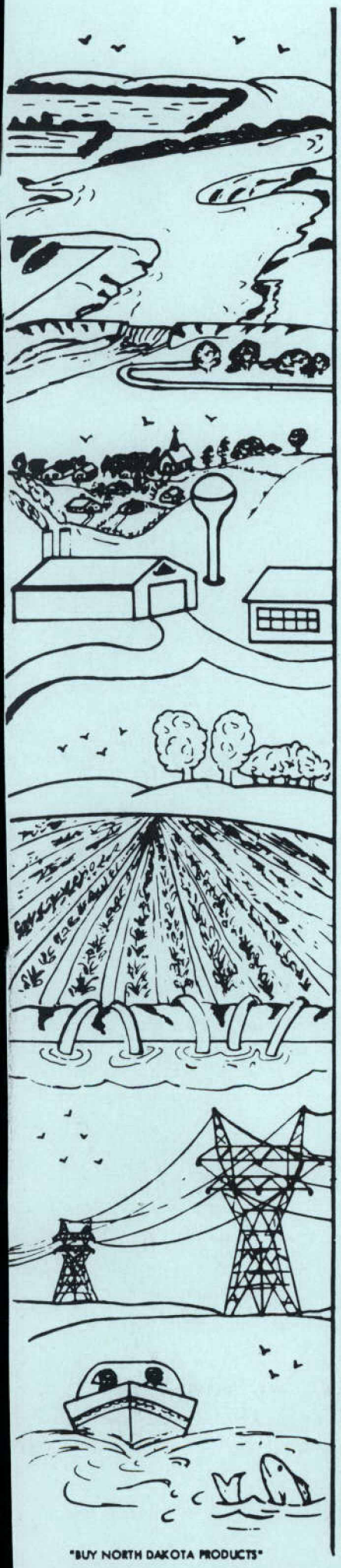


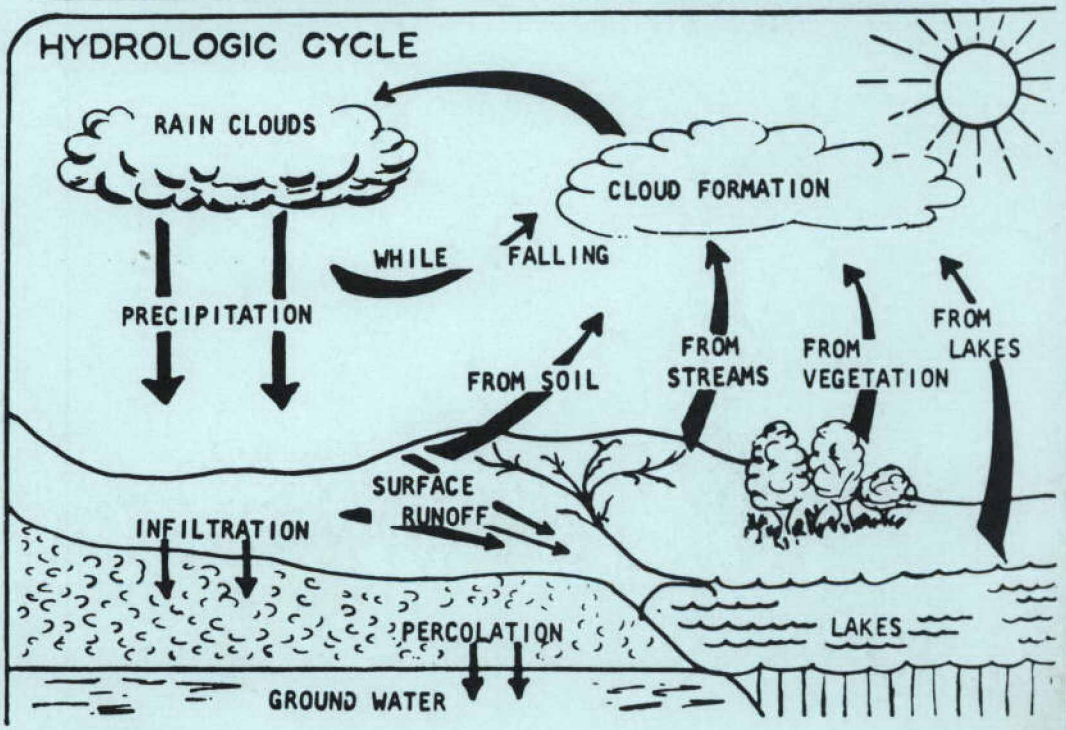
GROUND-WATER RESOURCES OF THE POWERS LAKE AREA
BURKE COUNTY, NORTH DAKOTA

NORTH DAKOTA GROUND-WATER STUDIES
NUMBER 85

By
Allen Comeskey, Hydrologist
North Dakota State Water Commission

Published By
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505

-1983-



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INTRODUCTION

On September 1, 1977 the mayor of Powers Lake requested a study to be conducted by the North Dakota State Water Commission to locate a supplementary municipal water supply. The Water Commission approved sharing equally the estimated costs of $7,260.00 with the city of Powers Lake. On July 7, 1978 the city of Powers Lake and the North Dakota State Water Commission entered into agreement to study the availability and quality of ground water in the vicinity of the city.

The study was conducted from June 6 to June 20, 1978 by the Water Commission drilling crew, equipment, and hydrologist. Nineteen test holes were drilled totaling 2,160 feet.

Location

The city of Powers Lake is located in the southwest corner of Burke County, North Dakota (fig. 1). Southern Burke County is located in the glaciated Missouri Plateau physiographic province (Simpson, 1929). The test drilling was conducted in Township 159 North, Range 92 West, Section 31 and Township 159 North, Range 93 West, Sections 25-28 and 34-36.

Present Water Supply

Powers Lake previously obtained its water from two wells located in town. Well #1 is located at 159-93-26DDD and is reported to be 103 feet deep. City well #2 is located at 159-93-35AAA and is reported to be 101 feet deep with the depth to the aquifer being 85 feet. The city if allowed to appropriate 220 acre-feet per year at a maximum rate of withdrawal of 110 gallons per minute.

After completion of this study, Powers Lake installed two wells in December, 1978. City well #3 is located at 159-93-36BAC. It penetrated

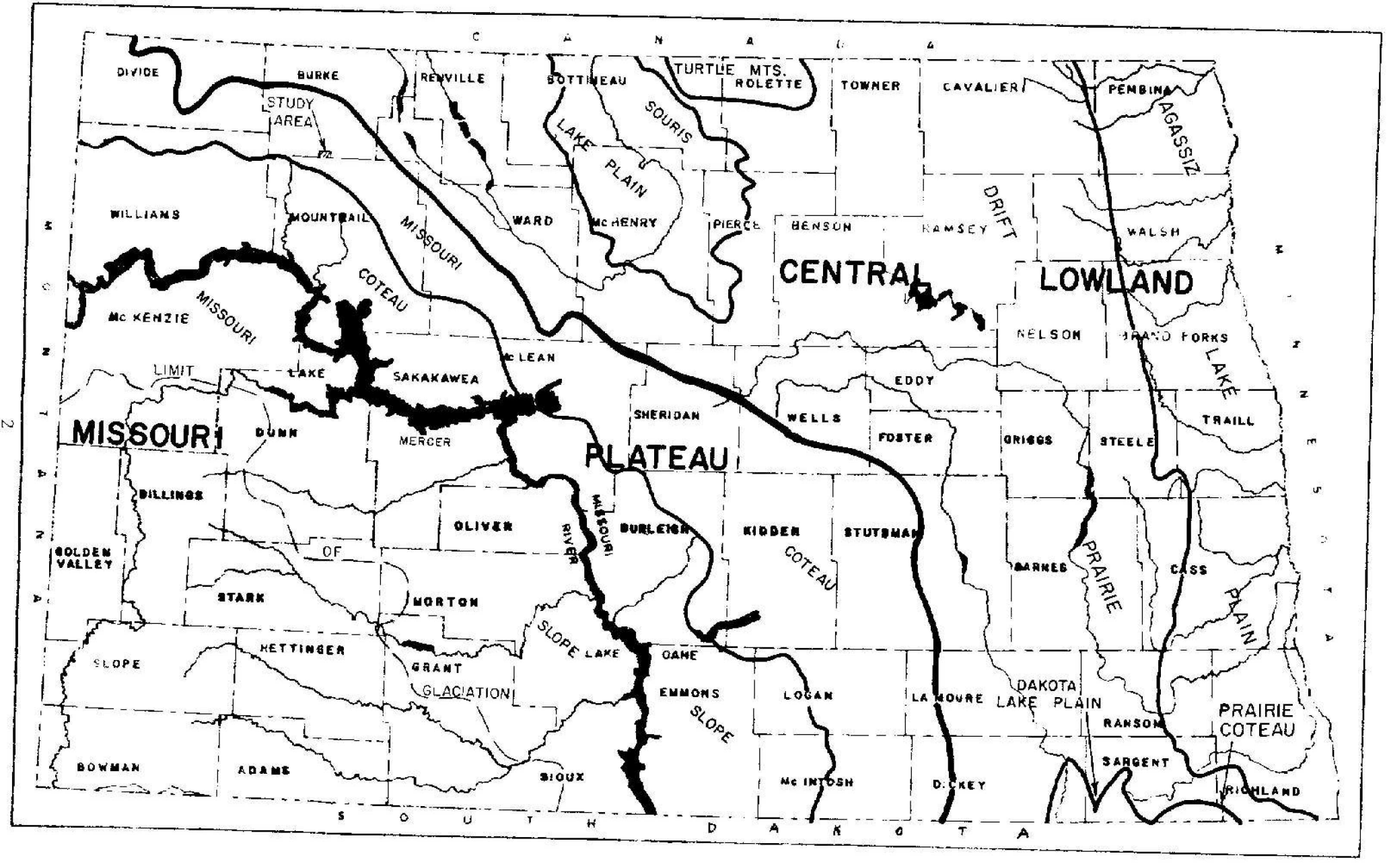


FIG. 1-STUDY AREA LOCATION

12 feet of sand and gravel from 65-71 feet and is screened from 66-77 feet. City well #4 is located at 159-93-36ABC. It penetrated 11 feet of sand and gravel from 62-73 feet and is screened from 64-73 feet.

Previous Investigations

In the USGS Water Supply Paper No. 598, pages 90-94, Simpson (1929) describes the general availability and quality of ground water from bedrock and glacial aquifers in Burke County. On page 91 he describes the numerous springs issuing from the morainal hills in the vicinity of Powers Lake. He also describes the general availability of water from the Fort Union Formation throughout the county.

In North Dakota Ground Water Study No. 23, pages 11-12 and 19, Paulson (1954) describes the origin and occurrence of water in the White Lake depression south of Powers Lake.

In North Dakota Ground Water Study No. 28, pages 53-57, Brookhart and Powell (1961) describes the results of their test drilling within the city limits of Powers Lake. They mention the occurrence of glacial and bedrock aquifers and the quantity and quality of water obtained from both.

In the North Dakota State Water Commission County Ground Water Study No. 14, pages 30 and 53-59, Armstrong (1971) describes the areal extent of and water quality in the Shell Creek aquifer which is in the vicinity of Powers Lake.

