped area of approximately 750 square miles west of the Rio Grande. In order to provide for orderly development of the ground-water supplies in the northern West Mesa, information is needed about the geohydrologic characteristics of the aquifer in the Santa Fe Group. The Santa Fe Group consists of Quaternary and Tertiary piedmont-slope, fluvial, playa, and lacustrine deposits composed of clay, silt, sand, gravel, and caliche, and igneous rocks composed of volcanic ash and basalt.

The saturated thickness of the aquifer in the Santa Fe Group ranges from about 3,440 feet at the Boles No. 1 Federal oil test well to zero at the western and northern borders of the study area. Because of the heterogeneity of the Santa Fe Group, the hydrologic characteristics of the aquifer vary substantially from place to place. Hydraulic conductivities of 12 and 30 feet per day were estimated from aquifer tests for two wells in the eastern one-half of the study area. Some of the well yields in the eastern one-half of the study area are greater than 1,000 gallons per minute. Well yields in the western one-half of the study area generally are less than 5 gallons per minute. Across the eastern one-half of the study area, ground water flows southeastward at a gradient of less than 5 feet per mile. Group water flows southeastward across the western one-half of the study area at a gradient of about 50 feet per mile. Dissolved-solids concentrations in ground water range from 378 to 556 milligrams per liter in the eastern one-half of the study area and from 906 to 1,470 milligrams per liter in the western one-half.

INTRODUCTION

The West Mesa of the Mesilla Basin in south-central New Mexico encompasses an undeveloped area of approximately 750 square miles west of the Rio Grande (fig. 1). The Doña Ana County Fairgrounds and Las Cruces Crawford Airport, both located on the West Mesa near Las Cruces, currently (1982) receive water via a 4-inch-diameter pipeline from the Las Cruces municipal wells in the Mesilla Valley. Planned development of the West Mesa near Las Cruces includes construction of an industrial park and a prison facility for the State of New Mexico. The city of Las Cruces hopes to provide additional ground-water supplies for these facilities from the aquifer in the Santa Fe Group underlying the West Mesa. El Paso, Texas, through ongoing litigation, and the Strauss Land and Cattle Co., through permit applications, are also attempting to acquire water rights on the West Mesa south of Las Cruces and the study area. In order to provide for orderly development of these supplies, information is needed about the capacity of the aquifer to transmit and store water, the long-term effects of pumping in the West Mesa area on the aquifer to the east and on the flow of the Rio Grande, and horizontal and vertical water-quality changes within the aquifer.

The purpose of this study was to obtain geohydrologic information about the aquifer in the Santa Fe Group on the northern West Mesa near Las Cruces, New Mexico (fig. 1). The scope of the study was limited to collecting and summarizing existing data from published and unpublished sources and collecting new data from two test wells drilled by the city of Las Cruces. This information will aid in the planning of future studies to evaluate the hydrology of the aquifer in the West Mesa area and the effects of its development on the aquifer to the east and on flow in the Rio Grande. The data obtained in this study will contribute to the ongoing Southwest Alluvial Basins study that is part of the U.S. Geological Survey's Regional Aquifer Systems-Analysis Program (Wilkins, Scott, and Kaehler, 1980). This study was done in cooperation with the New Mexico State Engineer Office and the city of Las Cruces.

Description of the Study Area

The West Mesa is that part of the Mesilla Basin bordered on the north by the Rough and Ready Hills and Robledo Mountain, on the east by the Mesilla Valley, on the south by the Mexican border, and on the west by the Potrillo Mountains, Aden Hills, and Sleeping Lady Hills (fig. 1). The surface of the West Mesa ranges from 300 feet to 350 feet above the Rio Grande.

The climate in the West Mesa area is semiarid. The study area is characterized by minimal relative humidity and large diurnal and annual temperature ranges. The mean annual temperature for the area is 60 degrees Fahrenheit (Houghton, 1972, p. 3). Temperatures during the summer months will occasionally exceed 100 degrees Fahrenheit. During approximately 2 days in the winter, the temperature will be less than 10 degrees Fahrenheit. The average annual precipitation from 1853 to 1976 was 8.39 inches (Wilson and others, 1981, p. 7). The average annual evaporation from a free water surface of a Class A pan is 94 inches (Houghton, 1972).

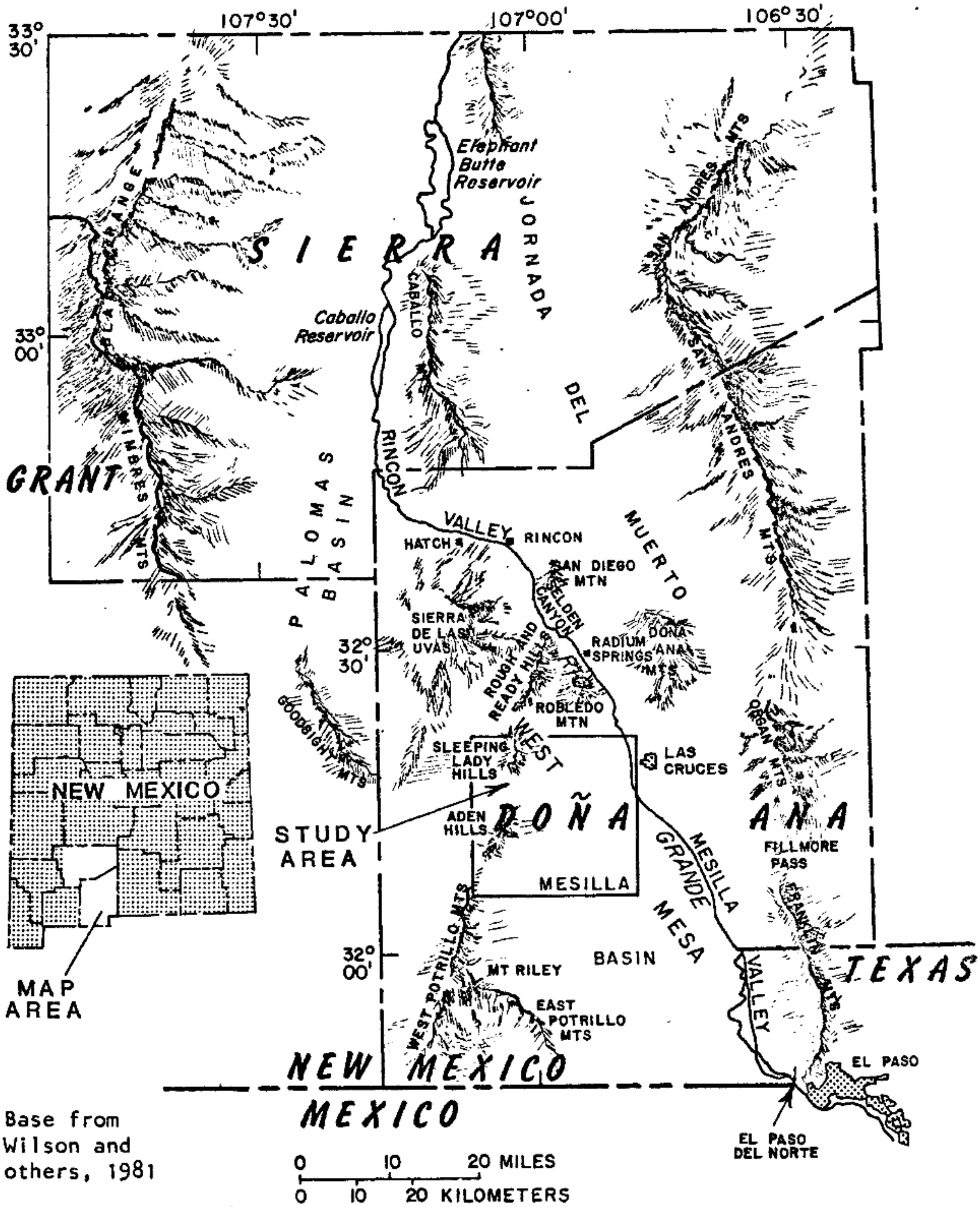


Figure 1.--Location of study area and physiographic features in south-central New Mexico.

There is little existing hydrologic information for the West Mesa. Previous hydrologic studies in Doña Ana County by Conover (1954), King and others (1971), Wilson and others (1981), and Wilson and White (1984) have concentrated on the Mesilla Valley (east of the West Mesa) because of the communities and agricultural development located along the Rio Grande. A few test wells have been drilled within the study area to obtain petroleum, hydrologic, or geologic information (Halpenny, Babcock, and Greene, 1972; Thompson and Bieberman, 1975; Wilson and others, 1981).

Well-Numbering System

The system of numbering wells and springs in New Mexico (fig. 2) is based on the common subdivision of public lands into sections. The well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land network. The number is divided by periods into four segments. The first segment denotes the township north or south of the New Mexico base line; the second denotes the range east or west of the New Mexico principal meridian; and the third denotes the section. The fourth segment of the number, which consists of three digits, denotes the 160-, 40-, and 10-acre tracts, respectively, in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is a tract of 160 acres. Similarly, the 160-acre tract is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 23S.01E.24.341 is in the NW¼ of the SE¼ of the SW¼, section 24, township 23 south, range 1 east. If a well cannot be located accurately within a 40 acre tract, zeros are used for both the second and third digits. The letters a, b, c, etc., are added to the last segment to designate succeeding wells in the same 10-acre tract.

Where sections are irregularly shaped, the well is located on the basis of a square section grid that is superimposed on the irregular section with the southeast corner and eastern section lines matching. The well is then numbered by its location in the superimposed square grid.

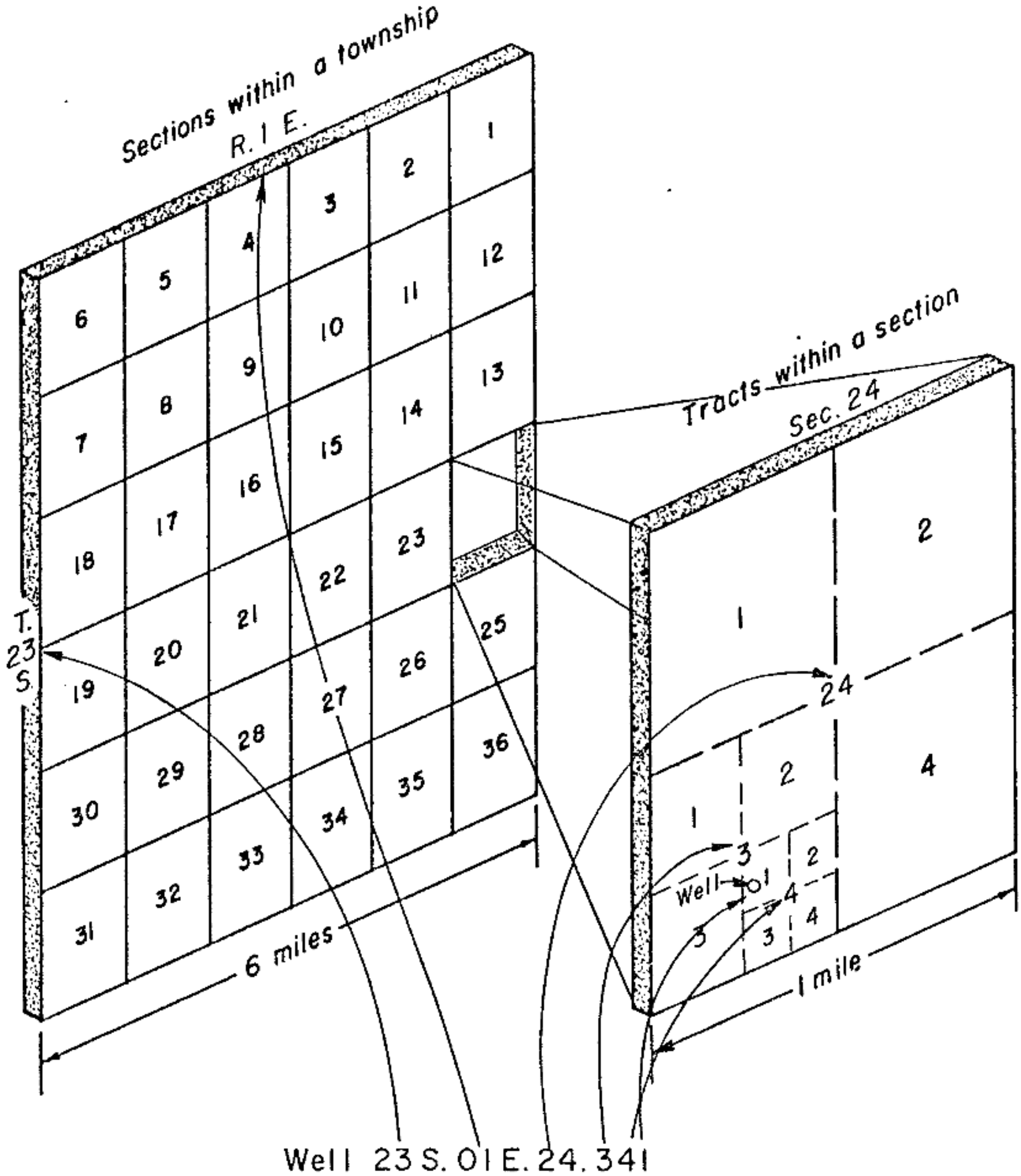


Figure 2.--System of numbering wells in New Mexico.

