CONSTRUCTION, LITHOLOGIC, AND HYDROLOGIC DATA FOR TEST WELLS IN THE CEDAR GROVE AREA, CARROLL COUNTY, TENNESSEE

By Stephanie E. Johnson and John K. Carmichael

U.S. GEOLOGICAL SURVEY

Open-File Report 92-166

Prepared in cooperation with the

CEDAR GROVE UTILITY DISTRICT

Nashville, Tennessee
1993

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1993**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE
Construction, Lithologic, and Hydrologic Data for Test Wells in the Cedar Grove Area, Carroll County, Tennessee

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of the Interior 1849 C Street, NW Washington, DC 20240

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**17**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
810 Broadway, Suite 500
Nashville, Tennessee 37203

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, Colorado 80225

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, VERTICAL DATUM, AND WELL-NUMBERING SYSTEM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06308	liter per second
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per foot

Abbreviated Water-Quality Units

milligrams per liter (mg/L)
micrograms per liter (μg/L)

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Well-Numbering System: Wells are identified according to the numbering system used by the U.S. Geological Survey throughout Tennessee. The well number consists of three parts: (1) an abbreviation of the name of the county in which the well is located; (2) a letter designating the 7.5-minute topographic quadrangle on which the well is plotted; and (3) a number generally indicating the numerical order in which the well was inventoried. The symbol Cr:A-006, for example, indicates that the well is located in Carroll County on the "A" quadrangle and is identified as well 6 in the numerical sequence. Quadrangles are lettered from left to right, beginning in the southwest corner of the county.

CONSTRUCTION, LITHOLOGIC, AND HYDROLOGIC DATA FOR TEST WELLS IN THE CEDAR GROVE AREA, CARROLL COUNTY, TENNESSEE

By Stephanie E. Johnson *and* John K. Carmichael

ABSTRACT

Four test wells were drilled near Cedar Grove in Carroll County, Tennessee, in 1991 to obtain geologic and hydrologic information about the post-Cretaceous strata in the study area. Samples of cuttings and geophysical logs were used to determine the lithology and stratigraphy at the drilling sites. Specific-capacity tests and water-quality analyses were conducted at two test wells completed in the Memphis Sand. Yields of the two test wells were 275 gallons per minute and greater than 350 gallons per minute. The specific capacities for the two wells equalled 17.8 and 10.0 gallons per minute per foot of drawdown, respectively.

INTRODUCTION

The Cedar Grove Utility District (CGUD), located in western Tennessee approximately 17 miles northeast of the city of Jackson, currently (1991) relies upon two production wells to supply ground water to approximately 400 customers. Both wells produce water which contains excessive concentrations (18 to 20 mg/L) of iron (C.S. Bennett, Cedar Grove Utility District, oral commun., 1991). Based on existing information, these wells are believed to have been completed in the Cretaceous McNairy Sand. Due to water-quality problems commonly associated with the McNairy Sand, the CGUD proposed that a new well field be developed west of Cedar Grove, with wells completed in either the Memphis or Fort Pillow Sands. However, the thickness, yield, and water quality of these aquifers were relatively undefined near the outcrop area. As part of an ongoing study of the post-Cretaceous aquifers in western Tennessee, the U.S. Geological Survey (USGS), in cooperation with the CGUD, conducted an investigation of the aquifers in an area about 3 miles northwest of the town of Cedar Grove. The purpose of this investigation was to explore the stratigraphy and obtain information on the hydraulic characteristics and water quality of the aquifers intersected.

This report presents data obtained during the investigation. It presents information on the construction and lithology of four test wells and the results of specific-capacity tests and water-quality analyses for two of the four wells.

SITE DESCRIPTION AND HYDROGEOLOGIC SETTING

The study area is located in southwestern Carroll County between the towns of Cedar Grove and Lavinia (fig. 1). Land surface altitudes range from 420 to 600 feet above sea level in the area, which is characterized by gently rolling to steep topography. Land use is rural-agricultural.

The study area lies in the outcrop area of the Memphis Sand. This formation, where saturated, comprises the Memphis aquifer, the principal source of water for municipal and industrial use in western Tennessee. The aquifer dips westward at 20 to 50 feet per mile and is upwardly confined by clays of the