Location Numbering System

The system for denoting the location of a test hole or observation well is based on the federal system of rectangular surveys of public lands. The first and second numbers indicate township north and range west of the 5th

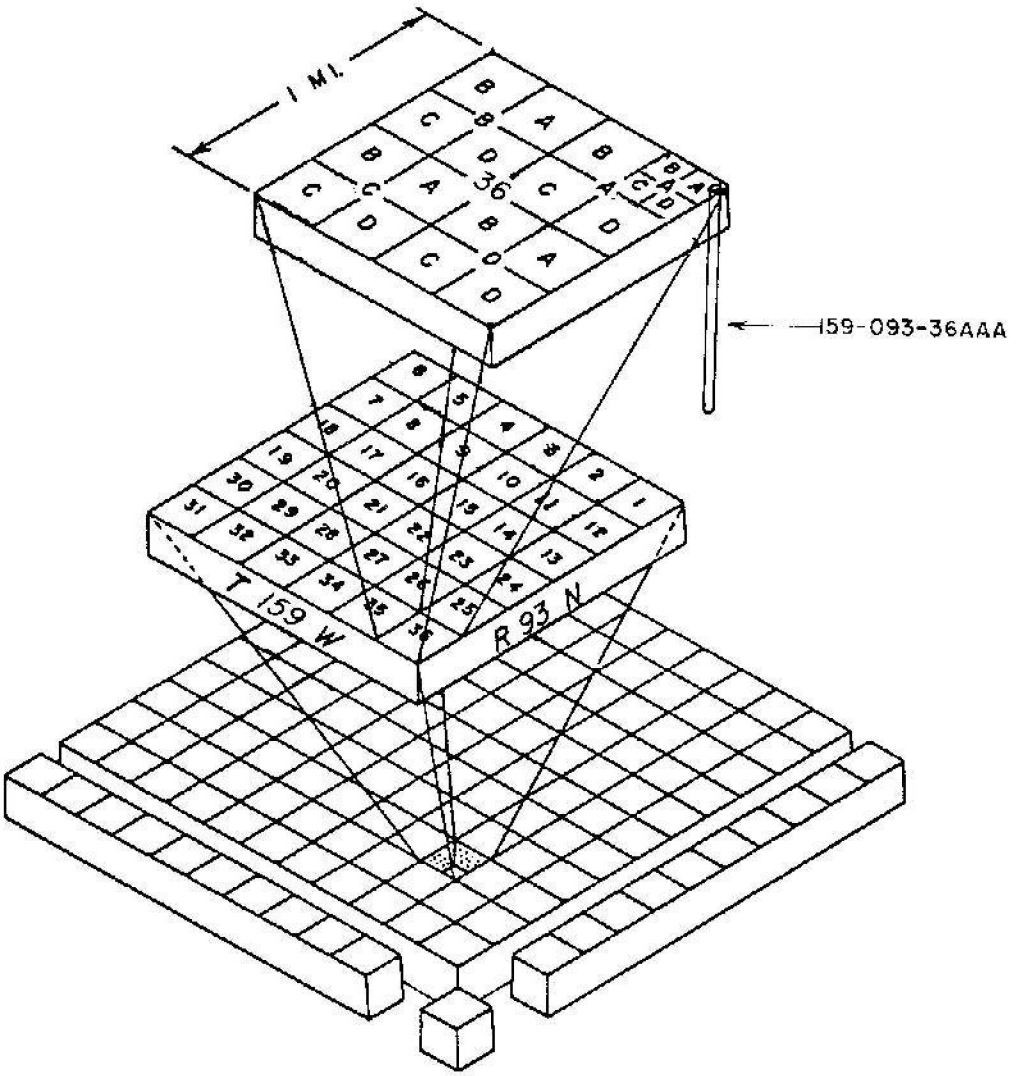


FIG. 2 WELL NUMBERING SYSTEM

Principal Meridian and base line. The third number refers to the section. The fourth, fifth, and sixth letters refer to quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections lettered consecutively A through D in a counter-clockwise direction (fig. 2).

Bedrock Aquifers

Armstrong (1971) discussed bedrock formations which possess a potential as aquifers in Burke and Mountrail Counties. Pre-Cretaceous Formations were discussed as a unit. Depth to the top of the pre-Cretaceous Formations is projected to a depth greater than 3900 feet. Water quality is variable but expected to be too saline for most purposes.

The top of the Dakota Group is projected to be at a depth of 3,500 feet in Burke County. Yields to wells completed in this formation in Mountrail County yield an average of 290 gallons per minute with specific capacities between 0.4-3.0 gpm per foot of drawdown. The water is a sodium chloride type.

The Fox Hills-Hell Creek undifferentiated of Cretaceous age is projected at a depth of 1,100 to 1,300 feet and contains about 100 feet of sandstone with interbedded silt and clay. It is expected to yield a few gallons per minute, possibly under artesian conditions, of a soft, sodium bicarbonate type water.

The Fort Union Formation of Paleocene age is found directly beneath the glacial till. It is comprised of the Ludlow, Cannonball, and Tongue River members and is composed of interbedded sandstone, lignite, and shale. Yields are expected to be a few gallons per minute of a predominantly sodium bicarbonate type water.

GLACIAL AQUIFERS

White Lake Branch of the Shell Creek Aquifer

State Water Commission test holes No. 784, 785, 10092, 10093, 10094, 10095, 10096, 10097, 10100, 10104, 10105, and city wells 2, 3, and 4 appear to penetrate the edge of the White Lake Branch of the Shell Creek aquifer (fig. 3, table 1). Of these only 10092, 10096, 10100, and 10104 are completed as observation wells (table 1). The thickness ranges from 12 to 90 feet. Depth to the aquifer ranges from 50 to 100 feet. The elevation of the deposit lies between 2000 and 2150 feet above msl as seen in the cross sections (fig. 4 and plate 1). The aquifer is composed of predominantly medium to coarse sand and fine to medium gravel. Grains are generally subangular to subrounded, predominantly subangular, and composed of equal proportions of carbonates, silicates, and detrital shale with minor amounts of igneous, metamorphics, and detrital coal. There are minor amounts of interbedded silt and clay also. The general areal extent is shown in figure 5. The boundary conforms roughly to the walls of the White Lake depression and is more clearly defined where test holes can lend control.

The water level is highest in test hole No. 10104 at an elevation of 2197.45 feet above msl and decreases in wells 10100 and 10092 at 2193.86 and 2188.74 feet above msl respectively. The slope of the piezometric surface is steeper at first, declining 3.59 feet in 0.1 mile between 10104 and 10100. It becomes flatter between 10100 and 10092, declining 5.12 feet in 0.8 mile. Overall, it declines 8.71 feet in 0.9 mile between 10104 and 10092. This indicates local ground-water flow to the northwest. The higher water level and slightly poorer water quality found in the vicinity of test hole No. 10104 relative to that found near No. 10100 may be a result of influence from the Fort Union Group.

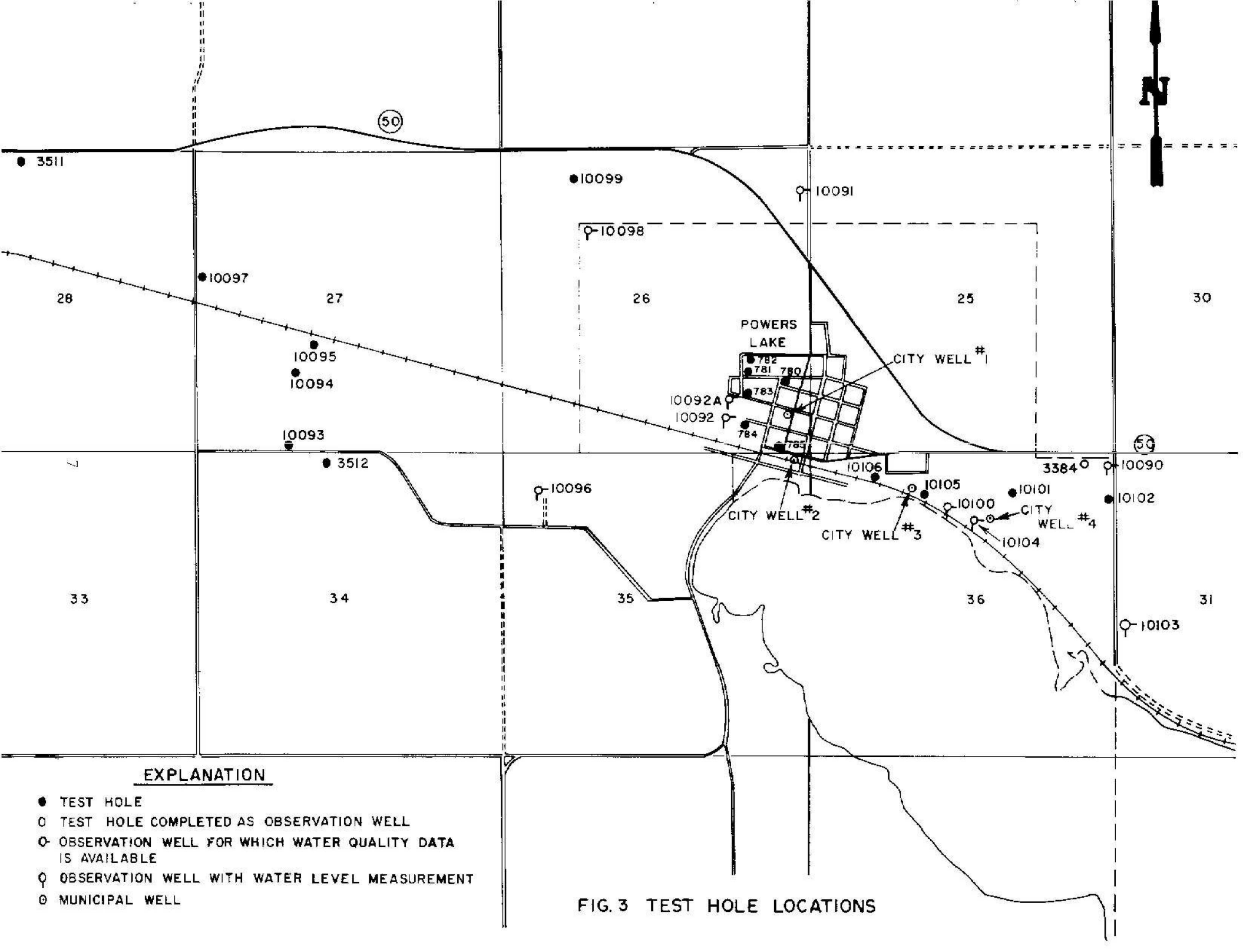


FIG. 3 TEST HOLE LOCATIONS

The aquifer material in 10104 is separated from bedrock by only a thin layer of clay whereas the aquifer material found in 10100 is separated from bedrock influences by 67 feet of glacial till and fluvial clay. It is also possible that, given the discontinuous and lenticular nature of the fluvial deposits in the White Lake depression, the units that have been screened in the three observation wells have no or very little hydrologic connection. This is most probably the case with test hole No. 10092, it being completed in an entirely different unit from holes 10100 and 10104.

The chemical analysis of the water is shown in table 2 and an explanation of the significance of each constituent is given in table 3. It is highly likely that the Shell Creek aquifer system receives the majority of its recharge from the Fort Union Formation (Armstrong, 1971) which influences the water quality and also increases the hydrostatic head (Paulson, 1954). The best overall water quality occurs in the vicinity of observation well No. 10100. Analysis of water obtained from this observation well indicates a concentration of total dissolved solids of 863 mg/l. This value is the lowest determined from samples from the three observation wells. The hardness, sodium, sulfate, and iron concentrations are 450 mg/l, 160 mg/l, 290 mg/l, and .02 mg/l, respectively. The hardness is the highest and the other values are the lowest occurring among the three observation wells. Hardness decreases and dissolved solids, sodium, sulfate, and iron concentrations increase with distance from observation well No. 10100. This is displayed in the analysis of water obtained from observation wells No. 10104 and 10092. The water obtained from No. 10092 had a total dissolved solids concentration of 1380 mg/l. The hardness, sodium, sulfate, and iron concentrations were 110 mg/l, 440 mg/l, 450 mg/l, and .45 mg/l, respectively. Increased hardness