GEOHYDROLOGY

Geology

The West Mesa study area is characterized by northeast-trending faults that border a horst in the northwest and a graben in the south (fig. 3). These faults cut the Tertiary and Quaternary deposits of the Santa Fe Group. Geohydrologic sections constructed from vertical-electrical-resistivity soundings (Wilson and others, 1981, plate 8) infer a fault in the subsurface in the vicinity of city of Las Cruces well 37 (23S.01E.30.322) (fig. 4).

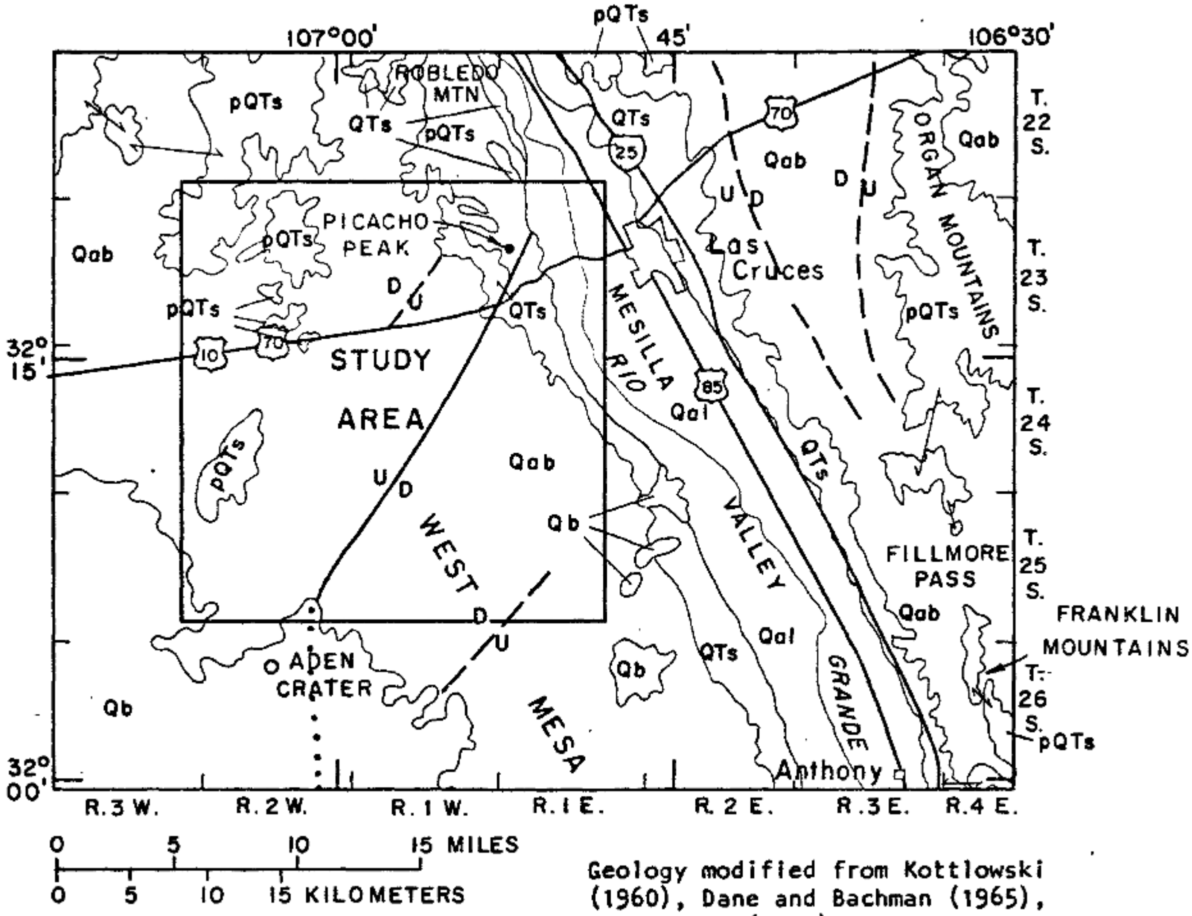
The Santa Fe Group in the West Mesa area overlies Tertiary volcanic and associated sedimentary rocks of early Oligocene to Miocene age and underlies the Quaternary deposits that postdate the beginning of the Rio Grande valley entrenchment in the middle Pleistocene (Hawley and others, 1969, p. 52). The Santa Fe Group consists of piedmont-slope, fluvial, playa, and lacustrine deposits composed of clay, silt, sand, gravel, and caliche, and igneous rocks composed of volcanic ash and basalt. The maximum reported thickness of the Santa Fe Group in the study area is 3,790 feet at the Boles No. 1 Federal oil test well (24S.01E.07.444) (fig. 4). The thickness of the Santa Fe Group decreases toward the western and northern borders of the study area. The Picacho Oil and Gas Syndicate, Armstrong No. 1, oil test well (23S.01W.15.211) (fig. 4) penetrated 165 feet of the Santa Fe Group (Kottlowski and others, 1956, p. 82).

The lower part of the Santa Fe Group in the Mesilla Basin is characterized by bolson deposits of locally derived materials. Deposition of these sediments was followed by a period of coalescing basins. During this period, the Mesilla Basin was characterized by deposition into large lakes from a system of shifting distributary channels (Hawley and others, 1969). At this time, the ancestral upper Rio Grande headwaters were north of the Mesilla Basin, whereas the ancestral lower Rio Grande headwaters were somewhere south of the Mesilla Basin. The channel of the ancestral upper Rio Grande was restricted near Rincon (fig. 1) at the southeastern end of the Palomas Basin. The integration of the upper and lower Rio Grande in the middle Pleistocene was followed by the entrenchment of the Mesilla Valley, which marked the end of Santa Fe deposition.

Aquifer Characteristics

The aquifer in the Santa Fe Group is the major source of fresh ground water within the Mesilla Basin. The aquifer in the West Mesa study area consists of clay, silt, sand, gravel, and caliche, and igneous rocks composed of volcanic ash and basalt. The saturated thickness ranges from about 3,440 feet at Boles No. 1 Federal oil test well (24S.01E.07.444) to zero at the western and northern borders of the study area (fig. 4).

The location of wells with borehole-geophysical and lithologic logs within the study area are shown in figure 4. Vertical-electrical-resistivity-sounding sites within the study area are shown in figure 5.



Geology modified from Kottlowski (1960), Dane and Bachman (1965), and Seager (1975).

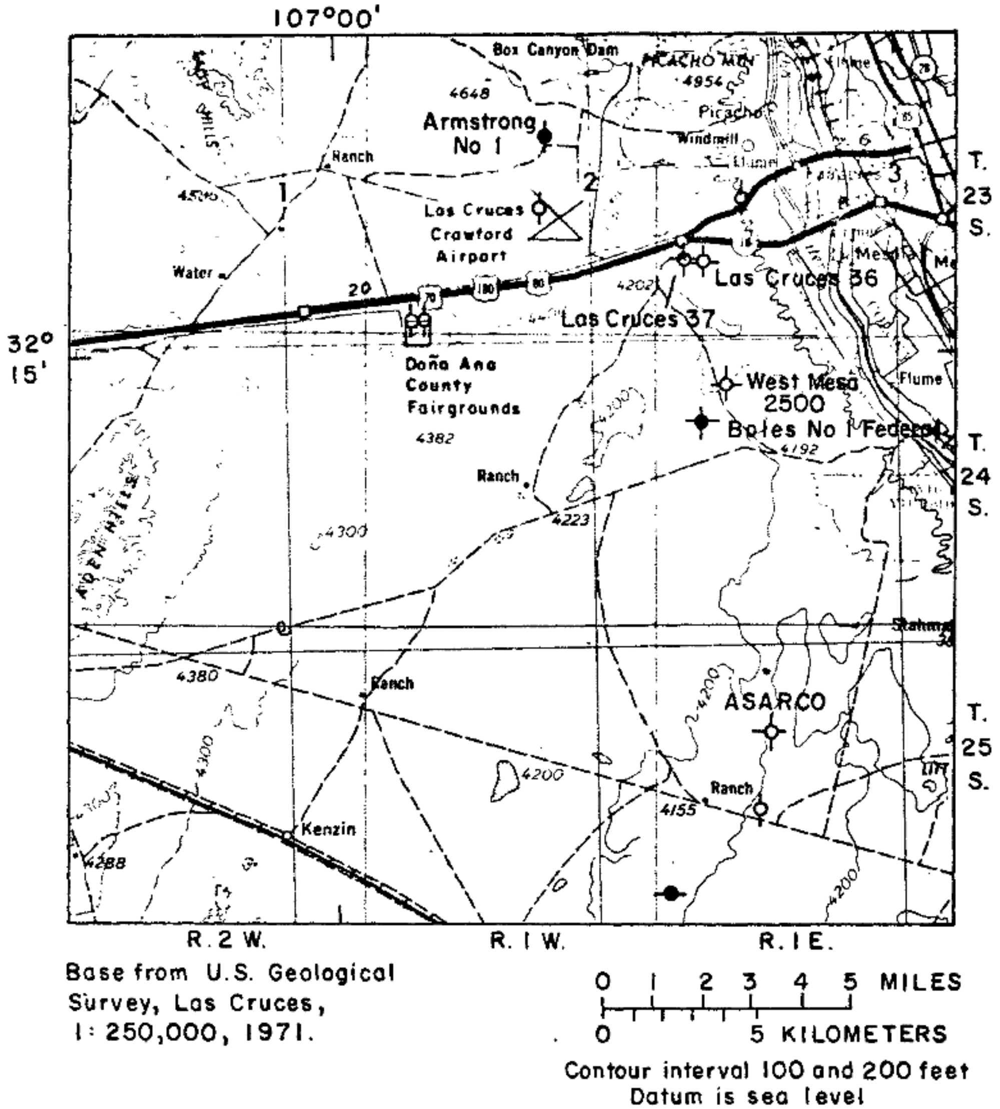
EXPLANATION

QUATERNARY	Qal	ALLUVIUM--Primarily in the Rio Grande Valley
	Qab	BASIN-FILL SURFICIAL DEPOSITS--Thin discontinuous cover of alluvial, eolian, and lacustrine deposits on the Santa Fe Group
	Qb	BASALT FLOWS AND CONES--Generally dated post-Santa Fe Group
QUATERNARY AND TERTIARY	QTs	SANTA FE GROUP
LOWER TERTIARY TO PRECAMBRIAN	pQTs	BEDROCK PRE-SANTA FE GROUP--Includes undifferentiated lower Tertiary, Mesozoic, Paleozoic, and Precambrian rocks.

——— CONTACT

D/U — — FAULT--Dashed where approximately located or inferred; dotted where concealed; D and U indicate downthrown and upthrown sides.

Figure 3.--Generalized geology of the study area and adjacent areas.