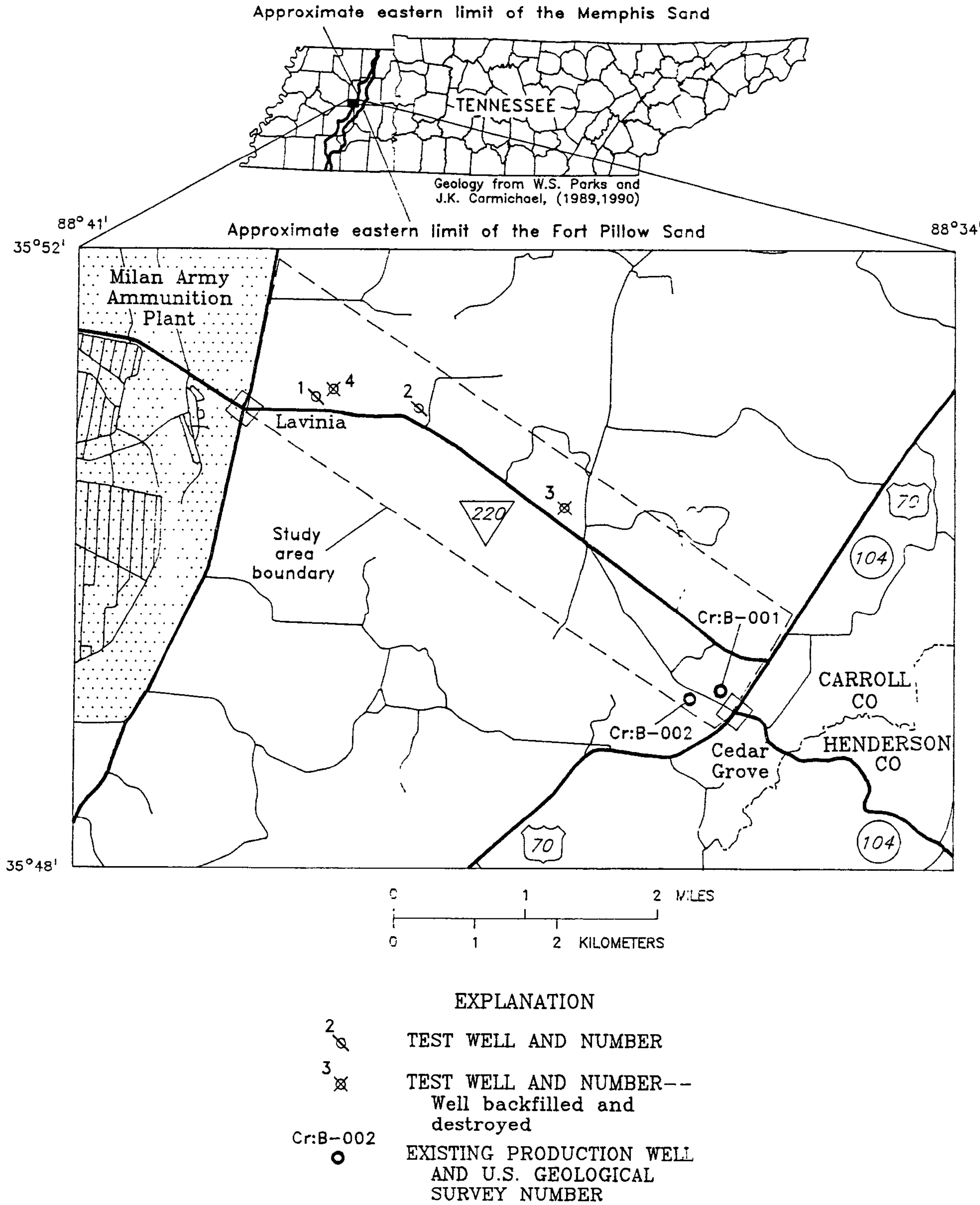


Figure 1. Locations of the Cedar Grove study area test wells and existing production wells.

Cook Mountain Formation. The Memphis aquifer is underlain by clays of the Flour Island Formation, which serves as a lower confining unit where present. Beneath the Flour Island Formation lies the fine- to very coarse-grained sand of the Fort Pillow Sand. The Fort Pillow Sand, where saturated, comprises the Fort Pillow aquifer (Parks and Carmichael, 1990, p. 5-9).

WELL CONSTRUCTION

From August through October 1991, four test wells were drilled in the study area at three sites adjacent to State Highway 220 (fig. 1). The wells were drilled by hydraulic-rotary method to depths expected to intersect both the Memphis and Fort Pillow aquifers. Construction details are summarized in table 1 and shown graphically in the appendix.

Test wells 1 and 2 were initially drilled to depths of 315 and 340 feet with nominal diameters of $5^7/_8$ and $7^7/_8$ inches, respectively. To accommodate hydrologic testing, the wells were then reamed to a nominal $12^7/_8$-inch diameter and completed with 6-inch-diameter polyvinyl chloride (PVC) casing with solvent cement joints and 20 feet of 0.020-inch-slot screen. Test well 1 was reamed to 235 feet and screened between 212 and 232 feet. Test well 2 was reamed to 195 feet and screened from 173 to 193 feet. Both wells were screened in coarse sand in the lower part of the Memphis aquifer. The remaining annular space in the wells was gravel and sand packed, sealed with bentonite clay to 5 to 10 feet below land surface, and then grouted with cement to land surface. Compressed air was used to develop the wells for 3 to 4 hours.

Test well 3 was drilled to a total depth of 280 feet, but was not completed with PVC casing and screen. The large amount of clay in the Memphis aquifer at this site would have dramatically limited the well yield; therefore, test well 3 was filled and abandoned.

A deep test well (test well 4) was drilled adjacent to test well 1 to obtain additional lithologic information about the post-Cretaceous strata underlying the Memphis Sand at this site. Test well 4 was drilled to a depth of 435 feet--120 feet deeper than test well 1--in an effort to penetrate the Fort Pillow Sand. No hydrologic tests were conducted at this well; therefore, test well 4 was filled and abandoned.

LITHOLOGY

Geologic samples collected at 10-foot intervals were examined to determine the lithology of the formations. Electric logs (spontaneous potential and point-resistance) and natural gamma logs were run in all four test wells to supplement the lithologic logs. The lithologic, electric, and natural gamma logs are presented in the appendix.

The stratigraphy can be summarized as follows: near-surface loess and fluvial deposits; fine- to very coarse-grained sand of the Memphis Sand with occasional thin clay layers; and thick, gray to dark-gray clay. The shallow surface material consisted of 10 to 20 feet of brown sandy silt and clay grading to a reddish-brown sand. The Memphis Sand consisted primarily of red-brown to light tan, fine- to very coarse-grained sand. The clay content of the Memphis Sand varied greatly among the four test wells. Test well 3 contained numerous white and red clay layers throughout the formation, whereas test well 2 contained only one small layer of clayey sand between the near-surface materials and the thick, gray clay.