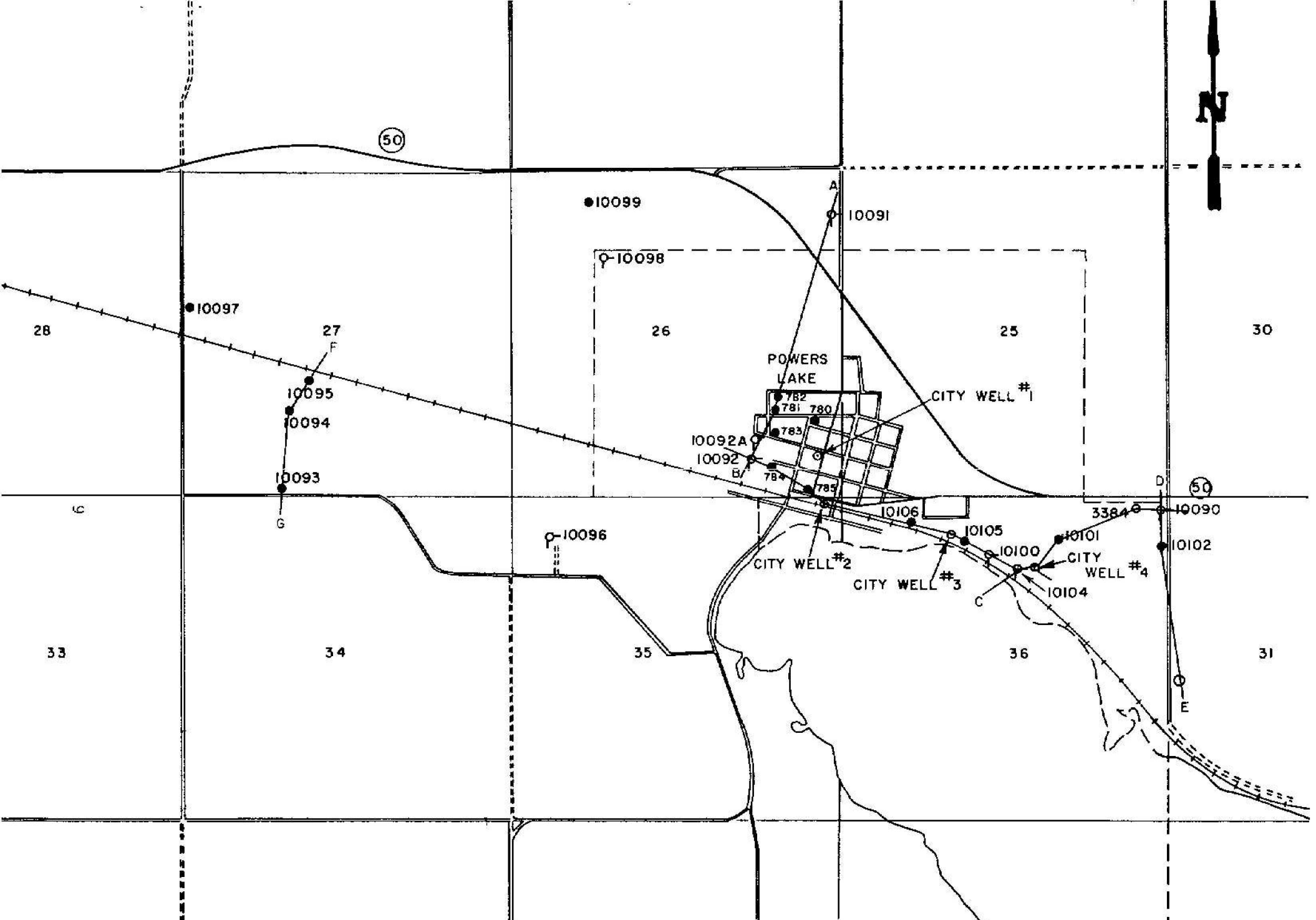


FIG. 4-LOCATIONS OF CROSS SECTIONS

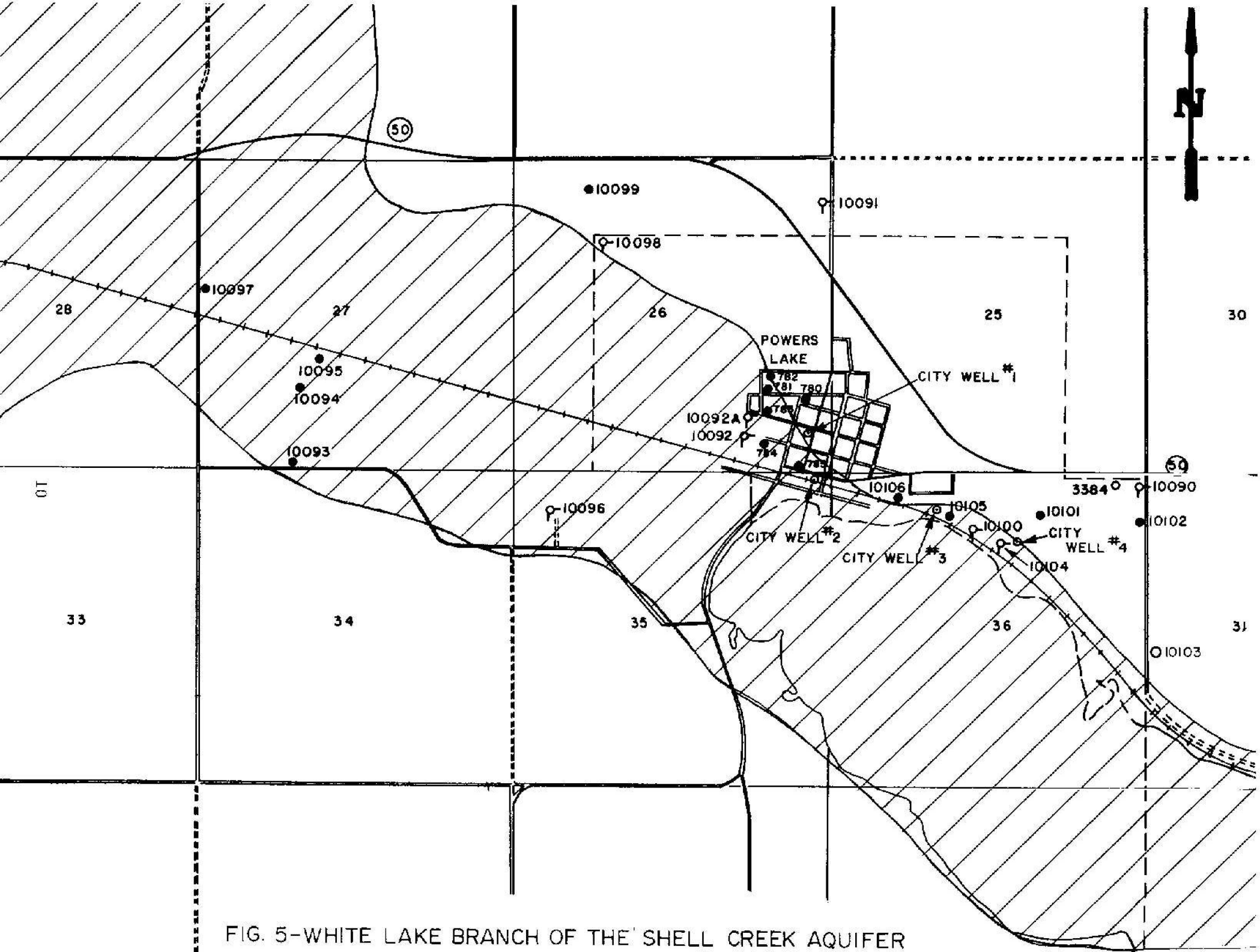


FIG. 5-WHITE LAKE BRANCH OF THE SHELL CREEK AQUIFER

and decreased sodium concentrations near 10100 may indicate local variations in the flow system and lithologies.

Outwash

A second glacial aquifer present in the area is composed of buried outwash. Its boundary is shown in fig. 6. It occurs at an elevation from 2150 to 2200+ feet above msl and may be bounded generally by the 2200 foot elevation in the wall of the White Earth River valley and White Lake depression (fig. 4 and plate 1). Test holes 780, 781, 782, 783, 785, 10090, 10091, 10092A, 10098, 10099, 10101, 10102, 10103, 10106, and 3384, and possibly city wells 1 and 2 have penetrated it. Test holes 10090, 10091, 10092A, 10098, and 10103 were completed as observation wells. The aquifer ranges from 15 to 50 feet thick. Depth to the aquifer ranges from 0 to 60 feet. It is composed of predominantly rounded, well sorted, medium or coarse sand and fine to medium gravel, where exposed at the surface. Carbonates, detrital shale, and silicates are found in nearly equal proportions. Some finer sands occasionally contain considerable quantities of clay and silt.

The highest water levels are found in the vicinity of observation wells No. 10090 and 10091 at 2208.15 and 2208.37 feet above msl respectively (tables 1 and 2). Lower water levels are found in observation wells No. 10103, 10092A, and 10098 at 2200.23, 2188.74, and 2187.36 feet above msl respectively. Ground water movement is from the higher elevations north and east of Powers Lake toward the White Earth River valley and the White Lake depression.

Relatively better quality is found in the vicinity of observation well No. 10103. Analysis of a sample obtained from the observation well indicates a total dissolved solids concentration of 854 mg/l. The hardness, sodium, sulfate, and iron concentrations are 320 mg/l, 170 mg/l, 170 mg/l, and .08 mg/l,

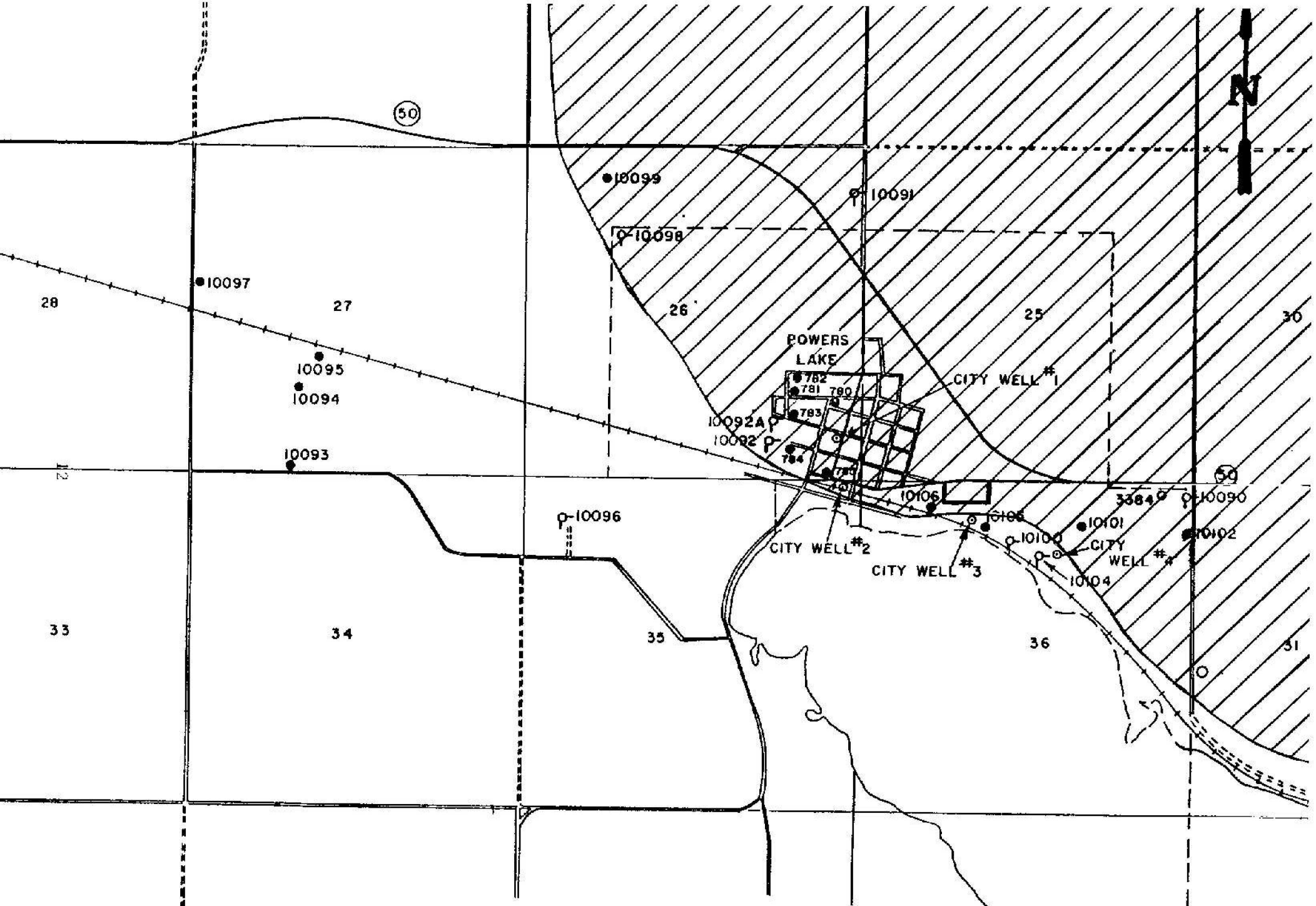


FIG. 6.- AREAL EXTENT OF BURIED OUTWASH

respectively. The poorest quality water is found in the vicinity of city well No. 1. Analysis of a sample obtained from this well indicates a concentration of total dissolved solids of 1480 mg/l. Hardness, sodium, sulfate, and iron concentrations are 320 mg/l, 430 mg/l, 530 mg/l, and 1.7 mg/l, respectively.

The existence of two distinct aquifers is inferred from the test hole logs and cross sections. The degree of connection between the units is not known. Water levels vary only slightly between the units. Observation wells No. 10092 and 10092A have been completed in the White Lake Branch and the outwash with water levels of 2187.2 and 2188.74 feet above msl, respectively. It is unlikely that the two units are connected, the valley-ward flow in the upper unit intersecting the White Lake Branch aquifer and contributing to its northwesterly flow.

Summary

Test drilling revealed the presences of two aquifers in the area. They are the fluvial sands and gravels deposited in the White Lake depression and glacial outwash found in the higher elevations north of the city of Powers Lake. The deposits of the White Lake depression posses a greater saturated thickness and slightly superior water quality. Within the White Lake depression, deposits possessing relatively better quality water and higher water levels were encountered at the southeast corner of the city along the railroad tracks. The two new city wells (wells No. 3 and 4), were completed in these deposits.

Table 1 - Logs of Test Holes

The following test hole logs are compiled data of geologist's sample descriptions, driller's logs, and geophysical logs which include resistance and spontaneous potential. Grain-size classification throughout this report uses K. C. Wentworth's scale from Compton (1967). Color descriptions are of wet samples and are based upon color standards of the national research council (Goddard, et.al., 1948). Test holes completed as observation wells have surveyed elevations, all others are inferred from topographic maps published by the U. S. Geological Survey. Observation wells are composed of 1¼" pvc plastic casing and screened bottoms. Well depths and screened producing intervals (S.I.) are also noted.