EXPLANATION

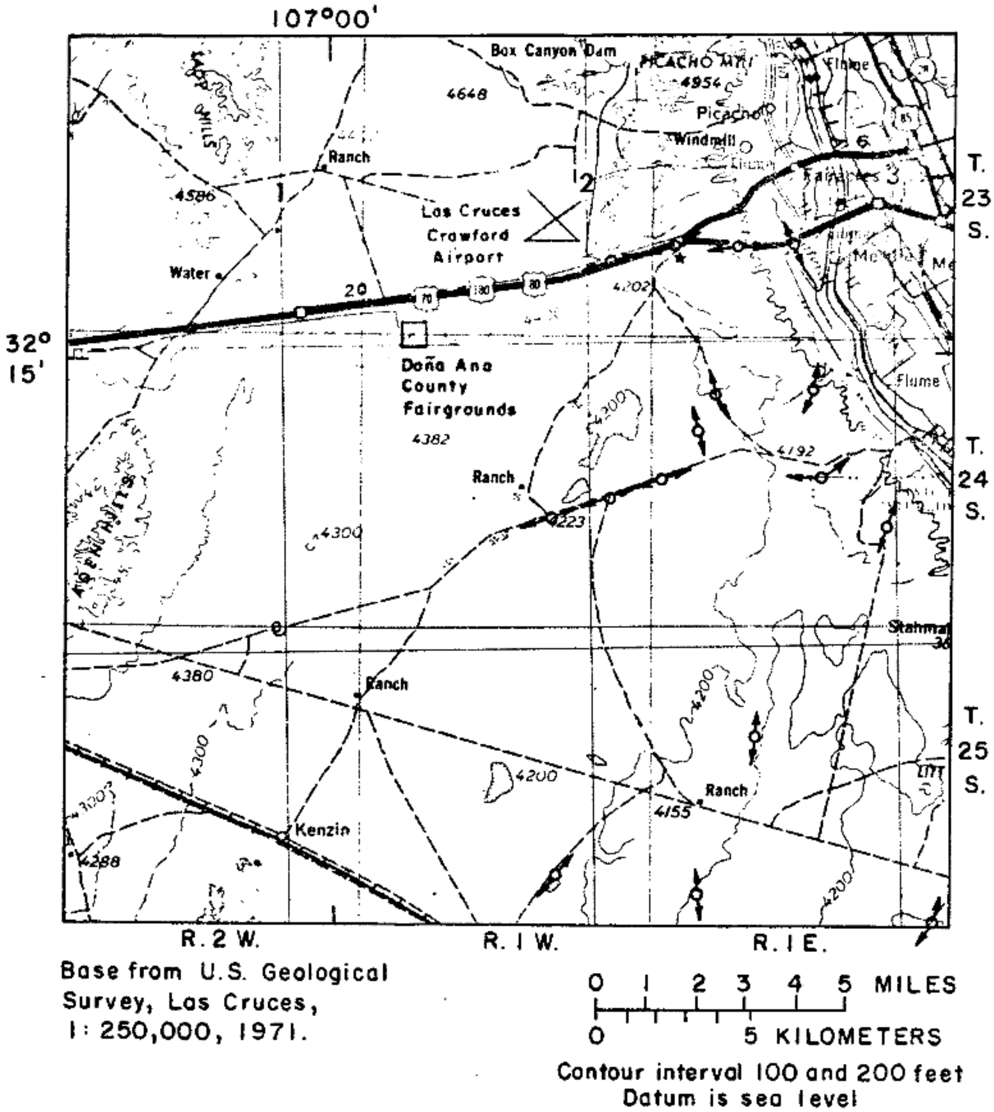
● OIL TEST WELL

○ WATER TEST WELL

ϕ WELL WITH LITHOLOGIC LOG

-○- WELL WITH BOREHOLE-GEOPHYSICAL LOG(S).

Figure 4.--Location of wells with lithologic and borehole-geophysical logs (Conover, 1954; King and others, 1971; Thompson and Bieberman, 1975).



EXPLANATION

 VERTICAL-ELECTRICAL-RESISTIVITY-SOUNDING SITE--Arrows indicate directions of sounding layouts.

Figure 5.--Location of vertical-electrical-resistivity soundings within the study area (Wilson and others, 1981, plate 2).

The ASARCO test production well (25S.01E.16.114) is located in the southeastern part of the study area (fig. 4). The ASARCO well was drilled in May and June 1972 to a depth of 1,650 feet (Halpenny, Babcock, and Greene, 1972) without reaching the base of the Santa Fe Group. The borehole was reamed to an 18-inch diameter from the surface to 600 feet and to a 15-inch diameter from 600 to 1,650 feet. The well was cased with 12 3/4-inch-diameter steel casing from the land surface to a depth of 600 feet and with 8 5/8-inch-diameter steel casing from 600 to 1,650 feet. The casing was perforated with machine-cut slots (3/16-inch width) from a depth of 450 to 1,650 feet, and gravel was emplaced between the casing and the wall of the hole in this interval. The static water level in the completed well was 354 feet below land surface on June 30, 1972. Borehole-geophysical and lithologic logs from Halpenny, Babcock, and Greene (1972) are shown in figure 6.

A production test was conducted on the ASARCO well on June 30, 1972. The well was pumped for 24 hours at a discharge rate that fluctuated between 1,002 and 1,077 gallons per minute. The total drawdown at the end of the test was 26 feet, resulting in a 24-hour specific capacity of about 40 gallons per minute per foot of drawdown.

Water-level data from the pumping and recovery parts of the ASARCO test were analyzed by Spiegel (1972a, 1972b) to determine aquifer characteristics. From this analysis, Spiegel estimated a transmissivity of approximately 10,000 feet squared per day and a storage coefficient of 2×10^{-5} for the tested interval (Spiegel, 1972a). An estimate of transmissivity of approximately 14,000 feet squared per day was derived from the specific capacity of the ASARCO well using a technique described by Brown (1963), Meyer (1963), and Theis (1963). Based on examination of borehole-geophysical logs (fig. 6), approximately 28 percent of the Santa Fe Group in the 1,200 feet of perforated interval in the ASARCO well consists of clay layers with minimal hydraulic conductivity. If the remaining 864 feet of the perforated interval yielded water to the well, the average hydraulic conductivity for the non-clay interval would be approximately 12 feet per day based on Spiegel's transmissivity estimate and approximately 16 feet per day based on the transmissivity estimate derived from the specific capacity.

Spiegel (1972a) noted that the aquifer in the Santa Fe Group in the vicinity of the ASARCO well probably will respond to pumping stress as a leaky-confined aquifer, and that boundary conditions such as faults and intrusive dikes could affect the shape of the cone of depression around a pumping well in the area. He also indicated that, in order to better define geohydrologic conditions in the West Mesa area, it is necessary to determine the effects from vertical leakage of water through and storage depletion from clay beds within the Santa Fe Group.

Las Cruces city test well 37 (23S.01E.30.322) was drilled by Layne Western Co., Inc., for the city of Las Cruces in May 1982 to a depth of 1,004 feet without reaching the base of the Santa Fe Group (fig. 4). The U.S. Geological Survey obtained borehole-geophysical logs from test well 37 as a part of this study. The borehole was reamed from the land surface to a depth of about 645 feet. The borehole-geophysical logs and cutting samples indicated that the water quality and permeability decreased below 645 feet.

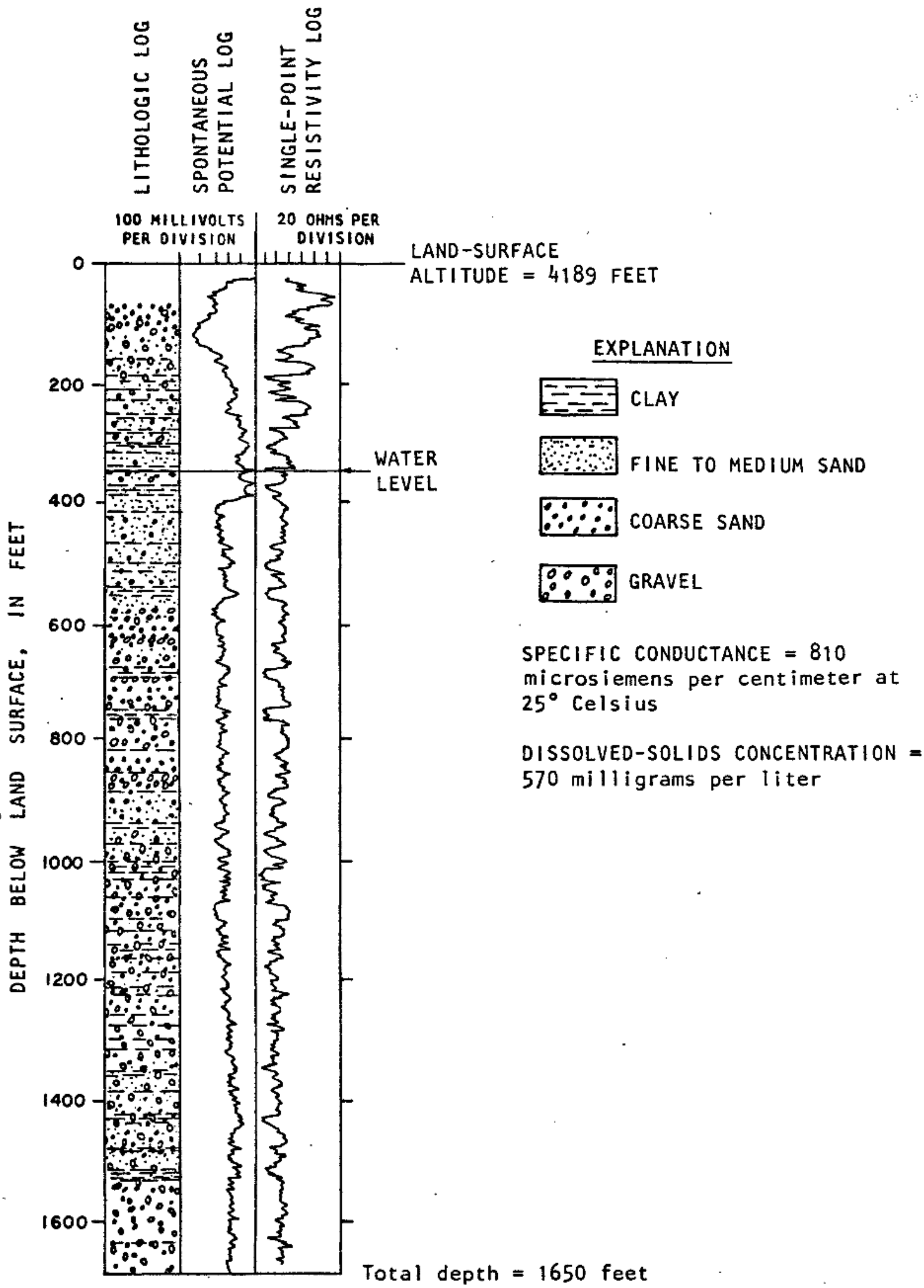


Figure 6.--Lithologic and borehole-geophysical logs from well 25S.01E.16.114.

The well was cased with 12-inch-diameter blank steel casing to a depth of 440 feet and screened with continuously wound 10-inch-diameter steel screen (0.06-inch slot size) from 440 to 640 feet. A gravel-pack was emplaced at the screened interval. The well was developed by adding a polyphosphate dispersing agent to water in the well bore, then bailing until the water was cleared of sediment. The static water level in the completed well was about 315 feet below land surface on August 9, 1982 (table 1).

Driller's logs (table 2) and U.S. Geological Survey borehole-geophysical logs (fig. 7) of test well 37 indicate the lithologic sequence below the water table predominantly consists of interbedded, fine-grained sand, silt, and clay units with some gravel. Examination of the electrical-resistivity log indicates an increase in dissolved solids in the formation water from a depth of approximately 400 feet to the bottom of the well.

A production test was attempted in test well 37 in July 1982. This test was aborted shortly after pumping began because the water level in the pumping well reached the depth of the pump-bowl assembly. The pump assembly could not be lowered deeper into the well because of the smaller diameter of the screened interval. As a result, the driller halted further attempts to test the production capacity of test well 37.