Table 1. Construction data for test wells drilled in the Cedar Grove study area

[——, not applicable; ?, uncertain; ft, feet; in., inches]

Test well number	1	2	3	4
USGS well number	Cr:A-006	Cr:A-007	Cr:B-006	Cr:A-008
Latitude	355058	355054	355015	355058
Longitude	883911	883812	883709	883911
Land surface altitude (ft)	553	511	595	550
Construction date	8-28-91	9-05-91	9-10-91	10-17-91
Nominal diameter (in.)				
Initial borehole	5 7/8	7 7/8	7 7/8	7 7/8
Reamed interval	12 7/8	12 7/8	——	——
Depth of hole (ft)	315	340	280	435
Depth reamed (ft)	235	195	——	——
Screened interval (ft)	212-232	173-193	——	——
Depth to the top of gravel pack (ft)	170?	142	——	——
Depth to the top of sand pack (ft)	40?	130	——	——
Depth to top of bentonite (ft)	5	15?	——	——

The thick unit of gray to dark-gray clay, at the westernmost site, was intersected at approximately 244 feet below land surface in test well 1, and at 240 feet in test well 4 (309 and 310 feet above sea level, respectively). The clay was intersected at a depth of 200 feet (311 feet above sea level) in test well 2 and, at the easternmost site (test well 3), at a depth of 219 feet (376 feet above sea level). The deepest well, test well 4, was drilled to 435 feet in an effort to penetrate the Fort Pillow Sand. However, only a 20- to 25-foot sandy zone within the gray clay was intersected at approximately 333 feet below land surface. Because none of the test wells were drilled below the clay, the thickness of the gray clay unit in the study area was not determined.

HYDROLOGIC DATA

Specific-Capacity Tests

Step-drawdown tests were conducted in test wells 1 and 2 in September 1991 to determine well yields and specific capacities. Each well was pumped a total of 6 hours in three equal steps using a 4-inch-diameter submersible pump. Prior to the tests, water levels were recorded at the two wells periodically over several days to determine water-level trends and static levels. Test well 1 produced a maximum yield of 275 gal/min while test well 2 was estimated to produce greater than 350 gal/min at the full capacity of the pump. At the end of the 6-hour pumping period, the specific capacity equaled 17.8 gal/min/ft of drawdown for test well 1 and 10.0 gal/min/ft for test well 2. The water-level recovery in both wells after pumping was nearly instantaneous. Hydrographs of drawdown and recovery for the indicated pumping rates are shown in figures 2 and 3.

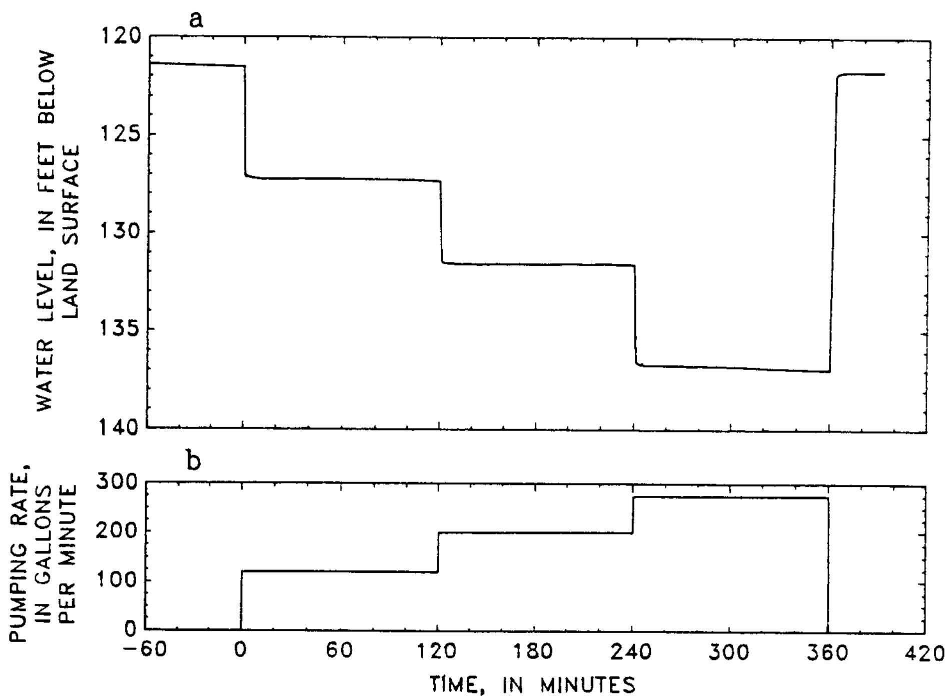


Figure 2. (a) Water-level drawdown and recovery, and (b) pumping rate for test well 1, during specific-capacity test, September 18, 1991.