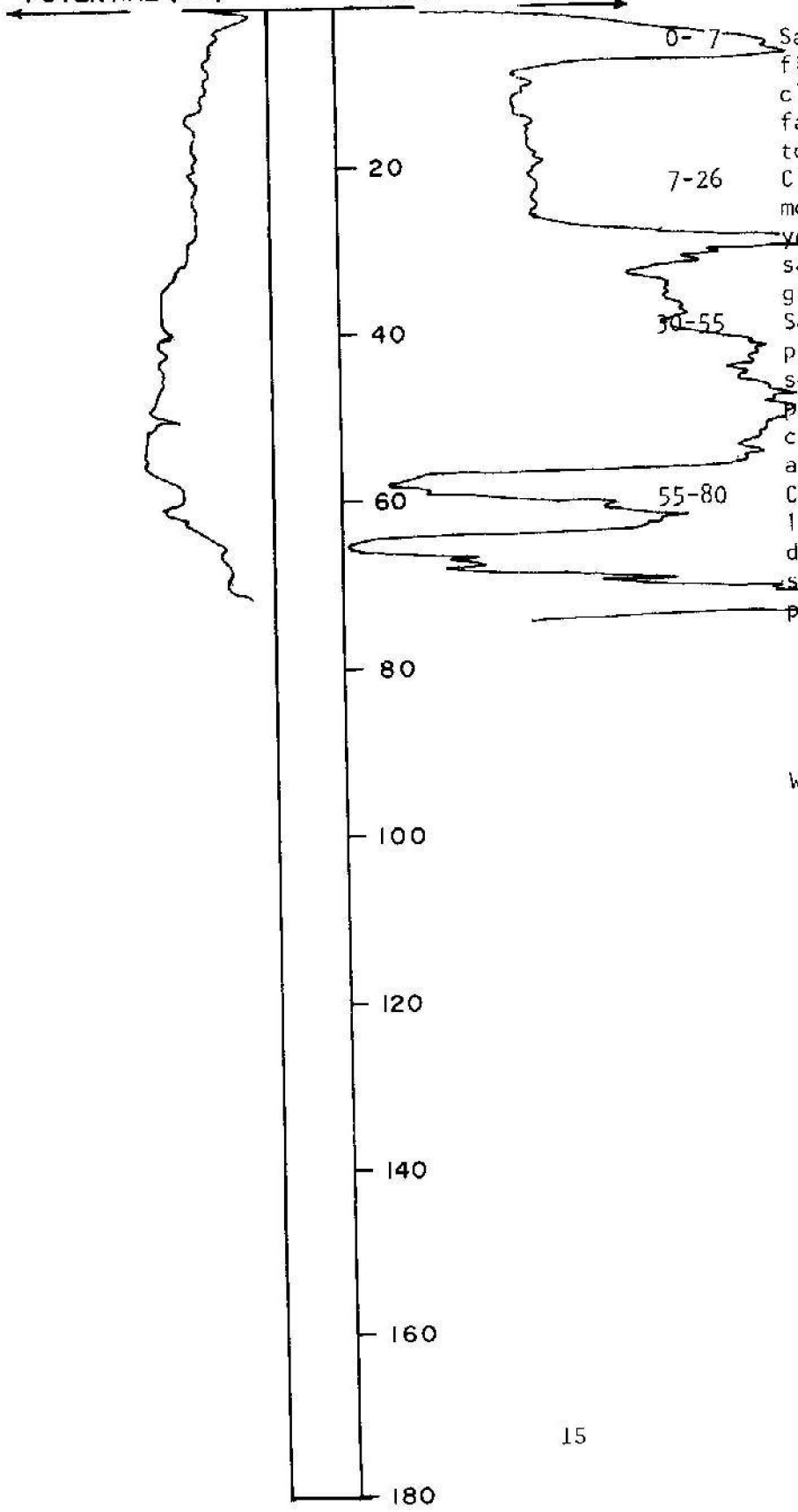
TEST HOLE 10091

LOCATION: 159-93-26AAD

DATE DRILLED: 6/6/78

ELEVATION: 2240
(FT, MSL)

DEPTH: 80
(FT)



DESCRIPTION OF DEPOSITS

0- 7 Sand, gravelly, clayey, very fine to coarse sand, yellow clay, predominantly coarse sand, fair to poor sorting, subangular to rounded, oxidized.

7-26 Clay, sandy, silty, pebbly, moderately compact and plastic, yellow-brown clay, oxidized, sand lense 21'- 23', coarse gravel 26'- 30' (till).

30-55 Sand, very fine to coarse, predominantly fine, very well sorted, rounded to subangular, predominantly quartz (30%), carbonates (20%), lignite (20%), and shale.

55-80 Clay interbedded with lignite, lignite beds 58'-61' and 68'-73', dark gray to medium gray clay, silty, moderately compact to poorly cohesive.

Observation Well
Depth = 54'
S.I. = 48'- 54'

Water level below land surface
6/14/78 31.63'

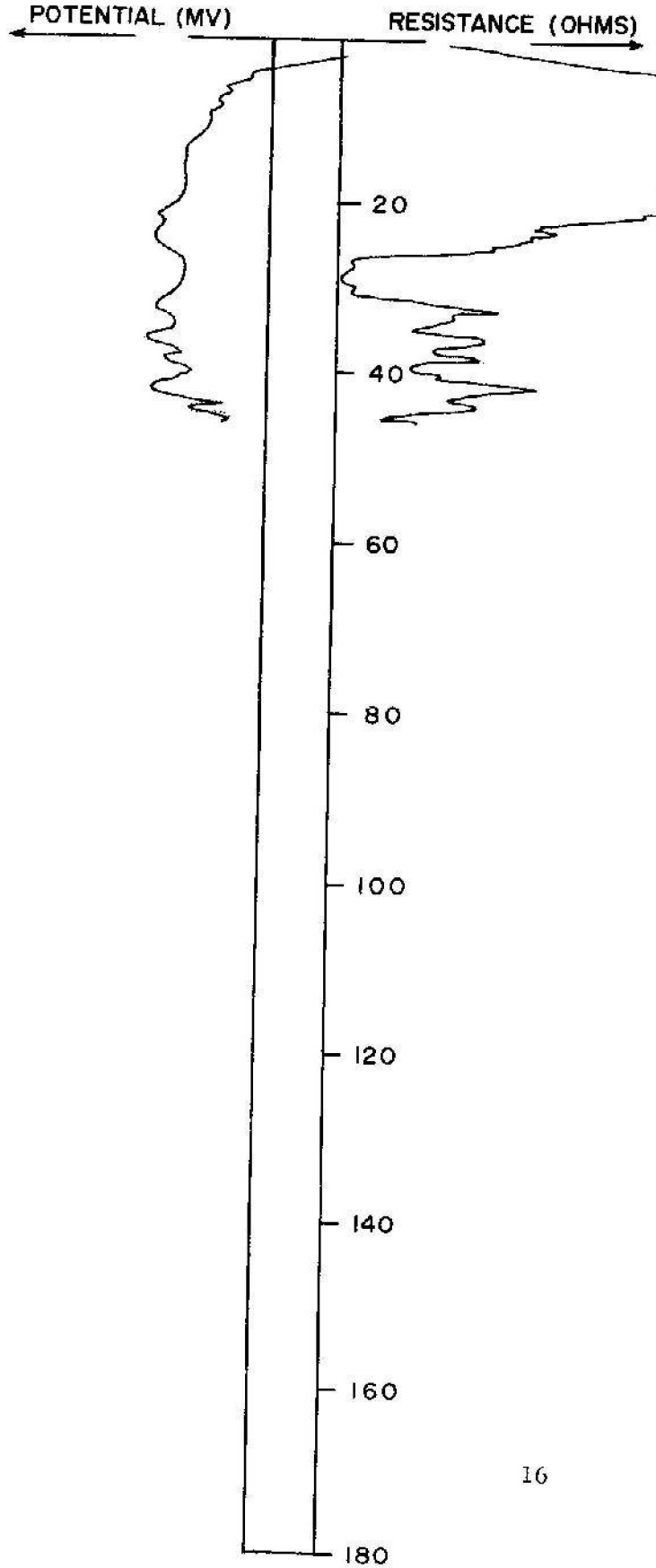
TEST HOLE 10099

LOCATION: 159-93-26BAC

DATE DRILLED: 6/8/78

ELEVATION: 2193
(FT, MSL)

DEPTH: 60
(FT)



DESCRIPTION OF DEPOSITS

0-22 Gravel, sandy, fine to coarse, fine to coarse sand, predominantly fine gravel, fairly well sorted, subrounded, predominantly carbonates, shale and quartz, oxidized to 12', interbedded dark brown clay.

22-52 Clay, silty, dark gray, very silty, 40% silt, moderately to very compact, interbedded dark brown carbonaceous clay, poorly cohesive.

52-60 Clay, silty and gravelly, interbedded dark brown, very silty carbonaceous clay, and subangular to subrounded gravel, predominantly medium gravel, well sorted.

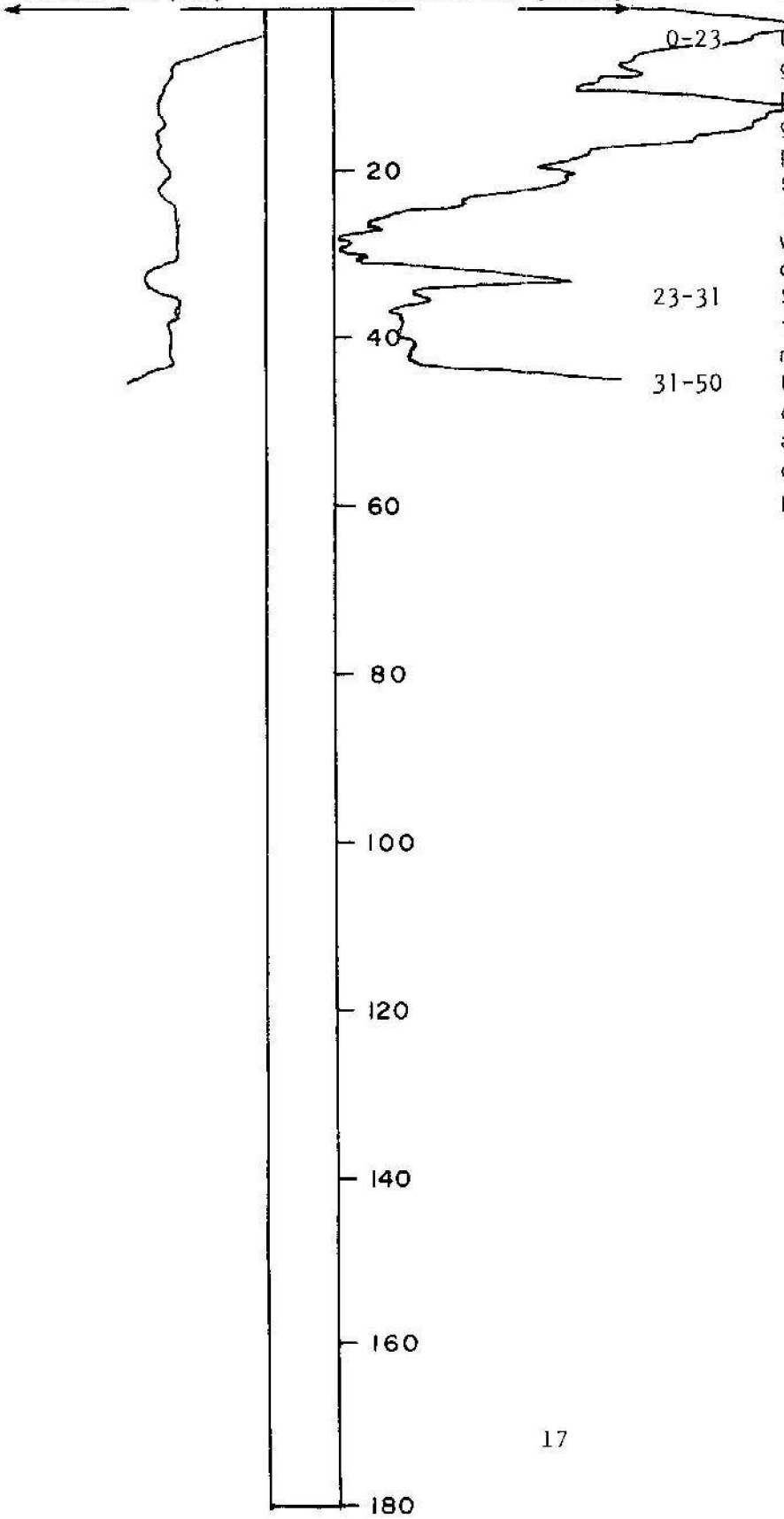
TEST HOLE 10098

LOCATION: 159-93-26BDB

DATE DRILLED: 6/8/78

ELEVATION: 2192
(FT, MSL)

DEPTH: 50
(FT)



DESCRIPTION OF DEPOSITS

0-23 Gravel, sandy, fine to coarse gravel, fine to coarse sand, predominantly fine to medium gravel (40%), well sorted, predominantly carbonates (40%), shale (20%), quartz (15%), and igneous and metamorphics, taking water, subrounded to subangular, oxidized to 17'.

23-31 Sand, clayey, light gray, very fine sand, 40% clay, sticky and moderately compact.