Las Cruces city test well 36 (23S.01E.30.422) was drilled by Layne Western Co., Inc., for the city of Las Cruces in August 1982 to a depth of about 1,500 feet without reaching the base of the Santa Fe Group at a location 0.5 mile east of test well 37 (fig. 4). The U.S. Geological Survey conducted a recovery test, obtained borehole-geophysical logs, and collected a water sample for analysis from test well 36 as a part of this study. The hole was reamed from the land surface to a depth of about 1,240 feet, and a cement plug was installed from a depth of 1,210 feet to the bottom of the hole. The well was cased with 16-inch-diameter blank steel casing to a depth of 710 feet and was screened with 260 feet of continuously wound 10-inch-diameter steel screen (0.06-inch slot size) at selected intervals from 710 to 1,210 feet. Gravel was emplaced between the wall of the hole and the well screen. The well was developed by adding a polyphosphate dispersing agent to water in the well bore, then bailing until the water was cleared of sediment. The static water level in the completed well was about 317 feet below land surface on August 9, 1982.

Based on borehole-geophysical and driller's logs (fig. 8, table 3), lithologic units penetrated in test well 36 include sand, silt, clay, and some gravel deposits. Major lithologic changes in test well 36 can be correlated on borehole-geophysical logs with lithologic changes in test well 37. From these logs, no vertical displacement of lithologic units is evident between the two wells.

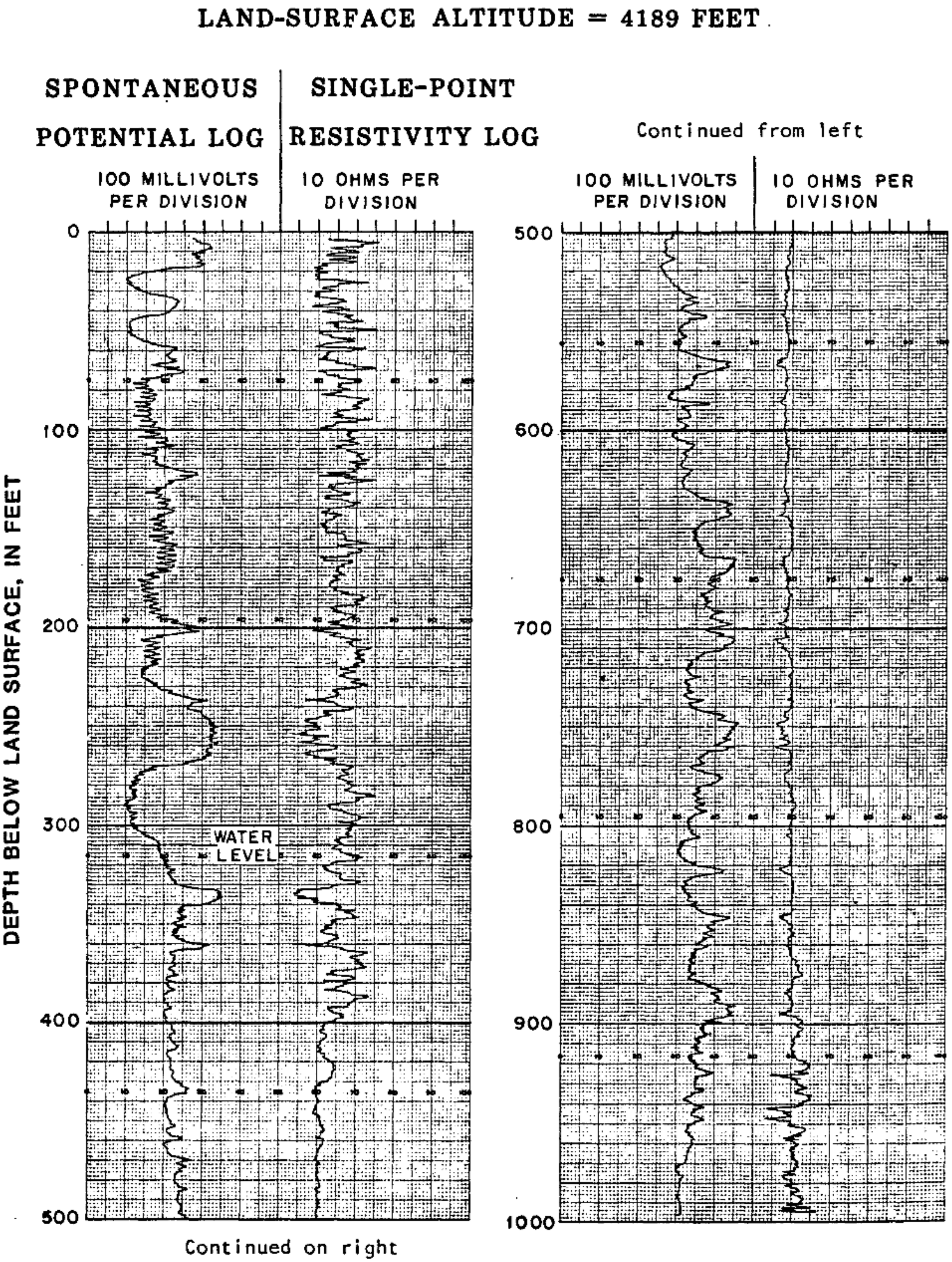
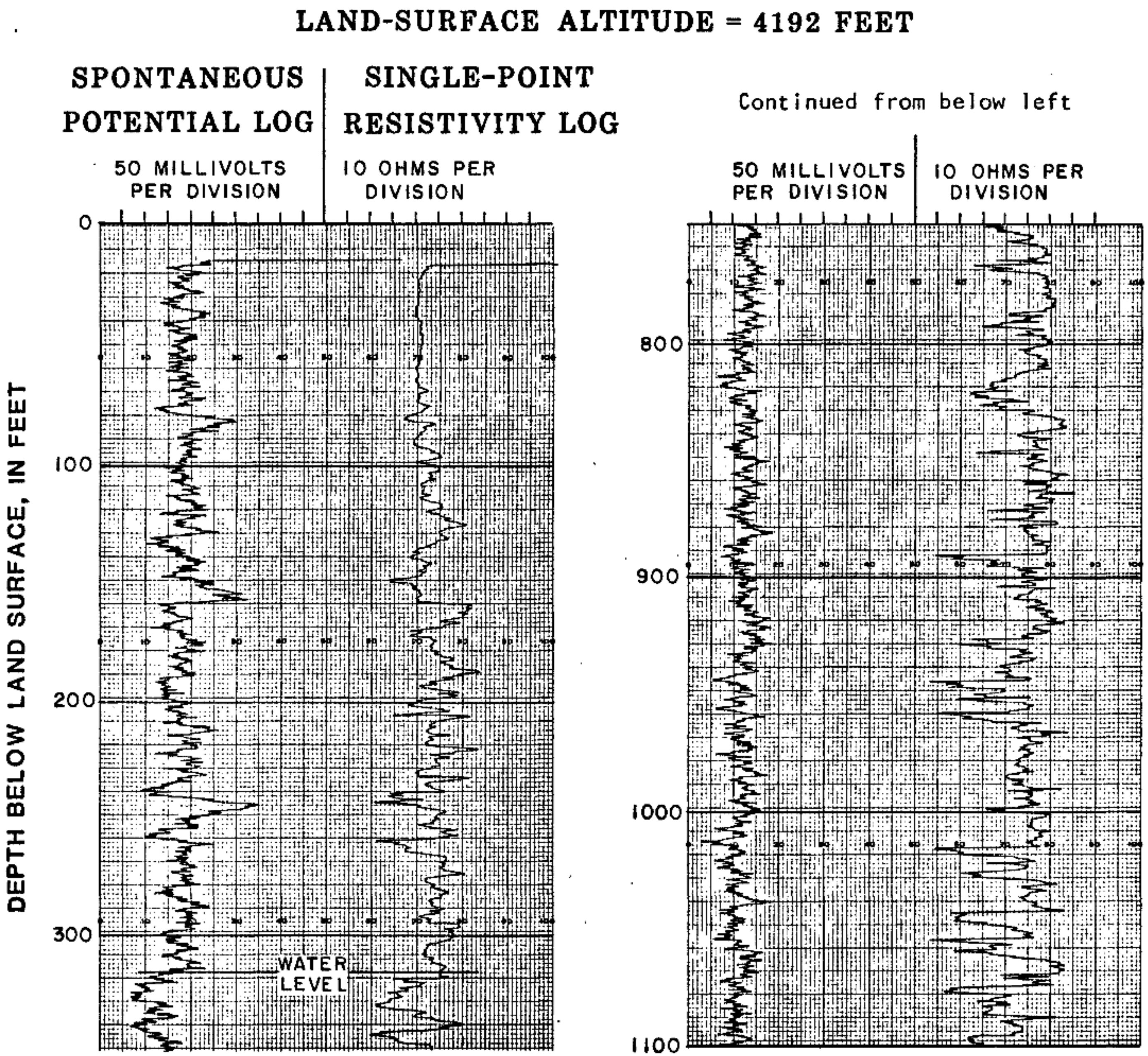
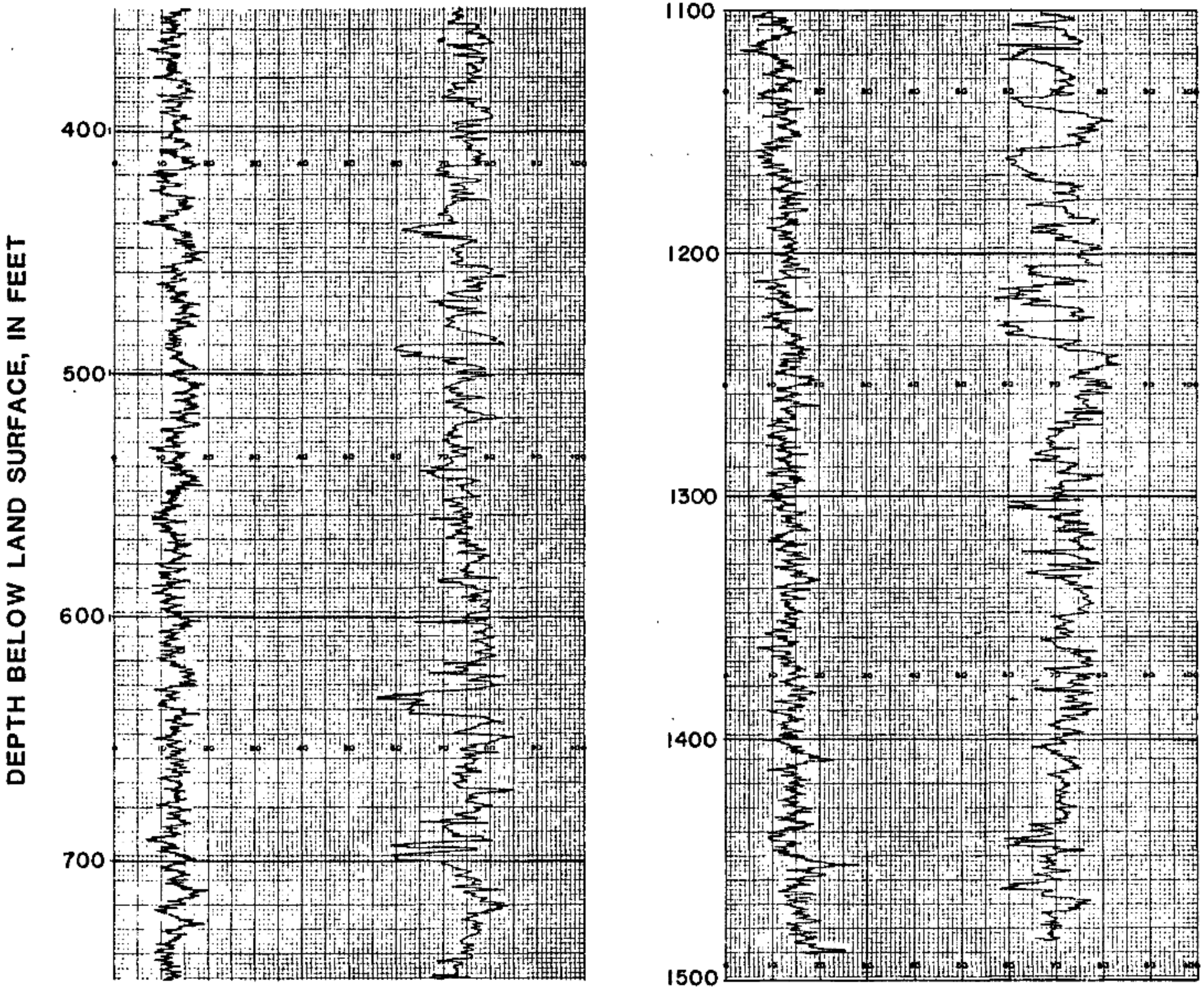


Figure 7.--Borehole-geophysical logs from well 23S.01E.30.322.