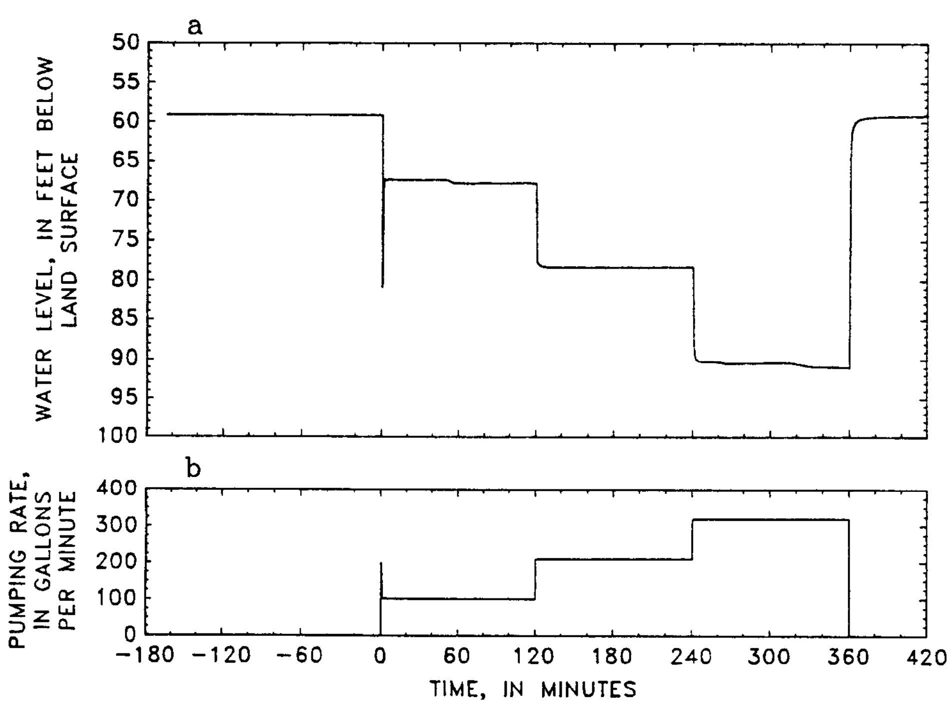


Figure 3. (a) Water-level drawdown and recovery, and (b) pumping rate for test well 2, during specific-capacity test, September 19, 1991.

Water Quality

Samples for water-quality analysis were collected from test wells 1 and 2 at the end of the 6-hour specific-capacity tests. The samples were analyzed for major constituents and selected trace metals, and were scanned for organic compounds at the USGS Water Quality Regional Laboratory in Ocala, Florida (table 2).

The results of the inorganic analyses showed low concentrations of dissolved solids (less than 25 mg/L), dissolved chloride (less than 2 mg/L), and dissolved iron (10 µg/L). Of the constituents and properties analyzed, only the pH values were not within the recommended limits for drinking water set by the U.S. Environmental Protection Agency (USEPA). The USEPA suggests a secondary maximum contaminant level for pH within the range of 6.5 to 8.5 units. Test wells 1 and 2 had field pH values of 5.4 and 5.5 units, respectively.

Table 2. Water-quality data for test wells drilled in the Cedar Grove study area

[µS/cm, microsiemens per centimeter at 25°C; mg/L, milligrams per liter; µg/L, micrograms per liter; wat wh tot it, water whole total incremental titration]

Test well number	Station number	Date	pH, field (standard units)	pH, lab (standard units)	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	Calcium, dissolved (mg/L as Ca)
1	355058088391101	09-18-91	5.4	5.9	29	30	1.4
2	355054088381201	09-19-91	5.5	5.9	29	30	1.4

Test well number	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Alkalinity, wat wh tot it, field (mg/L as $CaCO_3$)	Alkalinity, lab (mg/L as $CaCO_3$)
1	0.50	3.2	0.90	1.4	0.40	<0.10	9	8.1
2	0.50	3.4	0.90	1.8	0.80	<0.10	9	7.6

Test well number	Iron, total recoverable (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Manganese, total recoverable (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Zinc, dissolved (µg/L as Zn)	Zinc, total recoverable (µg/L as Zn)	Solids, residue at 180 deg. C, dissolved (mg/L)	Carbon dioxide, dissolved (mg/L as CO_2)
1	40	10	10	<10	<10	10	24	22
2	50	10	10	<10	<10	10	23	21

Organic compound scans were conducted using the gas chromatography/flame-ionization detection (GC/FID) method. This analytical method provides a semi-quantitative means for determining the presence and estimated concentrations of natural and synthetic organic compounds; however, specific compounds are not identified using this technique. The results of the GC/FID scans for both wells sampled indicate the presence of a few unidentified organic compounds in concentrations estimated at between 1 to 5 μg/L. Trace organic compound concentrations such as these are sometimes found in water from wells completed with PVC casing and screen joined with PVC solvent cement.