31-50 Clay, silty, medium gray, very compact, clay with 30-40% silt, and interbedded medium brown carbonaceous clay, very sticky, poorly compacted.

Observation Well
Depth = 21'
S.I. = 18'- 21'

Water level below land surface
6/13/78 6.39

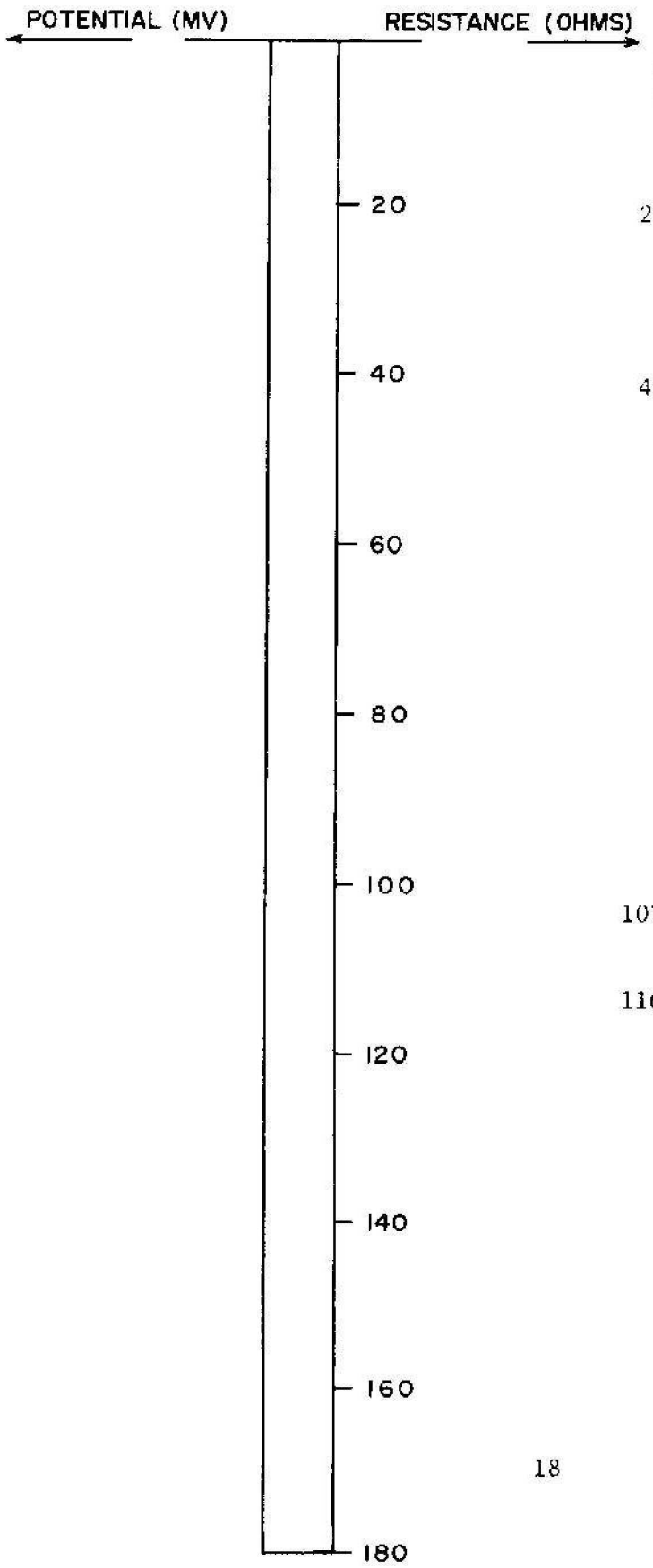
TEST HOLE 781

LOCATION: 159-093-26DAB

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 130
(FT)



	DESCRIPTION OF DEPOSITS
0- 1	Topsoil, sandy, black.
1-24	Sand, fine to coarse, and fine gravel.
24-46	Clay, very sandy, light greenish-gray, and fine to medium gravel, and shale pebbles.
46-107	Clay, sandy, medium gray, and streaks of light gray.
107-116	Sand, coarse, clayey, and fine gravel, and the coarser fraction consists of shale fragments.
116-130	Clay, sandy, gray, and fine to medium gravel.

Observation Well
Depth = 80'
S.I. = 70'- 80'

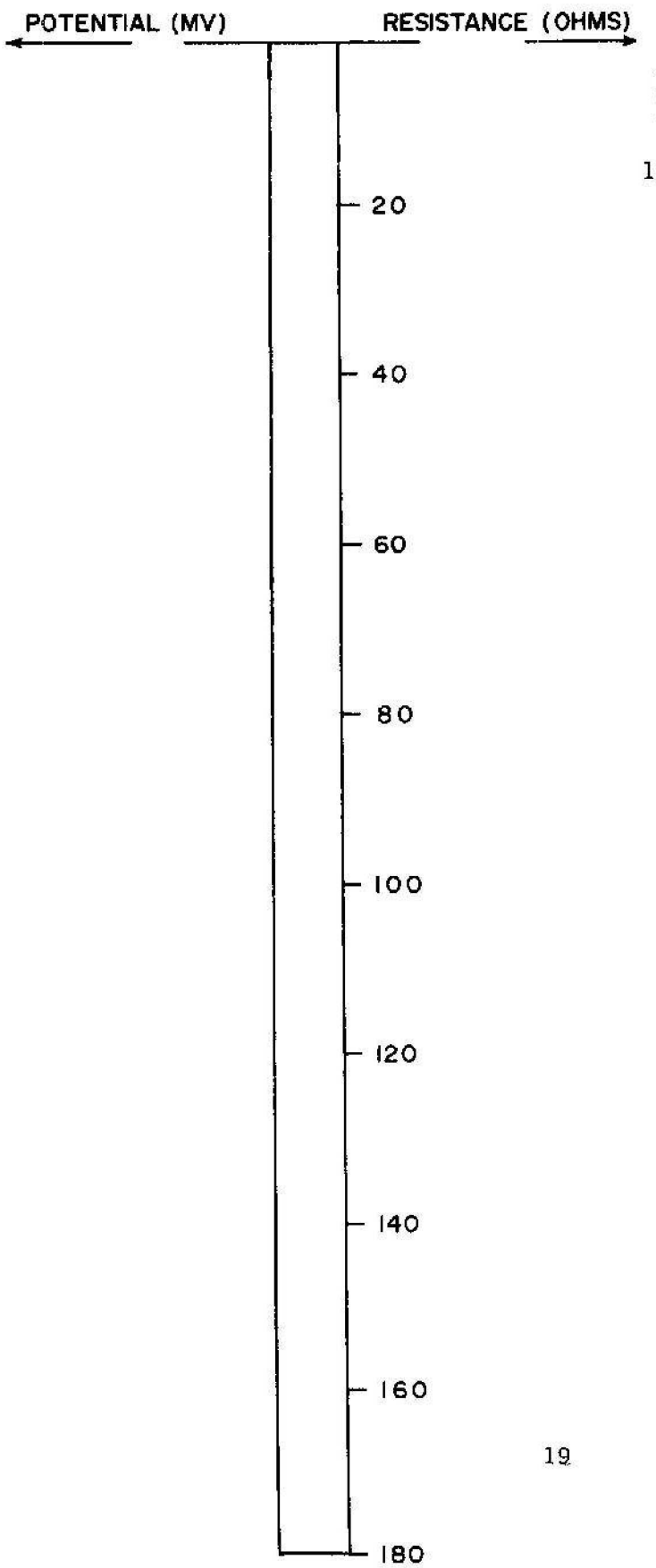
TEST HOLE 782

LOCATION: 159-093-26DAC

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 30
(FT)



DESCRIPTION OF DEPOSITS

0- 1	Topsoil, black.
1-16	Sand, medium to coarse, and coarse gravel.
16-30	Clay, sandy, light greenish-gray.

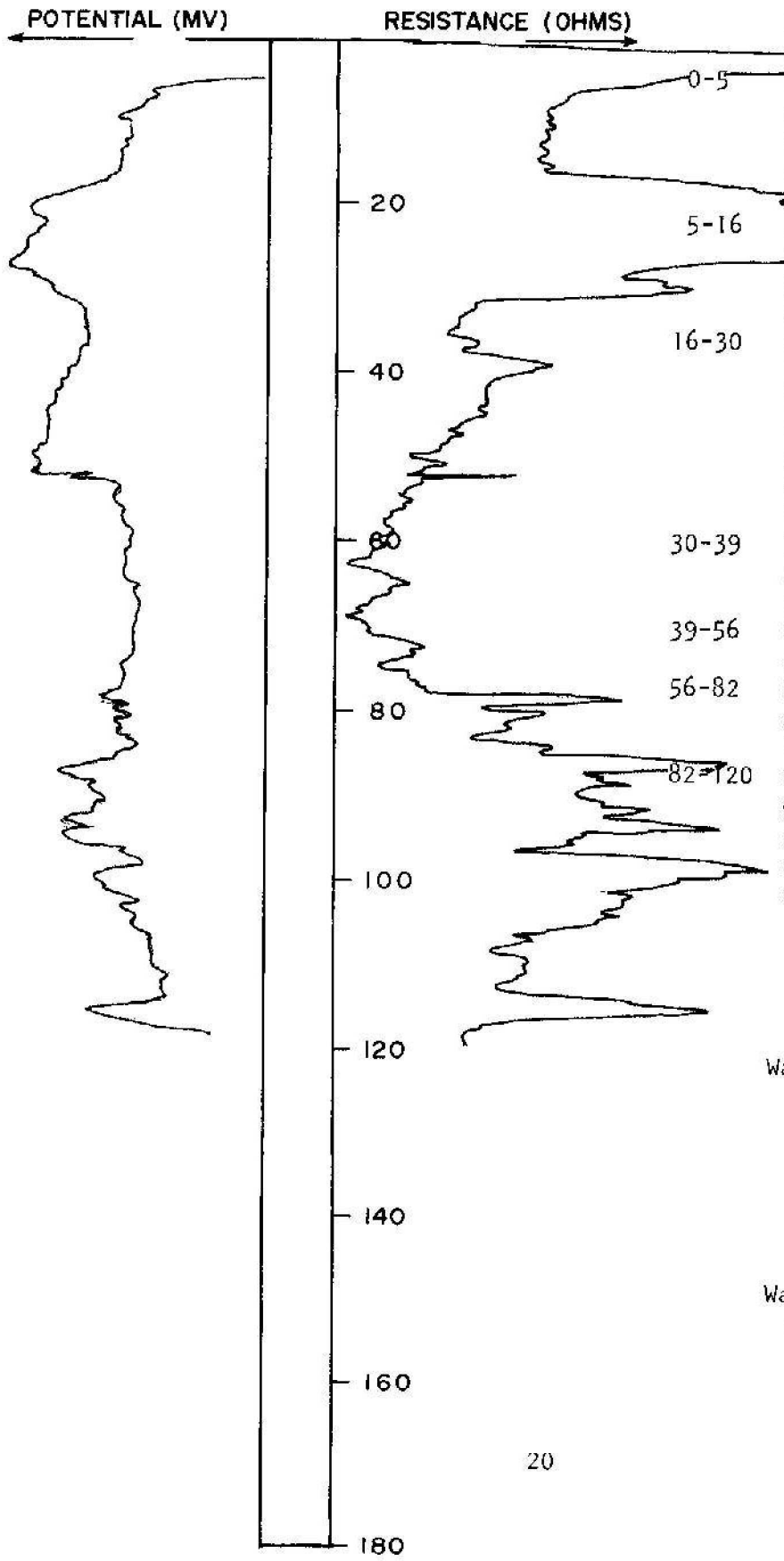
TEST HOLE 10092

LOCATION: 159-93-26DDA$_{1 \text{ and } 2}$

DATE DRILLED: 6/6/78

ELEVATION: 2192
(FT, MSL)

DEPTH: 120
(FT)



DESCRIPTION OF DEPOSITS

0-5	Gravel, sandy, fine to coarse gravel, fine to coarse sand, predominantly fine gravel, fairly well sorted, carbonates 30%, shale 20-30%, subrounded.
5-16	Clay, silty, sandy, gravelly, moderately compact to slightly plastic, dark gray, very silty and sandy.
16-30	Gravel, sandy, fine gravel and fine to coarse sand, predominantly fine gravel (60%), well sorted, subangular to subrounded, predominantly shale (40%), carbonates (30%), quartz (20%), takes water.
30-39	Clay, silty, dark gray, compact and plastic, hard and silty (20-30%).
39-56	Clay (as above), silty, sandy, dark gray, 20% sand, 20-30% silt.
56-82	Shale, dark gray, soft shale, compact, slightly silty, thin lignite 78'- 79'.
82-120	Gravel, sandy, fine to medium gravel, medium to coarse sand, predominantly fine gravel, well sorted, predominantly carbonates, shale and detrital lignite.