LAND-SURFACE ALTITUDE = 4192 FEET
SPONTANEOUS POTENTIAL LOG
SINGLE-POINT RESISTIVITY LOG
50 MILLIVOLTS PER DIVISION
10 OHMS PER DIVISION
Continued from below left
DEPTH BELOW LAND SURFACE, IN FEET
0
100
200
300
800
900
1000
1100
WATER LEVEL



Continued above right

Figure 8.--Borehole-geophysical logs from well 23S.01E.30.422.

A 3-day step-drawdown production test was conducted on test well 36 from August 9 to August 12, 1982. The test was conducted by Layne Western Co., Inc. Water-level changes measured by the contractor during the pumping part of this test are shown in figure 9. Test well 36 was pumped at an initial rate of 1,000 gallons per minute for 23 hours. The water-level drawdown at the end of this step was 79 feet, resulting in a 23-hour specific capacity of 12.7 gallons per minute per foot of drawdown. The pumping rate was increased to 1,400 gallons per minute for 24 hours and then to 1,800 gallons per minute for the final 24.5 hours of the test. The total drawdown at the end of the test was 162 feet.

Water-level recovery was monitored in test well 36 (fig. 10). Barometric pressure was monitored throughout the production test and the recovery test. No significant changes in barometric pressure occurred. Water-level recovery data were analyzed using the Harrill method for determining transmissivity from a step-drawdown test (Harrill, 1970). From the resulting semilog plot of drawdown against discharge-weighted time, transmissivity of the aquifer in the Santa Fe Group penetrated by well 36 was estimated to be at least 5,900 feet squared per day and probably about 6,800 feet squared per day (fig. 10). The specific-capacity technique (Brown, 1963; Meyer, 1963; Theis, 1963) was used to estimate a transmissivity for the screened interval of approximately 4,000 feet squared per day. Analyses of borehole-geophysical logs from test well 36 (fig. 8) indicate that approximately 30 feet of the screened interval consist of thin clay beds. The average hydraulic conductivity for the remaining 230 feet of screened interval is approximately 30 feet per day based on a transmissivity of 6,800 feet squared per day and is approximately 20 feet per day based on the specific-capacity estimate of 4,000 feet squared per day.

No change in water level was observed in test well 37 throughout the pumping and recovery parts of the 3-day production test of test well 36. In this short-term test, no change was anticipated because the two wells are screened at different depth intervals. In order to better define the effect of pumping stress on the aquifer in the Santa Fe Group near test wells 36 and 37, a long-term aquifer test using multiple observation wells is needed.

A test well (West Mesa 2500, 24S.01E.08.123) was drilled by the U.S. Geological Survey in 1975 to a depth of almost 2,500 feet without reaching the base of the Santa Fe Group. The well was drilled to obtain water samples at specific intervals, lithologic data, and borehole-geophysical data. The borehole-geophysical and lithologic logs (fig. 11) and the summarized descriptive lithologic log (table 4) have not been previously published. Robert R. White (U.S. Geological Survey, oral commun., 1981) believes that the samples of cuttings from this well were washed, which may have removed some of the clays and thus account for the lack of clay in the description of the analyzed samples.

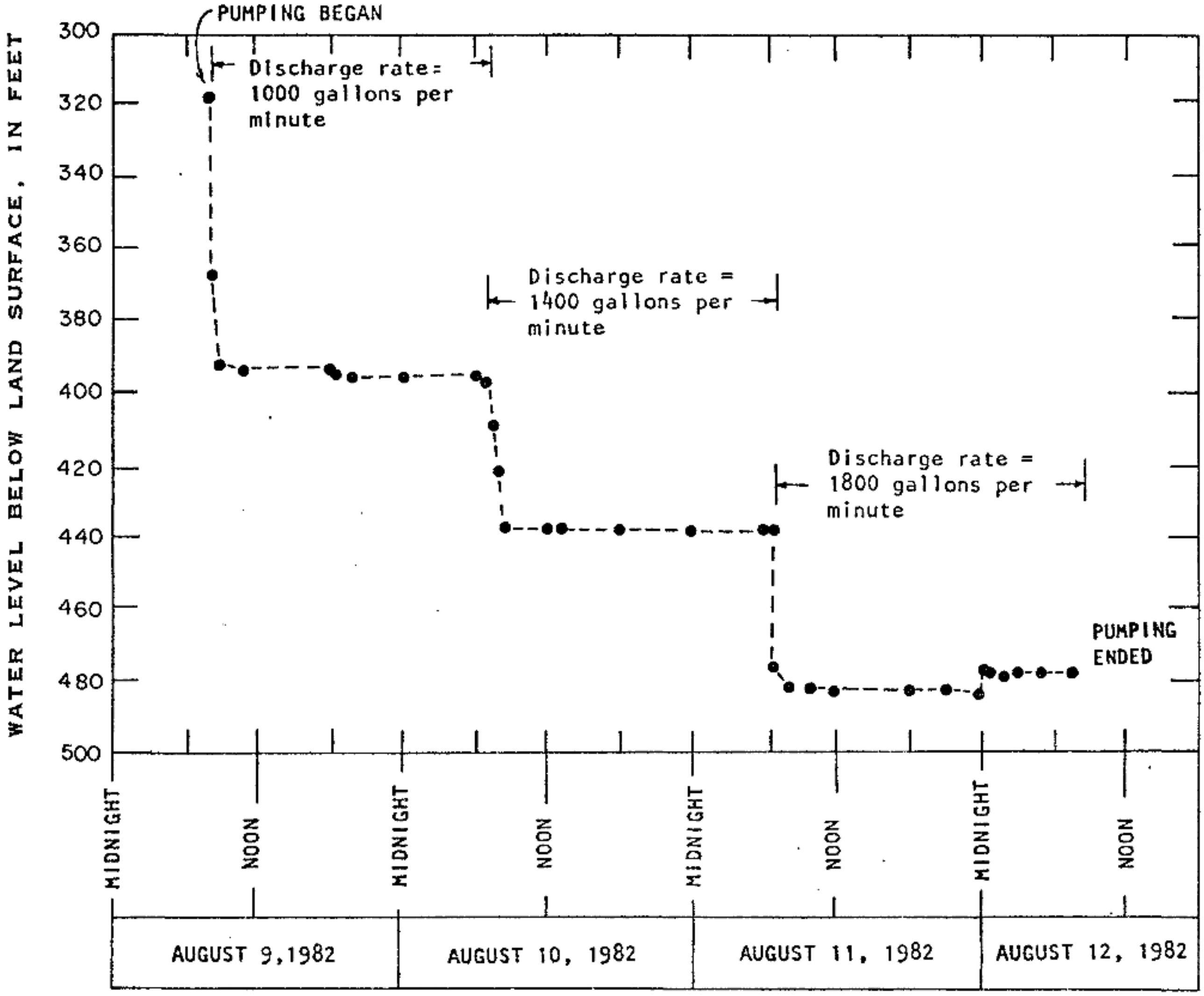


Figure 9.--Water-level drawdown measurements made by the driller during a step-drawdown production test of well 23S.01E.30.422.

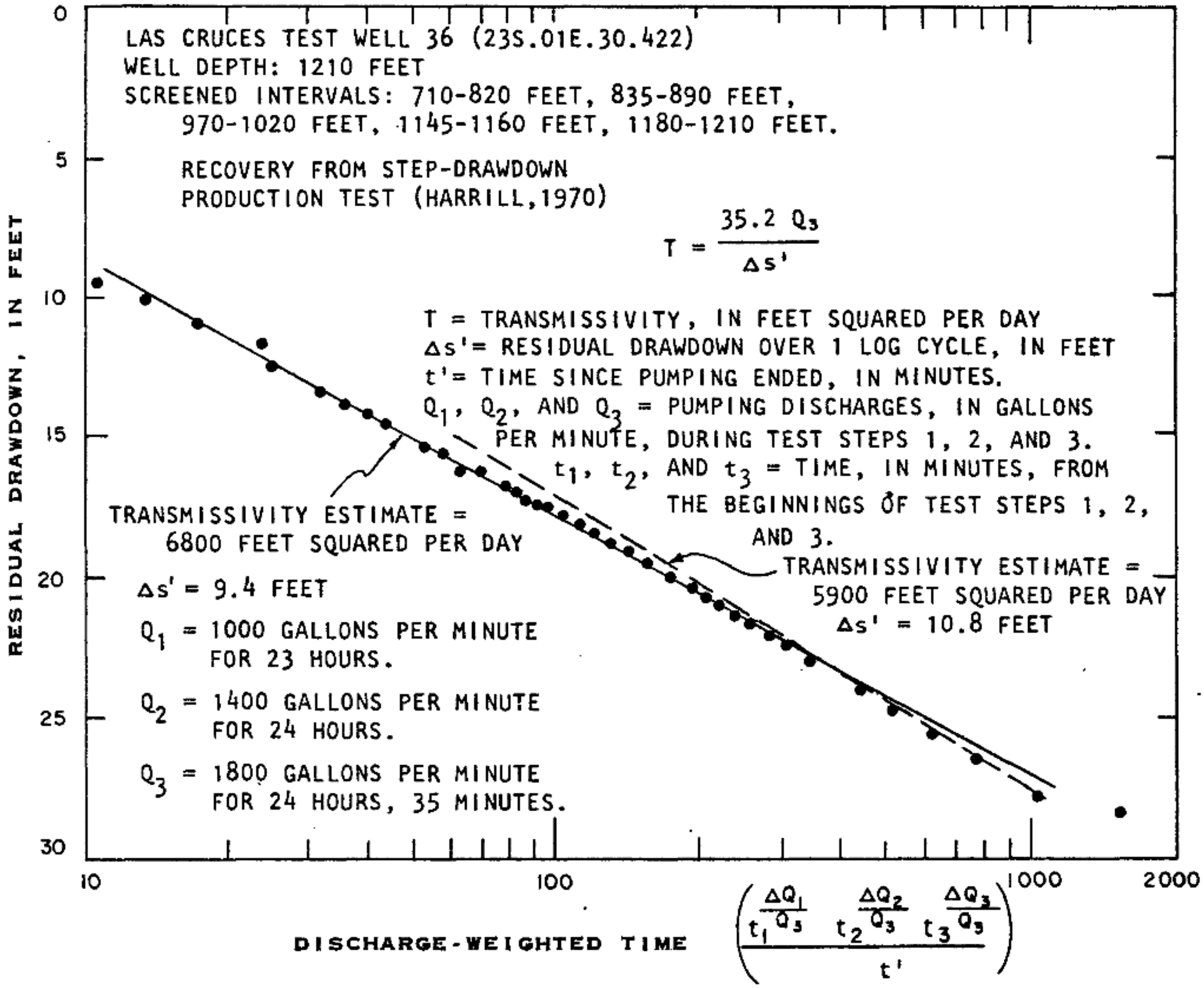


Figure 10.--Water-level-recovery aquifer test of well 23S.01E.30.422, August 9-12, 1982.