REFERENCES CITED

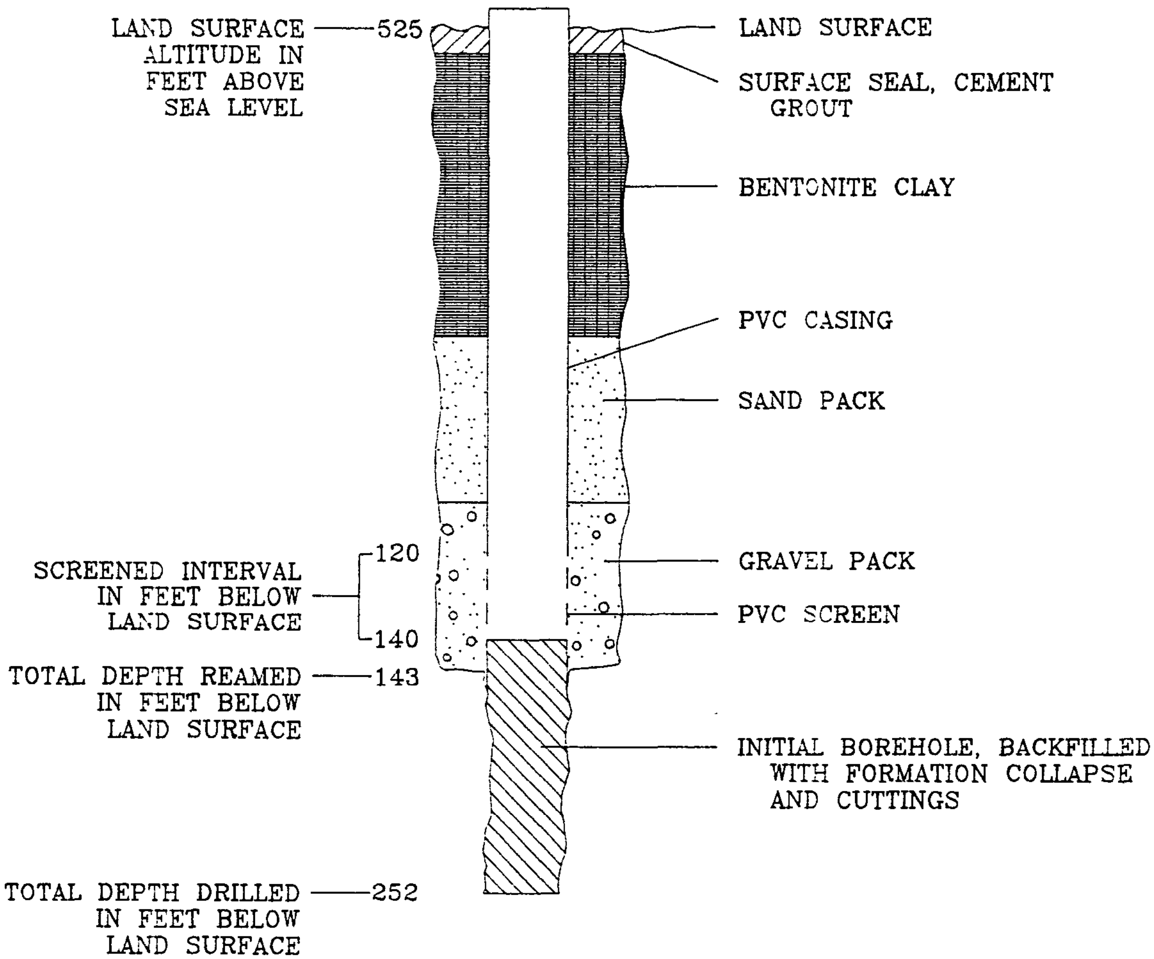
Parks, W.S., and Carmichael, J.K., 1989, Geology and ground-water resources of the Fort Pillow Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4120, 20 p.

-----1990, Geology and ground-water resources