Observation Well #1
(south)
Depth = 97'
S.I. = 94'- 97'
Water level below land surface
6/14/78 4.8'

Observation Well #2
(north)
Depth = 26'
S.I. = 23'- 26'
Water level below land surface
6/14/78 3.26'

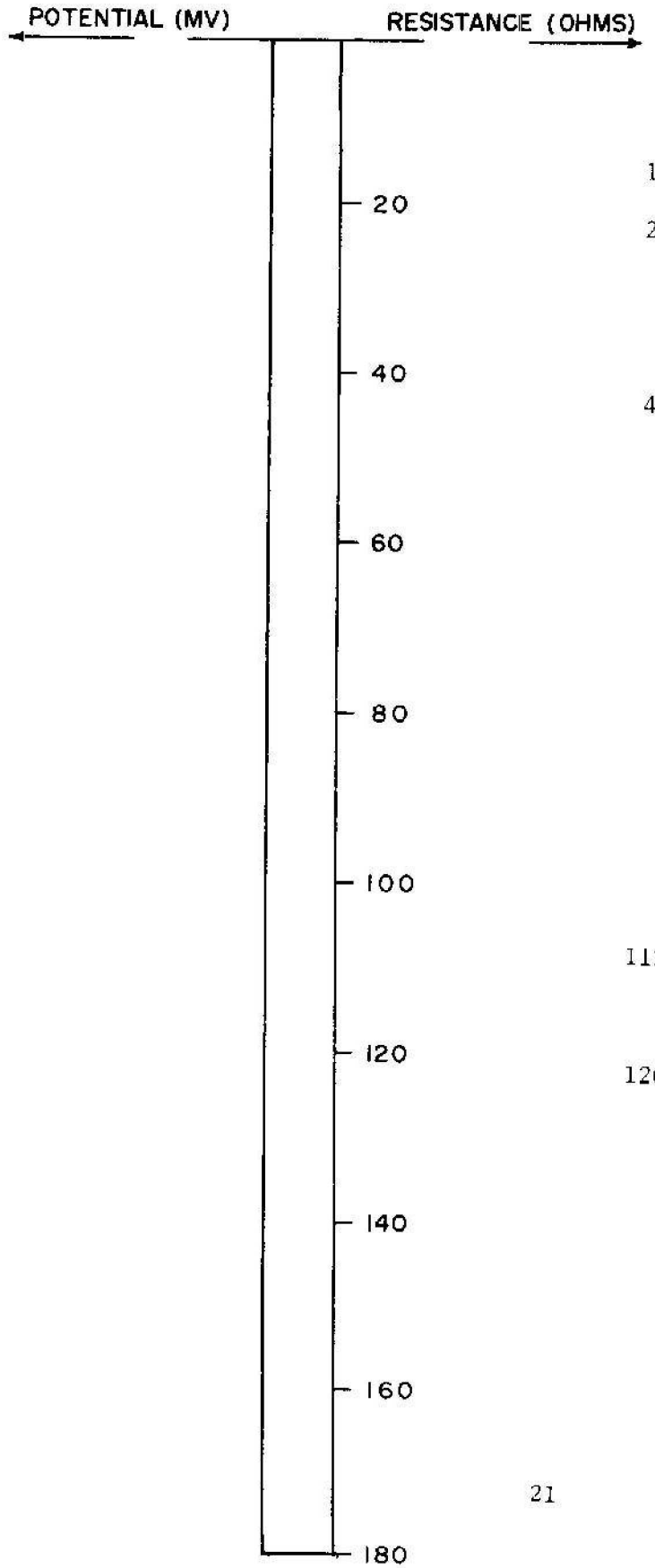
TEST HOLE 780

LOCATION: 159-093-26DDA

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 150
(FT)



	DESCRIPTION OF DEPOSITS
0- 1	Topsoil, black.
1-15	Sand, medium to coarse, and fine to medium gravel.
15-26	Clay, yellowish-gray, and fine to medium gravel, and shale pebbles.
26-48	Clay, sandy, light greenish-gray, and medium gravel.
48-112	Clay, sandy, dark gray.
112-126	Sand, fine to medium clayey, and fine gravel, and the coarser fraction consists of shale fragments.
126-150	Clay, very sandy, dark gray.

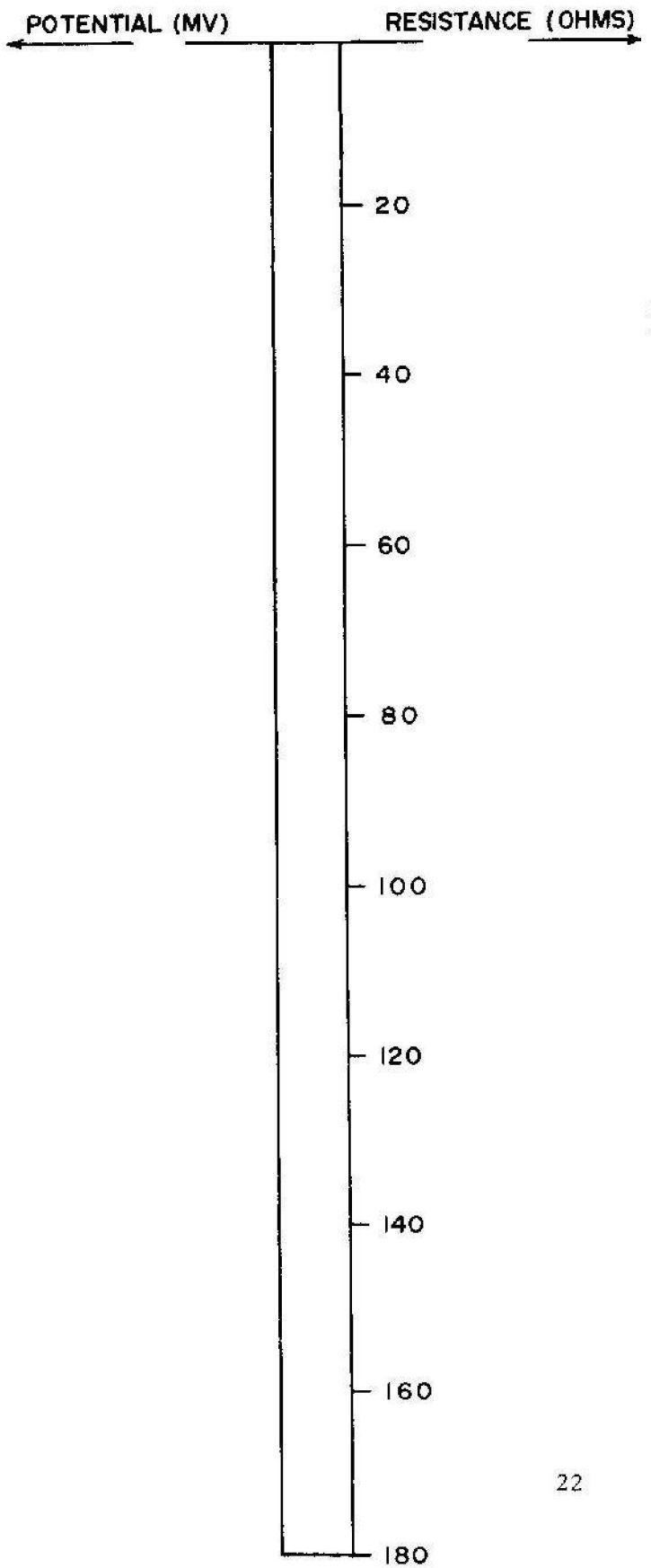
TEST HOLE 783

LOCATION: 159-093-26DDB

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 30
(FT)



DESCRIPTION OF DEPOSITS

0- 2	Topsoil, black.
2- 6	Sand, silty, and fine to medium gravel.
6- 8	Clay, yellowish gray, and fine to medium gravel, and shale pebbles.
8-16	Clay, gray, and fine to medium gravel and shale pebbles.
16-18	Gravel, fine to medium.
18-30	Clay, light greenish-gray.

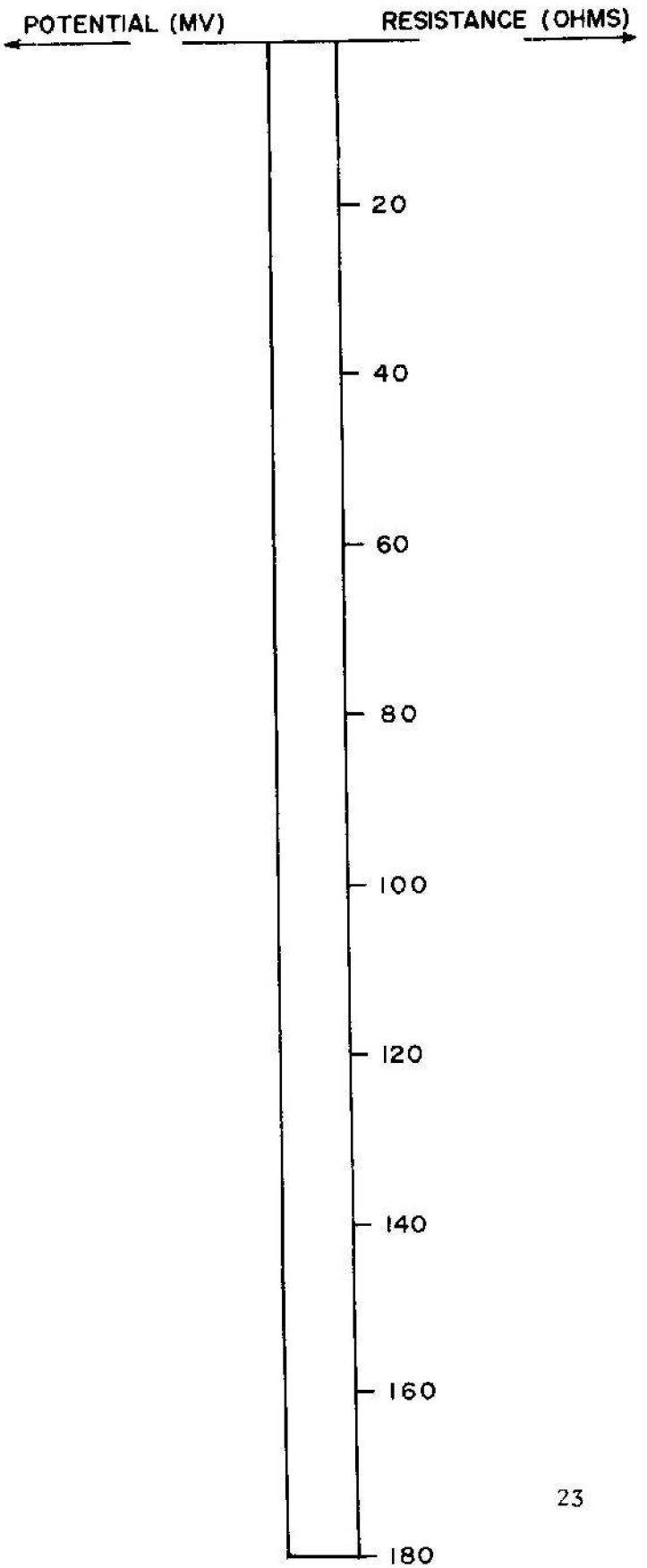
TEST HOLE 784

LOCATION: 159-093-26DDC

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 140
(FT)



DESCRIPTION OF DEPOSITS

0- 1	Topsoil, black.
1-12	Sand, very coarse, and fine gravel.
12-19	Clay, gray, and fine to medium gravel, and shale pebbles.
19-24	Sand, medium to coarse, and fine to medium gravel, and the coarser fraction consists of shale fragments.
24-40	Clay, sandy, light gray.
40-50	Clay, sandy, medium gray.
50-67	Clay, smooth, medium gray.
67-72	Sand, fine, clayey.
72-82	Clay, sandy, medium gray.
82-94	Sand, fine to coarse, and fine gravel and the coarser fraction consists of shale fragments.
94-126	Sand, very coarse, and fine gravel and the coarser fraction consists of shale fragments.
126-140	Clay, medium gray.