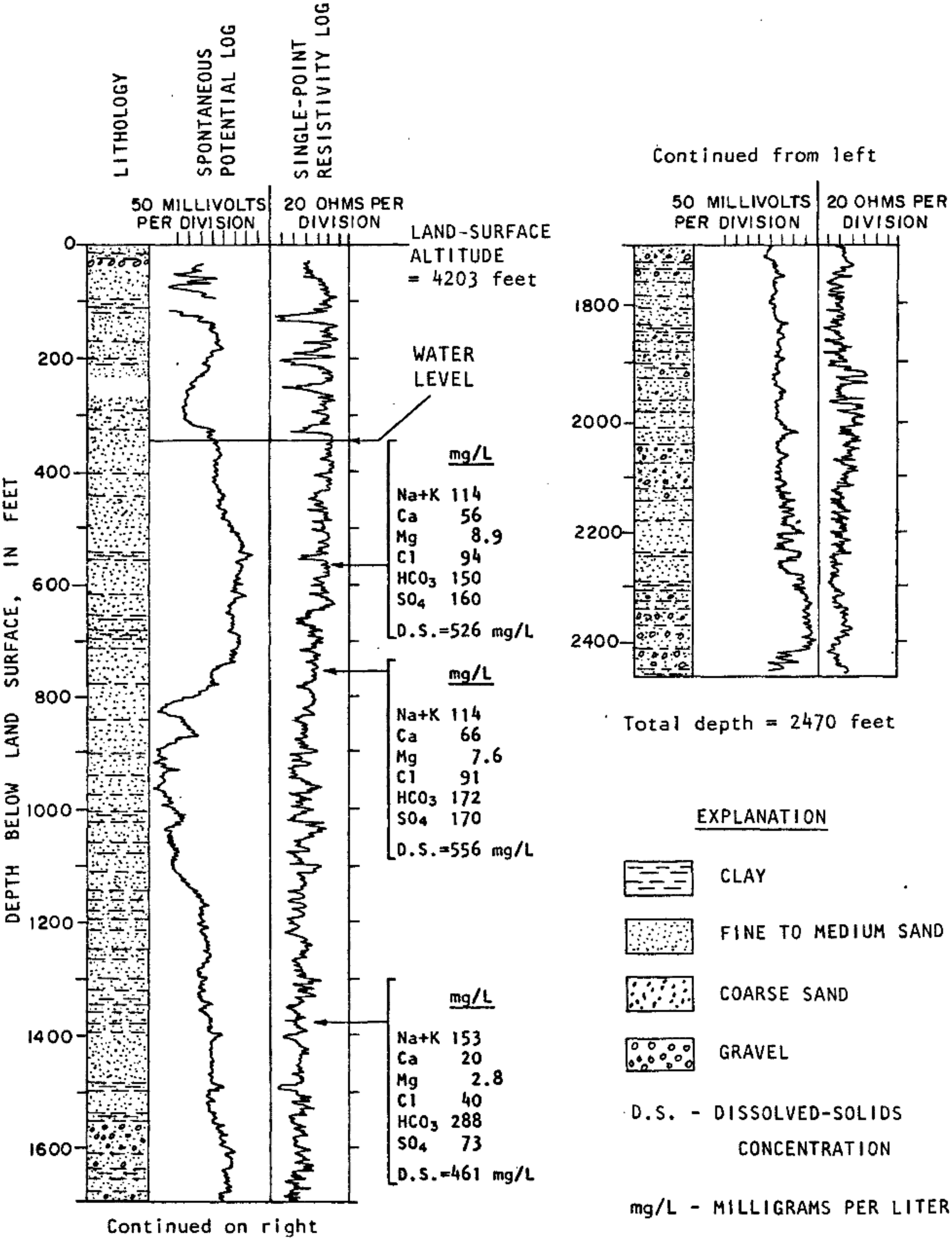


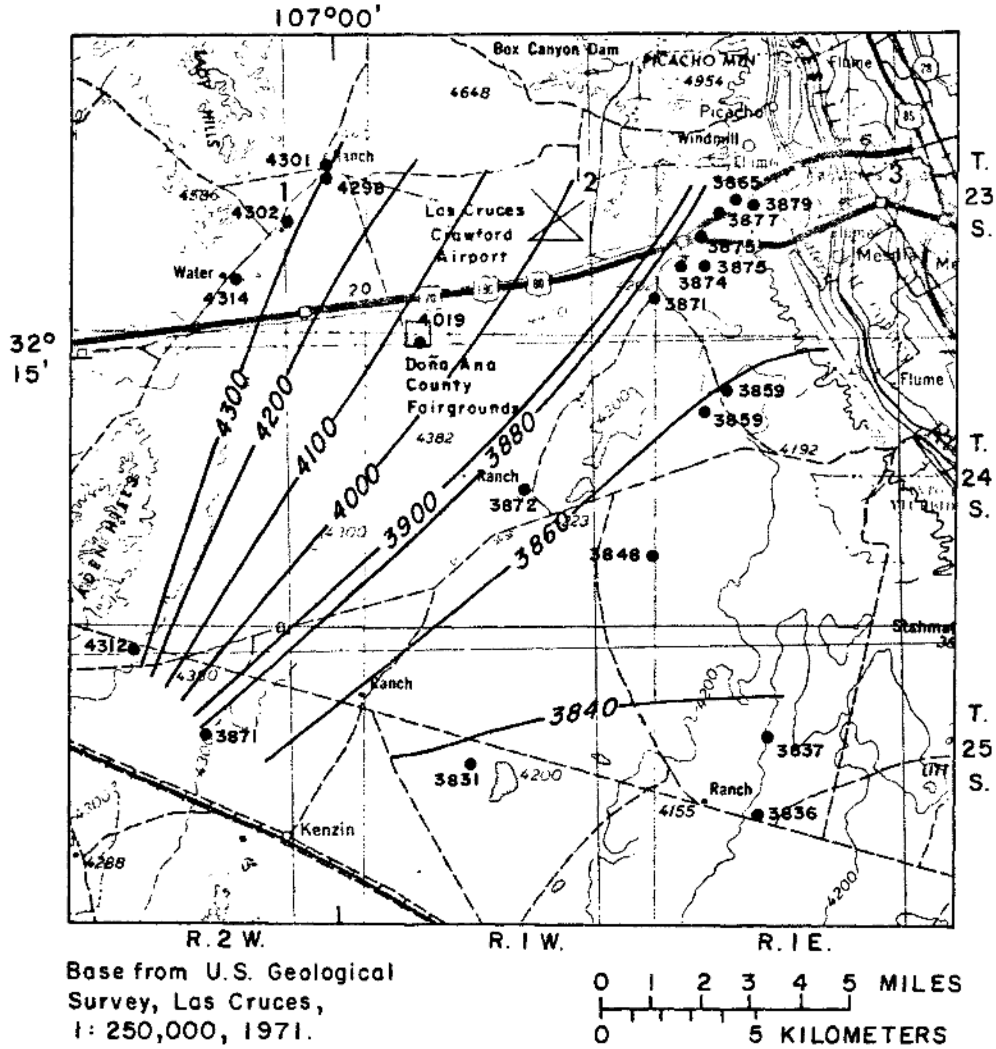
Figure 11.--Lithologic and borehole-geophysical logs from well 24S.01E.08.123.

Northeast-trending faults in the study area delineate a graben or downfaulted block in the Santa Fe Group (fig. 3). The ASARCO well and the U.S. Geological Survey West Mesa 2500 test well are located within this graben. The two Las Cruces test wells (36 and 37) are probably located in the same downfaulted block immediately to the east of the northwest fault boundary. The large hydraulic-conductivity values estimated for water-producing zones in the ASARCO and Las Cruces wells indicate that water-producing zones of the aquifer in the Santa Fe Group in this downfaulted area may be characterized by large transmissivity. The widely spaced water-table contours (fig. 12) also indicate that the transmissivity of the aquifer in the Santa Fe Group may be large in this area.

A horst or uplifted block in the Santa Fe Group lies to the northwest of the downfaulted block (fig. 3). Wells drilled in this area have small yields compared to those from wells in the downfaulted area. Partial driller's logs are available from two wells drilled into the Santa Fe Group and older sediments in the uplifted area (King and others, 1971, p. 41). The West Las Cruces Airport well (23S.01W.22.000) originally was drilled to a depth of 550 feet. This well was deepened to 1,187 feet, presumably because of the reported small yield of the original well. King and others (1971, p. 41) speculated that this well penetrated the base of the Santa Fe Group at 575 feet below land surface. The interval from 550 to 1,187 feet was described by the driller as consisting predominantly of clay and other fine-grained sediments and reportedly contained no extractable water. The U.S. Army Radar Station well (23S.01W.31.440) was drilled to a depth of 685 feet and was later deepened to 1,200 feet. Sediments penetrated by this well were predominantly fine grained, and the well produced less than 25 gallons per minute. If the lithologic sequence in these wells is typical, the Santa Fe Group on the horst is characterized by small transmissivity values. The closely spaced water-table contours in this area (fig. 12) also indicate that small transmissivity values may be typical in the horst. Additional lithologic and hydrologic information is needed in both the downfaulted area and in the horst area to better define the extent and thickness of water-yielding units.

Direction of Ground-Water Flow

The approximate altitude of the water table for the aquifer in the Santa Fe Group (fig. 12) was constructed using water-level data collected between 1968 and 1982. The water-table map (fig. 12) was used to determine the approximate direction and gradient of ground-water flow. Ground water flows to the southeast across the western one-half of the study area at a gradient of 50 feet per mile or more. Across the eastern one-half of the study area, ground water also flows to the southeast, but the water-table gradient significantly flattens to less than 5 feet per mile. The change in gradient may be related to lateral lithologic changes within the Santa Fe Group and to structural controls on the hydrologic system. At present, geologic data are insufficient to adequately describe the lithologic and structural features affecting the movement of ground water through the study area.



Base from U.S. Geological Survey, Las Cruces, 1:250,000, 1971.

Contour interval 100 and 200 feet
Datum is sea level

EXPLANATION

3831 • WELL--Number is the altitude of water level, in feet above sea level.

—4300— APPROXIMATE WATER-TABLE CONTOUR--Shows approximate altitude of water table, 1968-82. Above altitude of 3900 feet, contour interval 100 feet; below altitude of 3900 feet, contour interval 20 feet. Datum is sea level.

Figure 12.--Approximate altitude of the water table.

Water Chemistry

Water-chemistry analyses were conducted on water samples from eight wells in the study area (tables 5 and 6). Histograms (fig. 13) were constructed from each analysis to show ionic concentrations, in milliequivalents per liter, of the major cations (calcium, magnesium, and sodium) and the major anions (bicarbonate, sulfate, and chloride). Dissolved-solids concentrations in water samples collected from four wells in the northeastern part of the study area (fig. 13) ranged from 378 to 556 milligrams per liter. The predominant cations were calcium and sodium; the predominant anions were bicarbonate and chloride, with the exception of samples from the depth intervals of 568 to 588 feet and 754 to 774 feet in well 24S.01E.08.123. In these analyses, sulfate was the predominant anion. Water samples from three wells to the west contained larger concentrations of dissolved solids (906 to 1,470 milligrams per liter) than water samples from wells to the northeast. Sodium was the predominant cation in all of these samples. Sulfate was the predominant anion in wells 23S.02W.13.311 and 23S.02W.35.411; chloride and bicarbonate were the predominant anions in well 24S.01W.22.123.

Water-chemistry differences in the study area probably are associated with structural and lithologic controls. The northeast-trending fault separating the uplifted block of the horst to the west from the downfaulted block to the east appears to delineate water-chemistry boundaries within the aquifer in the Santa Fe Group. Wells to the east of this fault produce water with smaller concentrations of dissolved solids than do wells to the west of the fault.

Three analyses from different depth intervals in well 24S.01E.08.123 indicated that water-chemistry changes occur not only from place to place, but also with depth. The predominant ions in water from the deepest interval (1,383 to 1,403 feet) were sodium and bicarbonate. In the shallower intervals (568 to 588 feet and 754 to 774 feet), sodium and calcium were the predominant cations; sulfate, chloride, and bicarbonate were the predominant anions. Additional ground-water-chemistry analyses are needed to better define lateral and vertical changes in water chemistry and the relationship between these changes and structural-lithologic controls across both the study area and the West Mesa in general.