of the Memphis Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4182, 30 p.

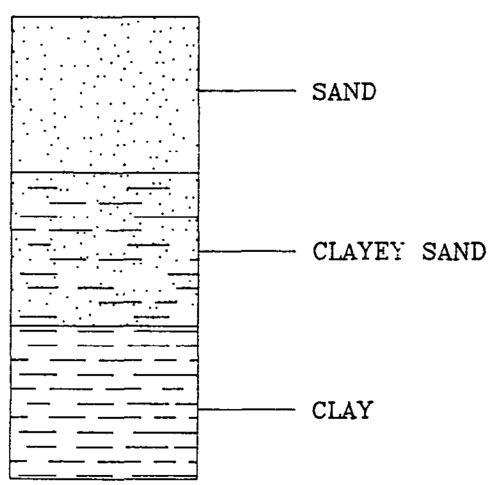
APPENDIX

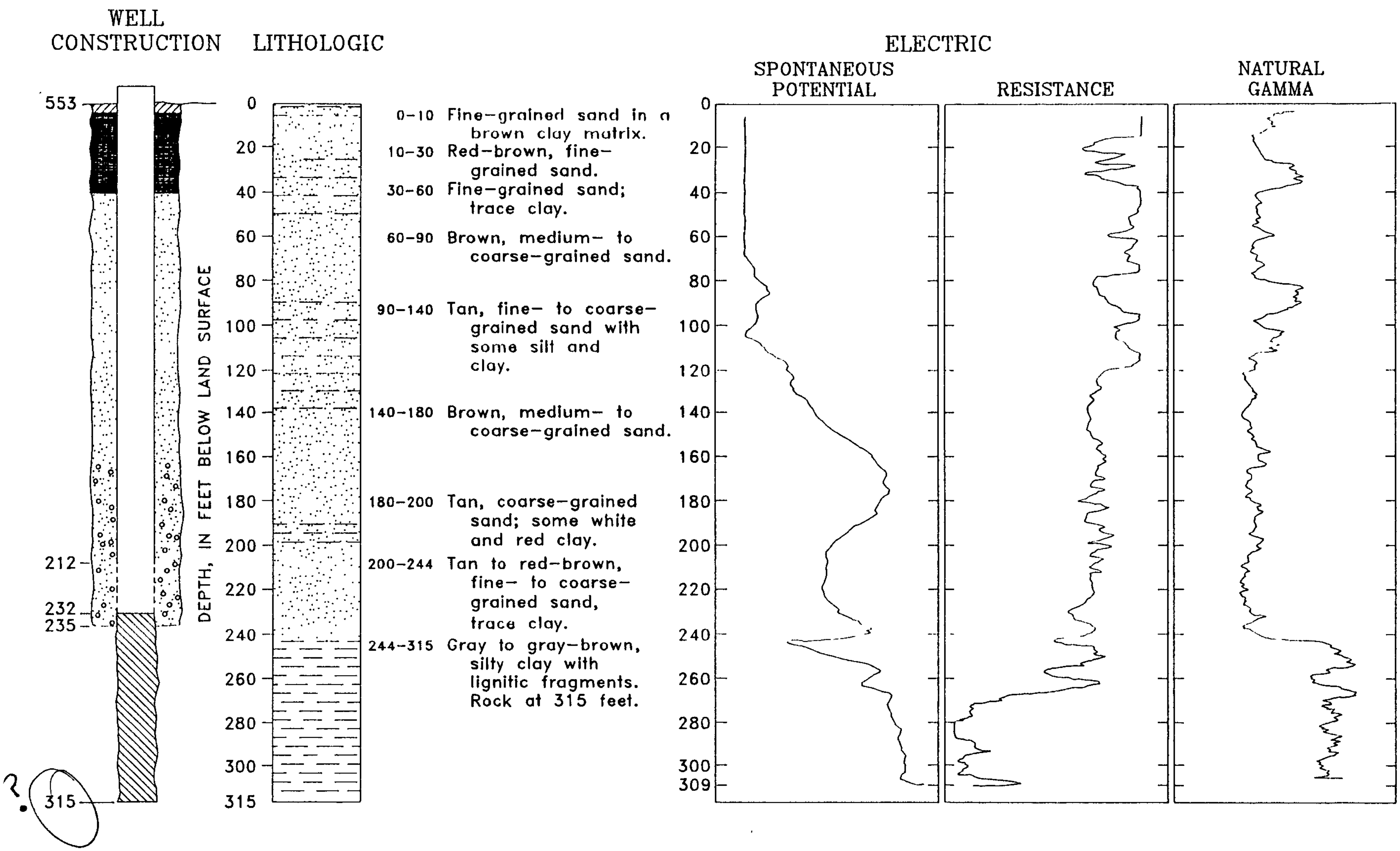
Well-construction diagrams, lithologic logs, electric logs,
and natural gamma logs