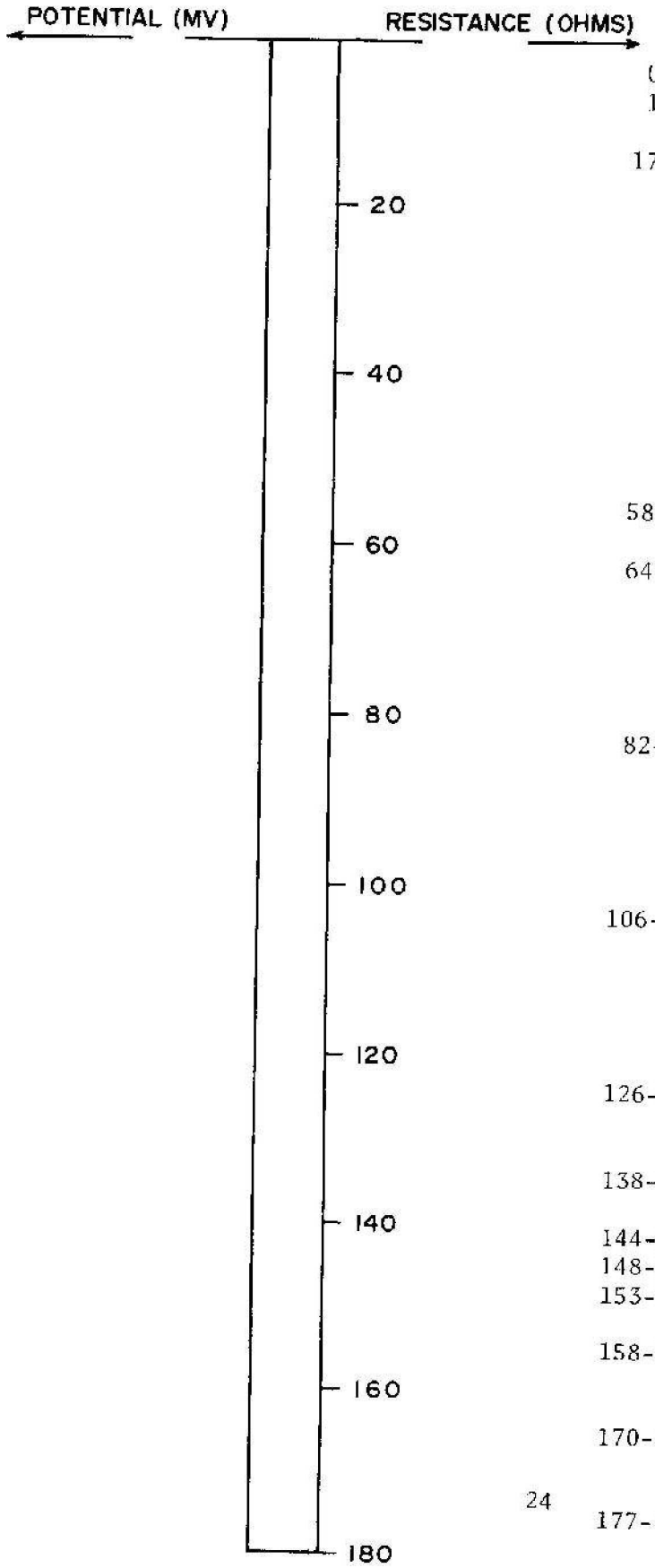
TEST HOLE 785

LOCATION: 159-093-26DDD

DATE DRILLED:

ELEVATION:
(FT, MSL)

DEPTH: 180
(FT)



	DESCRIPTION OF DEPOSITS
0- 1	Topsoil, black.
1-17	Sand, fine to coarse, fine to medium gravel.
17-58	Clay, sandy, light gray.
58-64	Sand, fine, clayey.
64-82	Clay, hard, gray.
82-106	Sand, fine to coarse, clayey, and the coarser fraction consists of shale fragments.
106-126	Lignite.
126-138	Clay, gray.
138-144	Sand, fine to coarse.
144-148	Clay, light gray.
148-153	Sand, fine to medium
153-158	Clay, gray, and fine to medium gravel.
158-170	Sand, medium to coarse, and fine gravel, drills hard as though it may be cemented.
170-177	Clay, gray, and fine to medium gravel.
177-180	Clay, hard, light gray.

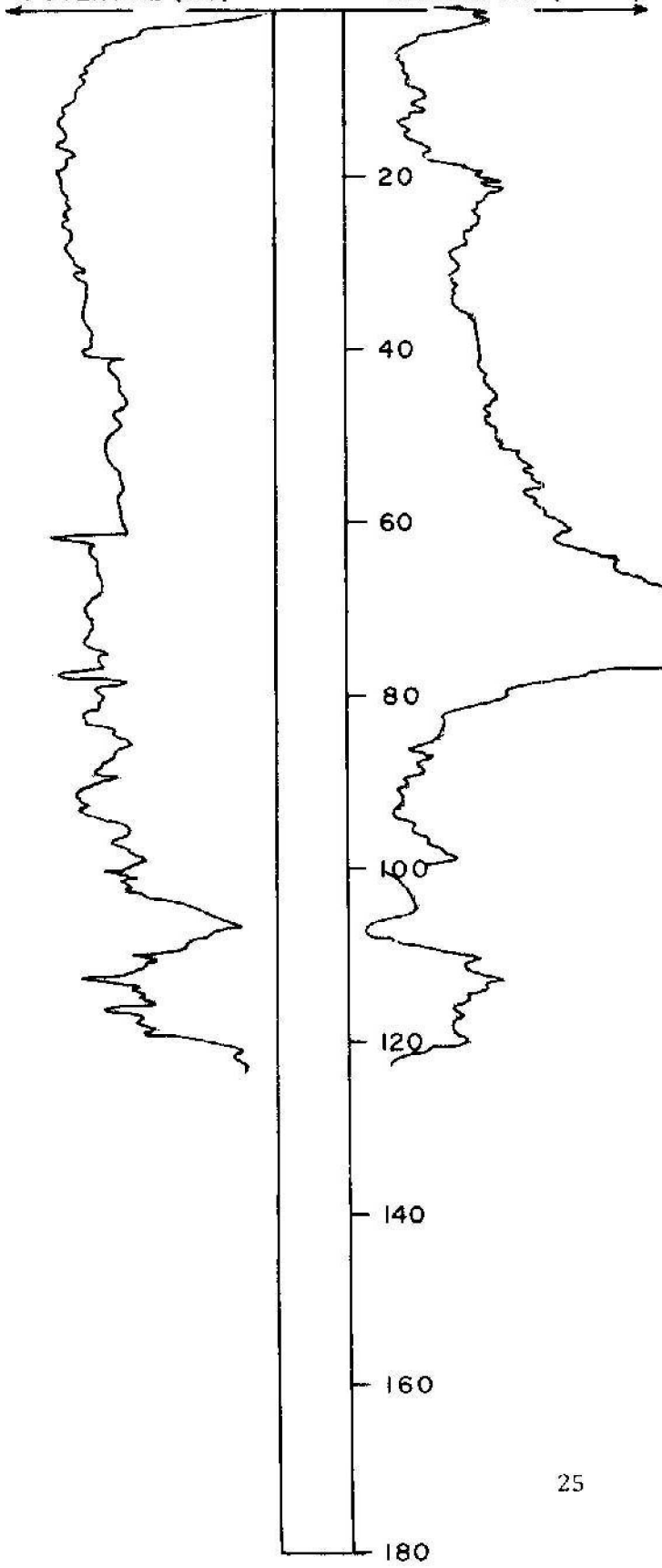
TEST HOLE 10097

LOCATION: 159-93-27BCC

DATE DRILLED: 6/8/78

ELEVATION: 2212
(FT, MSL)

DEPTH: 120
(FT)



DESCRIPTION OF DEPOSITS

0-24	Clay, silty, sandy, pebbly, moderately compact, moderately plastic, light brown-gray, oxidized, cobble 20'- 21' (till).
24-66	Clay (as above), dark gray, moderately compact to compact, plastic, gravel lense 45'- 46' (till).
66-74	Gravel, sandy, fine to medium gravel, fine to coarse sand, predominantly fine gravel, well sorted, subrounded, predominantly carbonates, shale, quartz, igneous and metamorphic.
74-82	Clay, silty, sandy, pebbly, dark gray, compact (as above) (till).
82-97	Clay, silty, sandy, dark gray-black, compact, 30% silt, 20-25% fine to medium sand.
97-120	Sand, clayey, light green-gray, very fine sand, 20% clay, interbedded with carbonaceous brown silty clay.

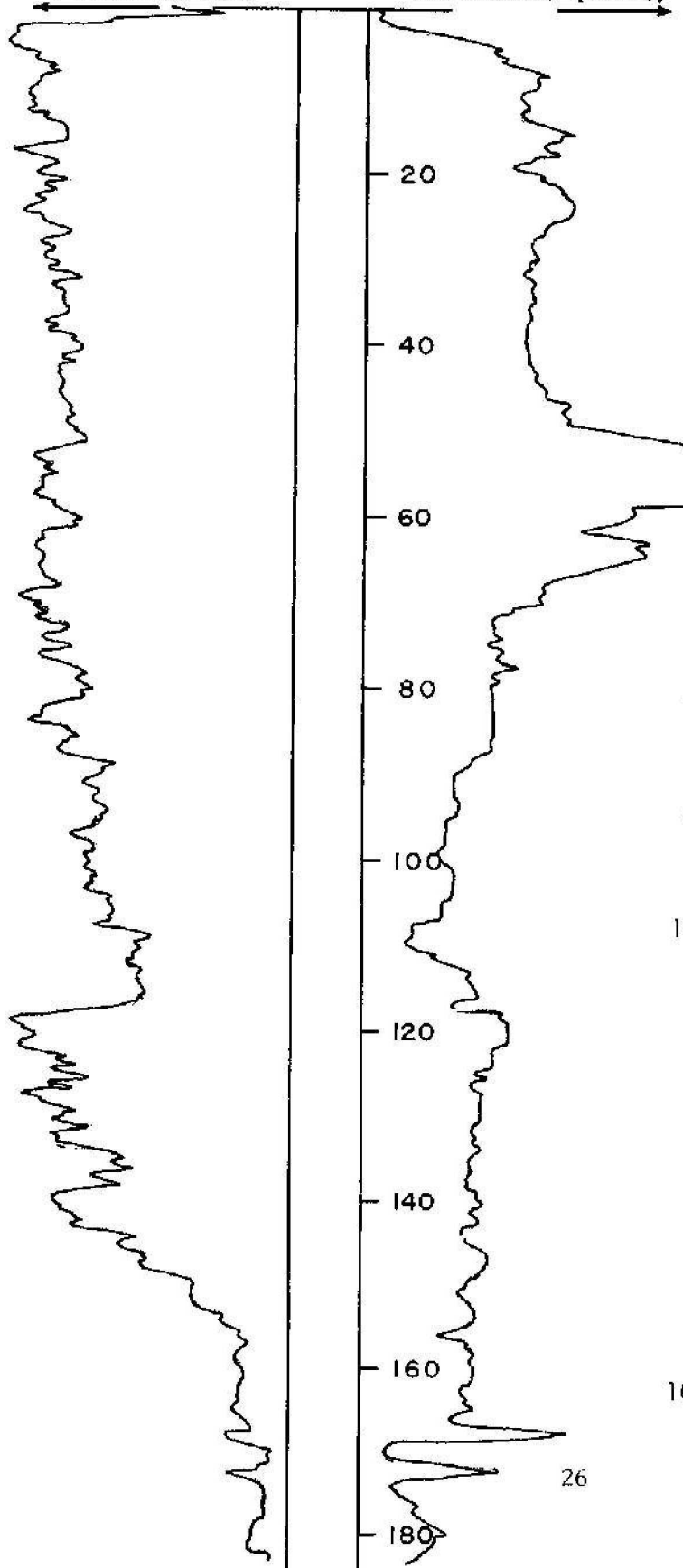
TEST HOLE 10095

LOCATION: 159-93-27CAA

DATE DRILLED: 6/7/78

ELEVATION: 2192
(FT, MSL)

DEPTH: 180
(FT)



	DESCRIPTION OF DEPOSITS
0-16	Clay, sandy, silty, pebbly, moderately compact, and plastic, yellowish, oxidized (till).
16-50	Clay (as above), dark grayish-green, unoxidized (till).
50-57	Gravel, sandy, fine to medium gravel, medium to coarse sand, predominantly medium gravel, well sorted, subangular to subrounded, predominantly shale and carbonates.
57-65	Clay (as above), dark gray, sandy, sand lense at 61'- 64', sand fine to medium (till).
65-84	Clay, silty, sandy, dark gray-brown, silt (30%), very fine sand, very plastic and moderately cohesive.
84-109	Clay, sandy, silty, pebbly, dark gray, moderately plastic and cohesive, very poorly sorted (till).
109-162	Clay (as above), abundant lignite sand.
162-180	Sand, clayey, very fine, greenish-gray, 40-50% clay, moderately to very compact, interbedded carbonaceous clay.