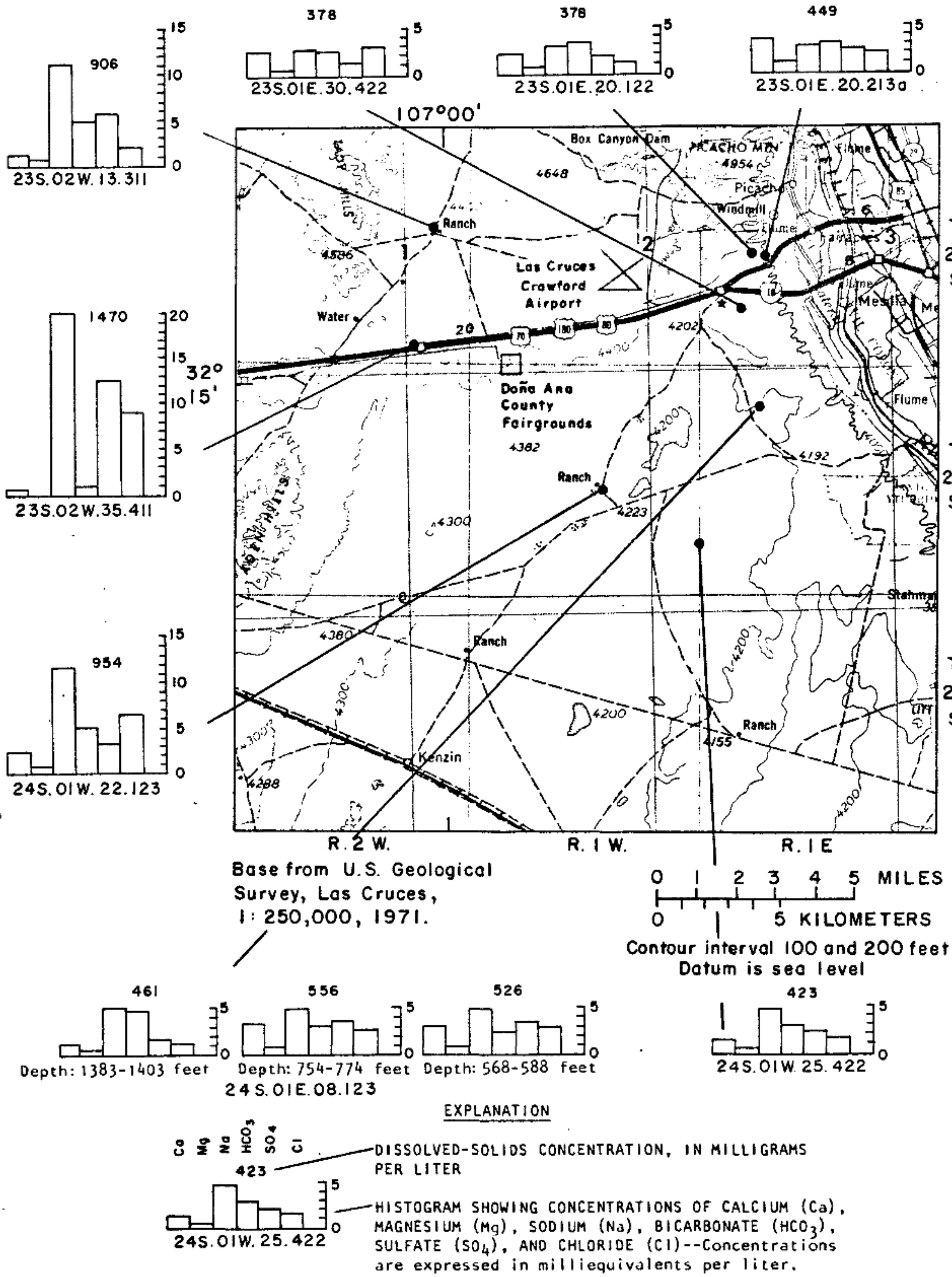


Figure 13.--Location of wells with water-chemistry analyses and histograms of major ions.

NEED FOR ADDITIONAL STUDIES

The aquifer in the Santa Fe Group consists of lenticular deposits of clay, silt, gravel, caliche, and volcanic material deposited in a number of different environments. Because of the heterogeneity of these deposits, the capability of the aquifer to store and transmit water may vary substantially from place to place. Within the study area and throughout the entire West Mesa area, presently available lithologic and structural information are insufficient to adequately describe the geologic factors affecting the hydrologic characteristics of the aquifer in the Santa Fe Group. Information needed to better define these geologic factors includes the distribution of lithologic units within the Santa Fe Group, the distribution of post-Santa Fe volcanic rocks and shallow igneous intrusions, and the location and orientation of faults and other structural features. This information could be obtained by geologic mapping, by further examination of existing borehole-geophysical logs and drill-cuttings samples, and by drilling test holes to obtain lithologic and borehole-geophysical data in selected areas. These test holes could be cased with small-diameter casing for later use as observation wells.

Aquifer tests are needed to better define hydrologic characteristics of the aquifer in the Santa Fe Group in the West Mesa area. These tests need to include long-term multiple-well tests to define storage, transmissivity, and vertical hydraulic conductivity. These tests would require drilling of production test wells with multiple observation wells at selected sites in the West Mesa area as determined from data obtained from geologic studies and from previously drilled test holes. Groups of observation wells, screened at specific intervals above, in, and below the zone of production, are needed to determine the vertical and horizontal hydraulic conductivity and storage coefficient of the aquifer. In addition to the long-term tests, short-term aquifer tests could be conducted in existing wells. Information obtained from these tests would be useful in further defining the distribution of transmissivity throughout the aquifer in the Santa Fe Group underlying the West Mesa.

Water samples for chemical analyses collected from test holes are needed to better characterize changes in ground-water chemistry in the study area and their relationship to lithologic and structural features. Samples also are needed from different depth intervals in test wells to define vertical changes in water chemistry.

SUMMARY

The aquifer in the Santa Fe Group is the major source of fresh ground water within the Mesilla Basin. The Santa Fe Group in the West Mesa study area consists of Quaternary and Tertiary piedmont-slope, fluvial, playa, and lacustrine deposits composed of clay, silt, sand, gravel, and caliche, and igneous rocks composed of volcanic ash and basalt. The saturated thickness of the aquifer ranges from 3,440 feet at the Boles No. 1 Federal oil test well to zero at the western and northern borders of the study area. The hydrologic characteristics of the aquifer vary substantially from place to place because of the heterogeneity of the Santa Fe Group. Hydraulic conductivities of 12 and 30 feet per day were estimated from aquifer tests for two wells in the eastern one-half of the study area. Well yields in the western one-half of the study area generally are less than 5 gallons per minute, whereas some of the well yields in the eastern one-half are greater than 1,000 gallons per minute. Ground water flows southeastward across the western one-half of the study area at a gradient of about 50 feet per mile. Across the eastern one-half of the study area, ground water flows southeastward at a gradient of less than 5 feet per mile. Dissolved-solids concentrations in ground water range from 906 to 1,470 milligrams per liter in the western one-half of the study area and from 378 to 556 milligrams per liter in the eastern one-half.

REFERENCES

Brown, R. H., 1963, Estimating the transmissibility of an artesian aquifer from the specific capacity of a well, in Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 336-338.

Conover, C. S., 1954, Ground-water conditions in the Rincon and Mesilla Valleys and adjacent areas in New Mexico: U.S. Geological Survey Water-Supply Paper 1230, 200 p.

Dane, C. H., and Bachman, G. O., 1965, Geologic map of New Mexico: U.S. Geological Survey map, scale 1:500,000, 2 sheets.

Halpenny, L. C., Babcock, J. A., and Greene, D. K., 1972, Basic data report, ASARCO La Mesa test production water well: Tucson, Arizona, Water Development Corp., 40 p.

Harrill, J. R., 1970, Determining transmissivity from water-level recovery of a step-drawdown test, in Geological Survey Research 1970: U.S. Geological Survey Professional Paper 700-C, p. 212C-213C.

Hawley, J. W., Kottlowski, F. E., Strain, W. S., Seager, W. R., King, W. E., and Lemone, D. V., 1969, The Santa Fe Group in the south-central New Mexico border region, in Border Stratigraphy Symposium: New Mexico Bureau of Mines and Mineral Resources Circular 104, p. 52-56.

Houghton, F. E., 1972, Climate guide, New Mexico State University, Las Cruces, New Mexico, 1851-1971: New Mexico State University Agricultural Experiment Station Research Report 230, 20 p.

King, W. E., 1972, Hydrogeology of La Mesa, Doña Ana County, New Mexico, in Guidebook to the geology of south-central Doña Ana County, New Mexico: El Paso Geological Society, 7th Annual Field Trip, p. 56-67.

King, W. E., Hawley, J. W., Taylor, A. M., and Wilson, R. P., 1971, Geology and ground-water resources of central and western Doña Ana County, New Mexico: New Mexico Institute of Mining and Mineral Resources Hydrologic Report 1, 64 p.

Kottlowski, F. E., 1960, Reconnaissance geologic map of Las Cruces thirty-minute quadrangle: New Mexico Bureau of Mines and Mineral Resources Geologic Map GM-14, 1 sheet.

Kottlowski, F. E., Flower, R. H., Thompson, M. L., and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 1, 132 p.

Meyer, R. R., 1963, A chart relating well diameter, specific capacity, and the coefficients of transmissibility and storage, in Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 338-340.

Seager, W. R., 1975, Geologic map and sections of south half San Diego Mountain quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 35, 1 sheet.

Spiegel, Zane, 1972a, Analysis of data from ASARCO La Mesa test production water well (T. 25 S.,R. 1 E., Section 16, NWNE): Consultant report, Santa Fe, New Mexico, 12 p.

_____, 1972b, Notes on vertical permeability in the La Mesa area of Doña Ana County, New Mexico: Consultant report, Santa Fe, New Mexico, 7 p.

Theis, C. V., 1963, Estimating the transmissibility of a water-table aquifer from the specific capacity of a well, in Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 332-336.

Thompson, Sam, III, and Bieberman, R. A., 1974, Oil and gas exploration wells in Doña Ana County, New Mexico, in Guidebook of the Las Cruces Country: New Mexico Geological Society, 26th Field Conference, p. 171-174.

Wilkins, D. W., Scott, W. B., and Kaehler, C. A., 1980, Planning report for the Southwest Alluvial Basins (East) Regional Aquifer-System Analysis, parts of Colorado, New Mexico, and Texas: U.S. Geological Survey Open-File Report 80-564, 39 p.

Wilson, C. A., and White, R. R., 1984, Geohydrology of the central Mesilla Valley, Doña Ana County, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 82-555, 144 p.

Wilson, C. A., White, R. R., Orr, B. R., and Roybal, R. G., 1981, Water resources of the Rincon and Mesilla Valleys and adjacent areas, New Mexico: New Mexico State Engineer Technical Report 43, 514 p.