EXPLANATION



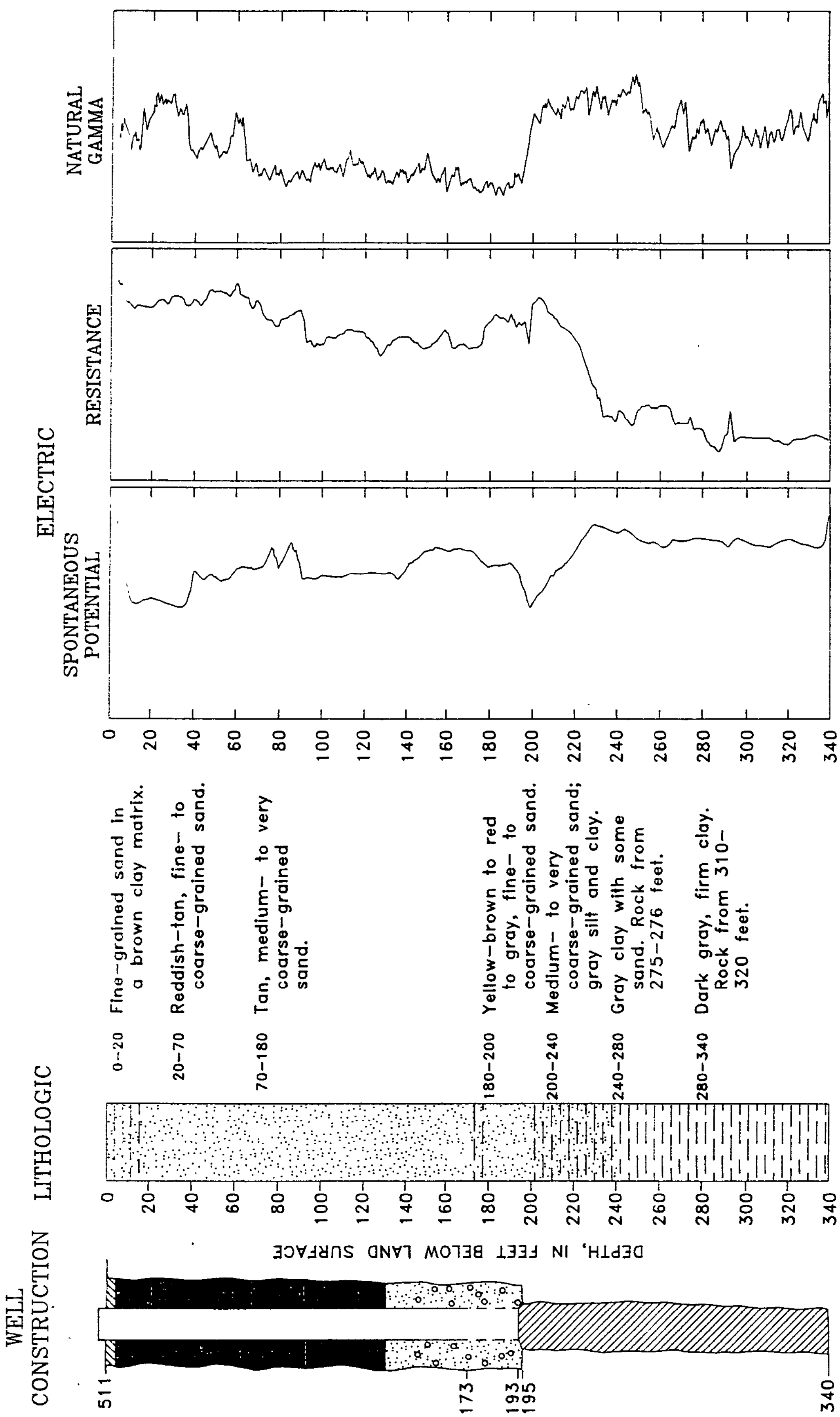
LITHOLOGY



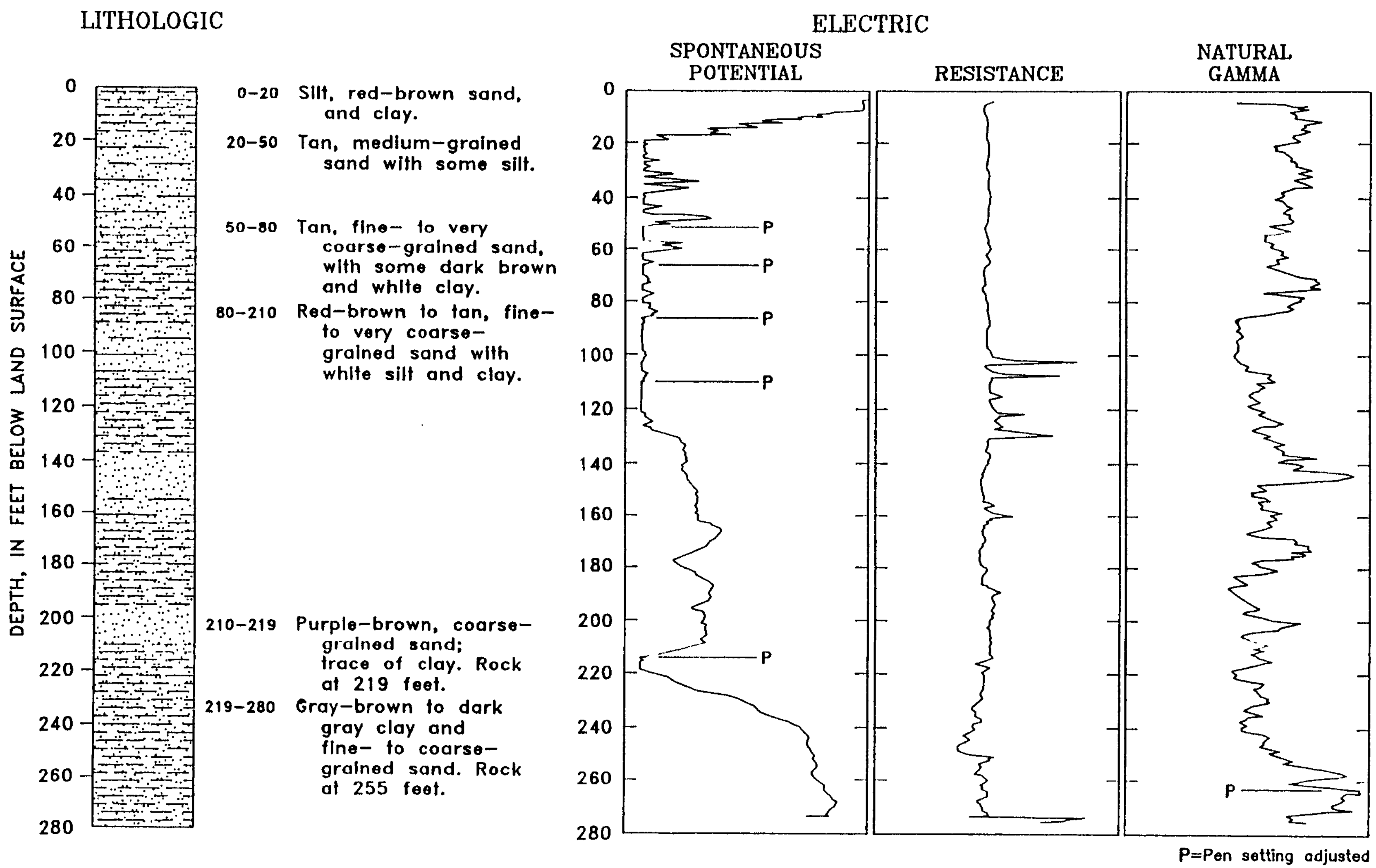


WELL CONSTRUCTION
LITHOLOGIC
ELECTRIC
SPONTANEOUS POTENTIAL
RESISTANCE
NATURAL GAMMA
553
212
232
235
315
DEPTH, IN FEET BELOW LAND SURFACE
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
309
315
0-10 Fine-grained sand in a brown clay matrix.
10-30 Red-brown, fine-grained sand.
30-60 Fine-grained sand; trace clay.
60-90 Brown, medium- to coarse-grained sand.
90-140 Tan, fine- to coarse-grained sand with some silt and clay.
140-180 Brown, medium- to coarse-grained sand.
180-200 Tan, coarse-grained sand; some white and red clay.
200-244 Tan to red-brown, fine- to coarse-grained sand, trace clay.
244-315 Gray to gray-brown, silty clay with lignitic fragments. Rock at 315 feet.