Table 1.--Water levels for selected wells

[R = reported values; King and others, 1971; Wilson and others, 1981]

Location number	Year completed	Altitude of land surface (feet)	Well depth (feet)	Water level below land surface (feet)	Date measured	Remarks
23S.01W.36.224	--	4201	--	330.2	02-08-74	Plugged
23S-02W.13.311	--	4438	300R	137.3	01-04-77	--
23S.02W.13.330	--	4432	--	134.0	02-17-68	--
23S.02W.23.341	--	4460	177R	158.0R	03-16-68	--
23S.02W.27.343	--	4465	172R	151.0	03-16-68	--
23S.01E.20.134	1968	4060	300R	182.9	11-06-72	--
23S.01E.20.213a	1965	4035	420	170.0	01-27-75	--
23S.01E.20.241	1959	3940	420R	60.8	11-01-72	--
23S.01E.30.212	--	4180	330	305.0	06-06-68	--
23S.01E.30.322	1982	4189	640	315.4	08-09-82	Hole depth 1,000 feet; Las Cruces well 37
23S.01E.30.422	1982	4192	1210	316.6	08-09-82	Hole depth 1,500 feet; Las Cruces well 36
24S,01W.05.110	--	4400	--	381.0	06-06-68	--
24S.01W.22.123	--	4224	--	352.4	03-21-73	--
24S.01W.25.422	--	4218	370R	369.8	02-03-75	--
24S.01E.07.444	--	4209	5180R	350.0	10-25-72	Boles No. 1 Federal
24S.01E.08.123	1975	4203	2470	344.5	01-30-75	Plugged
25S.01W.16.331	--	4226	--	395.0R	05-11-68	--
25S.02W.05.134	--	4425	--	113.2	01-22-73	--
25S.02W.16.210	--	4327	--	456.4	01-14-75	--
25S.01E.16.114	1972	4189	1650	352.2	03-31-76	ASARCO test well
25S.01E.21.331	--	4232	586	396.3	05-06-76	--

Table 2.—Driller's log for well 23S.01E.30.322

[Layne Western Co., Inc., Tempe, Arizona]

Depth (feet)	Lithology
0-10	Caliche with sand
10-20	Caliche with gravel
20-30	Sand with gravel
30-40	Clay with gravel
40-50	Big gravel
50-60	Sand with gravel
60-80	Sand with gravel and little clay
80-90	Clay with gravel
90-100	Clay with fine gravel
100-110	Sand with gravel and trace of clay
110-120	Sand with gravel
120-140	Clay with gravel
140-150	Sand with gravel
150-160	Sand with gravel and little clay
160-170	Gravel
170-180	Sand with little gravel
180-200	Sand with gravel
200-220	Caliche with gravel
220-240	Clay with gravel
240-260	Clay with little gravel
260-280	Clay
280-290	Clay with gravel
290-310	Sand with gravel
310-326	Clay with gravel
326-330	Sand with gravel
330-340	Clay sand with gravel
340-350	No sample
350-360	Clay with little sand and gravel
360-390	Clay
390-400	Clay with little sand and gravel

Table 2.--Driller's log for well 23S.01E.30.322 - Concluded

Depth (feet)	Lithology
400-430	Clay, sand, and gravel
430-450	Sand and gravel with little clay
450-480	Sand and gravel
480-490	Sand and gravel with a little clay
490-510	Sand with little gravel and clay
510-530	Sand and clay with little gravel
530-580	Sand and clay
580-620	Sand with little clay
620-680	Sand
680-690	Sandy clay
690-710	Sand with little clay
710-750	Sandy clay
750-770	Clay with little sand
770-780	Sandy clay
780-790	Clay with little sand
790-810	Sandy clay
810-820	Sand with little clay
820-840	Sandy clay
840-870	Sandy clay with little gravel
870-880	Sand and gravel with little clay
880-890	Sand and gravel
890-900	Sandy clay with little gravel
900-910	Clay with little sand
910-920	Clay
920-930	Sandy clay
930-940	Clay with little sand
940-950	Sandy clay
950-970	Clay
970-980	Clay with little sand and gravel
980-990	Clay
990-1,000	Clay with little sand

Total depth drilled = 1,004 feet

Table 3.--Driller's log for well 23S.01E.30.422
[Layne Western Co., Inc., Tempe, Arizona]

Depth (feet)	Lithology
0-10	Caliche with sand
10-20	Caliche with gravel
20-36	Caliche and sand with little gravel
36-40	Clay with little sand
40-50	Sand
50-60	Sandy clay with gravel
60-70	Clay with gravel
70-80	Sand with gravel
80-90	Big gravel
90-100	Gravel
100-110	Clay, gravel
110-120	Big gravel
120-130	Sand, gravel
130-140	Gravel
140-170	Clay with little gravel
170-180	Clay, gravel
180-200	Gravel with little clay
200-210	Clay with little gravel and sand
210-220	Gravel, clay, and sand
220-230	Gravel with little clay
230-250	Clay with little gravel
250-260	Clay
260-285	Clay and sand with little gravel
285-310	Gravel with little clay
310-325	Sand and gravel with little clay
325-385	Sandy clay with little gravel
385-390	Sandy clay and gravel
390-400	Sand with little gravel
400-420	Gravel with little sand
420-440	Sand
440-450	Clay
450-460	Clay and sand with little gravel
460-500	Sandy clay
500-540	Sand with little clay
540-550	Fine sand and silt

Table 3.--Driller's log for well 23S.01E.30.422 - Continued

Depth (feet)	Lithology
550-560	Clay with little sand
560-580	Clay and sand
580-600	Sand with little clay
600-640	Sand and clay
640-650	Clay and sand with little gravel
650-660	Clay, sand, and gravel
660-670	Clay and sand with little gravel
670-680	Sand with little clay
680-690	Clay and sand with little gravel
690-700	Clay, little sand, trace of gravel
700-760	Sand and clay
760-770	Sand with little clay
770-780	Sand, clay, trace of gravel
780-790	Sand with little clay and gravel
790-800	Clay with little gravel
800-810	Sand with little clay
810-920	Sandy clay
920-930	Sand
930-965	Sandy clay
965-980	Sand and clay with little gravel
980-990	Gray clay, sand, and silt
990-1,030	Gray clay
1,030-1,040	Clay
1,040-1,050	Clay and sand
1,050-1,060	Clay, sand, and pea-sized gravel
1,060-1,070	Clay and sand with little gravel
1,070-1,080	Sand and clay
1,080-1,140	Sticky clay and gravel
1,140-1,167	Sandy clay and gravel
1,167-1,180	Sandy clay

Table 3.--Driller's log for well 23S.01E.30.422 - Concluded

Depth (feet)	Lithology
1,180-1,230	Sticky clay with little gravel
1,230-1,260	Sandy clay
1,260-1,300	Sticky clay with gravel
1,300-1,320	Sand and clay with little gravel
1,320-1,330	Sand with little clay and gravel
1,330-1,340	Sand and clay
1,340-1,355	Sand and clay with little gravel
1,355-1,420	Sand and clay
1,420-1,440	Gray clay and sand
1,440-1,460	Sand and trace of gray clay
1,460-1,470	Gray clay and sand
1,470-1,480	Clay and sand with little gravel
1,480-1,500	Sand and gravel with little clay

Total depth drilled = 1,500 feet

Table 4.--Summarized lithologic log for well 24S.01E.08.123

Lithology	Thickness (feet)	Depth below land surface (feet)
Sand, fine-grained.	2	0-2
Caliche, white, variable hardness.	14	2-16
Sand with clay layers.	4	16-20
Gravel with sand.	3	20-23
Fine-grained sand with clay lenses.	81	23-104
Clay	19	104-123
Sand, fine-grained, with clay lenses.	29	123-152
Sand, medium- to fine-grained, with clay lenses.	57	152-209
No samples.	64	209-273
Sand, fine-grained, with occasional thin clay layers (less than 10 feet).	263	273-536
Clay lense.	14	536-550
Sand, fine-grained, with occasional thin clay layers (less than 10 feet).	86	550-636
Clay with many very fine to medium-grained sand lenses.	72	636-708
Sand, very fine to medium-grained, with clay lenses.	548	708-1,256
Clay, sandy, silty.	148	1,256-1,404
Sand, very fine to medium-grained, with some clay; thin gravel lenses in clay 1,570 feet to 1,600 feet.	172	1,404-1,576
Clay with many thin sand or sand and gravel lenses.	180	1,576-1,756
Sand, very fine to fine-grained, with many clay layers and lenses; 50 percent of unit is clay.	524	1,756-2,280
Clay with thin to thick silty sand layers and lenses and some small gravel. About 50 percent of unit is green to black rock material from 2,370 to 2,464 feet.	184	2,280-2,464

Table 5.--Chemical analyses of water from selected wells: major and minor constituents

[ft = feet; mg/L = milligrams per liter; µg/L = micrograms per liter; °C = degrees Celsius]

Location number	Date of sample	Total depth of well (ft)	Depth to top of sample interval (ft)	Depth to bottom of sample interval (ft)	Dissolved silica (SiO_2) (mg/L)	Total iron (Fe) (µg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)
23S.02W.13.311	11-14-72	300	-	-	51	-	-	-	29	10	260	15	304	0	280
23S.02W.35.411	01-11-73	1050	-	-	24	3400	20	10	23	.3	460	3.2	47	1	610
23S.01E.20.112	11-01-72	565	-	-	27	-	-	-	44	8.6	68	3.4	205	0	83
23S.01E.20.213a	11-10-72	420	380	420	26	30	9	150	74	11	61	3.3	190	0	110
23S.01E.30.422	08-11-82	1230	-	1210	26	-	41	29	52	5.8	63	8.9	-	-	51
24S.01W.22.123	03-06-75	-	-	-	30	-	10	70	50	10	270	35	316	-	160
24S.01W.25.422	02-03-75	370	-	-	26	-	-	-	26	4.4	110	6.1	167	-	110
24S.01E.08.123	01-30-75	2470	1383	1403	27	-	30	60	20	2.8	140	13	288	-	73
24S.01E.08.123	01-01-75	2470	754	774	21	-	60	130	66	7.6	110	4.3	172	-	170
24S.01E.08.123	02-02-75	2470	568	588	18	-	10	110	56	8.9	110	4.1	150	-	160

Table 5.--Chemical analyses of water from selected wells: major and minor constituents - Concluded

Location number	Date of sample	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Dissolved ortho phosphorus (P) (mg/L)	Phosphate dissolved ortho (mg/L)	Dissolved solids (residue at 180°C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (microsiemens)	pH (units)	Dissolved boron (B) (µg/L)
23S.02W.13.311	11-14-72	97	2.7	2.5	-	-	-	906	110	0	81	11	1400	8.0	-
23S.02.W.35.411	01-11-73	320	6.0	.11	0.02	0.06	-	1470	59	18	94	26	2310	8.6	-
23S.01E.20.112	11-01-72	42	.9	.04	-	-	-	378	150	0	50	2.5	599	7.9	-
23S.01E.20.213a	11-10-72	70	.4	.02	.02	.06	-	449	230	74	36	1.8	702	8.1	-
23S.01E.30.422	08-11-82	96	.4	.10	-	-	-	-	150	-	45	2.3	650	7.8	90
24S.01W.22.123	03-06-75	230	2.4	2.4	.04	.12	-	954	170	0	74	9.1	1610	-	-
24S.01W.25.422	02-03-75	57	.9	.05	.05	.15	431	423	83	0	73	5.3	688	8.0	-
24S.01E.08.123	01-30-75	40	2.3	.04	.05	.15	462	461	62	0	80	7.8	736	8.3	180
24S.01E.08.123	01-01-75	91	.5	.02	.04	.12	577	556	200	55	54	3.4	909	8.0	100
24S.01E.08.123	02-02-75	94	.6	.02	.04	.12	548	526	180	54	57	3.6	884	8.1	100

Table 6.—*Chemical analyses of water from selected wells: trace metals*

[ft = feet; μg/L = micrograms per liter]

Location number	Date of sample	Depth to top of sample interval (ft)	Depth to bottom of sample interval (ft)	Dissolved arsenic (As) (μg/L)	Dissolved barium (Ba) (μg/L)	Dissolved cadmium (Cd) (μg/L)	Hexavalent chromium (Cr+6) (μg/L)	Dissolved copper (Cu) (μg/L)	Total lead (Pb) (μg/L)	Dissolved lead (Pb) (μg/L)	Total mercury (Hg) (μg/L)	Dissolved selenium (Se) (μg/L)	Dissolved silver (Ag) (μg/L)	Dissolved zinc (Zn) (μg/L)
23S.01E.30.422	08-11-82	–	1210	6	73	<1	–	1	<1	–	<0.1	3	<1	20
24S.01E.08.123	01-30-75	1384	1404	2	<100	0	0	2	<100	3	0.2	0	1	50
24S.01E.08.123	02-01-75	754	774	2	<100	0	0	1	<100	2	0	0	0	20
24S.01E.08.123	02-02-75	568	588	0	<100	1	0	1	<100	2	0	1	0	20

☆ U. S. GOVERNMENT PRINTING OFFICE: 1985—579-626/25294 REGION NO 8