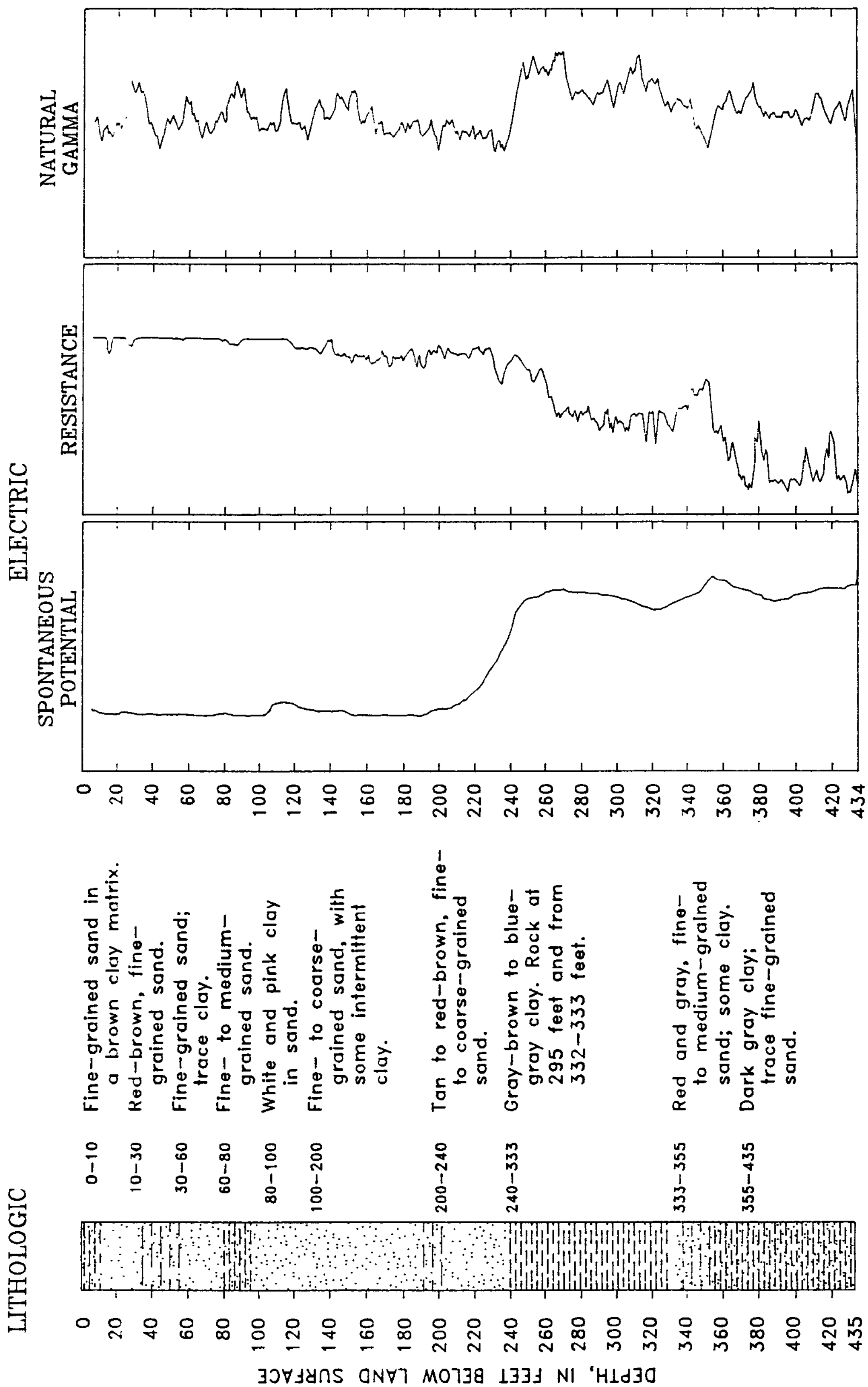
TEST WELL 1


WELL CONSTRUCTION
511
173
193
195
340
DEPTH, IN FEET BELOW LAND SURFACE
LITHOLOGIC
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
0-20 Fine-grained sand in a brown clay matrix.
20-70 Reddish-tan, fine- to coarse-grained sand.
70-180 Tan, medium- to very coarse-grained sand.
180-200 Yellow-brown to red to gray, fine- to coarse-grained sand.
200-240 Medium- to very coarse-grained sand; gray silt and clay.
240-280 Gray clay with some sand. Rock from 275-276 feet.
280-340 Dark gray, firm clay. Rock from 310-320 feet.
ELECTRIC
SPONTANEOUS POTENTIAL
RESISTANCE
NATURAL GAMMA

TEST WELL 2


LITHOLOGIC
DEPTH, IN FEET BELOW LAND SURFACE
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
0-20 Silt, red-brown sand, and clay.
20-50 Tan, medium-grained sand with some silt.
50-80 Tan, fine- to very coarse-grained sand, with some dark brown and white clay.
80-210 Red-brown to tan, fine- to very coarse-grained sand with white silt and clay.
210-219 Purple-brown, coarse-grained sand; trace of clay. Rock at 219 feet.
219-280 Gray-brown to dark gray clay and fine- to coarse-grained sand. Rock at 255 feet.
ELECTRIC
SPONTANEOUS POTENTIAL
RESISTANCE
NATURAL GAMMA
P
P=Pen setting adjusted

TEST WELL 3


LITHOLOGIC
0–10 Fine-grained sand in a brown clay matrix.
10–30 Red-brown, fine-grained sand.
30–60 Fine-grained sand; trace clay.
60–80 Fine- to medium-grained sand.
80–100 White and pink clay in sand.
100–200 Fine- to coarse-grained sand, with some intermittent clay.
200–240 Tan to red-brown, fine- to coarse-grained sand.
240–333 Gray-brown to blue-gray clay. Rock at 295 feet and from 332–333 feet.
333–355 Red and gray, fine- to medium-grained sand; some clay.
355–435 Dark gray clay; trace fine-grained sand.
ELECTRIC
SPONTANEOUS POTENTIAL
RESISTANCE
NATURAL GAMMA
DEPTH, IN FEET BELOW LAND SURFACE

TEST WELL 4