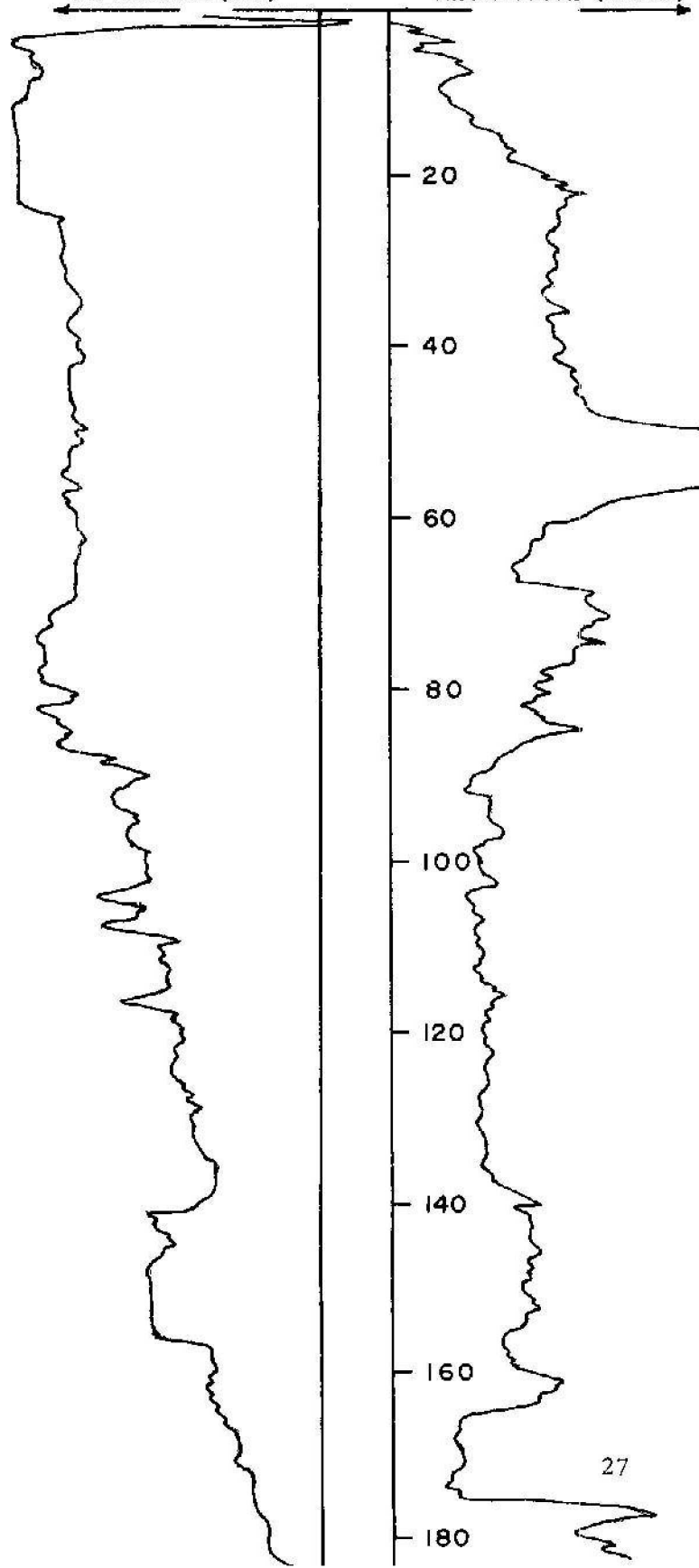
TEST HOLE 10094

LOCATION: 159-93-27CAC

DATE DRILLED: 6/7/78

ELEVATION: 2190
(FT, MSL)

DEPTH: 180
(FT)



DESCRIPTION OF DEPOSITS

0-17	Clay, silty, sandy, pebbly, yellow-brown, moderately compact, moderately plastic, cobbles and sandy gravel 2'- 4' (till).
17-48	Clay (as above), dark gray, unoxidized, very silty, sandy, pebbly (till).
48-53	Sand, very fine to medium, predominantly fine sand, well sorted, subrounded, predominantly quartz, carbonates and shale.
53-56	Gravel, sandy, fine to medium gravel, coarse sand, predominantly well sorted, subangular to subrounded, predominantly shale and carbonates.
56-67	Clay, sandy, silty, pebbly, dark gray, moderately plastic, and cohesive, 40% sand (till).
67-75	Gravel, sandy, clayey, fine to medium gravel, fine to coarse sand, predominantly fine gravel, interbedded clay, fair sorting, subangular to subrounded, upper section is predominantly fine sand, well sorted.
75-84	Gravel (as above), predominantly fine to medium gravel and medium to coarse sand, fairly well sorted.
84-104	Clay, sandy, silty, pebbly, dark gray, plastic and cohesive (till).
104-136	Clay (as above), interbedded detrital lignite (till).
136-151	Sand, gravelly, clayey, very fine sand interbedded with fine gravel poorly sorted, (poor sample return), predominantly very fine sand.
151-160	Clay, silty, sandy, dark gray, moderately compact, 30% silt, moderately cohesive, sand lense at 158-160' (till).
160-171	Clay, dark gray, very compact, interbedded with dark brown carbonaceous material and lignite.
171-180	Lignite.

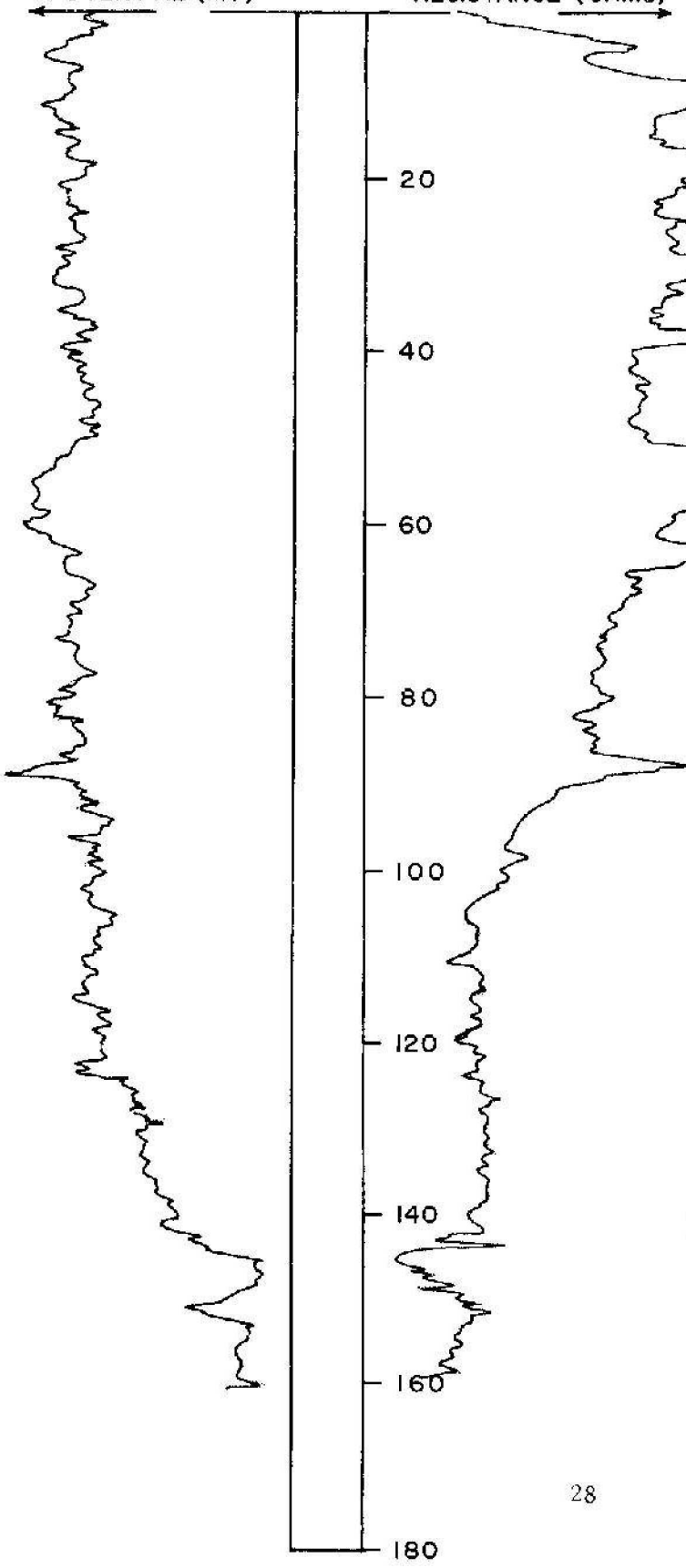
TEST HOLE 10093

LOCATION: 159-93-27CDC

DATE DRILLED: 6/7/78

ELEVATION: 2202
(FT, MSL)

DEPTH: 160
(FT)



DESCRIPTION OF DEPOSITS

0-11 Clay, silty, medium dark gray, stocky, poorly compact, not too plastic, 40% silt, oxidized.

11-23 Clay, silty, sandy, pebbly, yellow-brown, compact and plastic, oxidized, sand 11'-13' (till).

23-49 Clay (as above), unoxidized, compact, dark gray, plastic (till).

49-62 Gravel, sandy, clayey, fine to medium gravel, medium to coarse sand, slightly clayey, predominantly fine gravel, subangular, fairly well sorted.

62-144 Clay, silty, sandy, pebbly, dark gray, moderately compact to plastic, sand lense 88'-90' with detrital coal.

144-160 Clay, sandy, silty, interbedded, medium gray, silty clay and dark brown carbonaceous clay and lignite and thin bedded sand.

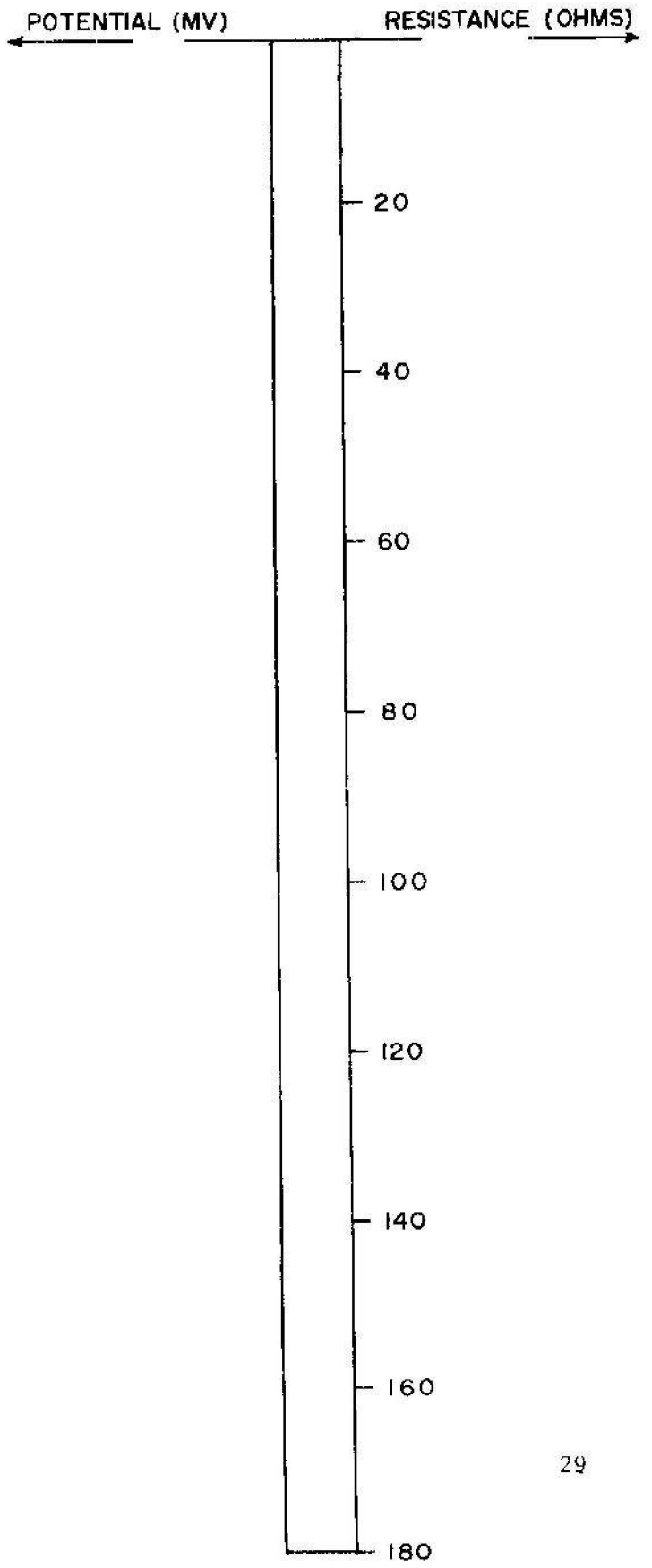
TEST HOLE 3511

LOCATION: 159-93-28BAA

DATE DRILLED: 7/31/67

ELEVATION: 2200
(FT, MSL)

DEPTH: 140
(FT)



	DESCRIPTION OF DEPOSITS
0-18	Gravel, fine to coarse, sandy, poorly sorted, subangular to subrounded, not too heavily iron-stained, predominantly limestone and granitics, moderately rough drilling, probably dry to 13'.
18-21	Clay, silty with pebbles, medium olive brown, soft, moderately cohesive, oxidized (till).
21-25	Sand, light gray, medium to coarse, generally subrounded samples poor, mud very thick.
25-29	Clay, silty with pebbles, olive gray, soft, cohesive (till).
29-37	Sand, medium to coarse, gray, subangular lignite chips but generally subrounded, well sorted.
37-45	Clay, sandy (fine), olive gray, occasional coarse sand, gray, soft, cohesive.
45-58	Clay, silty with pebbles and sand lenses, olive gray, soft, cohesive (sand is loose)(till).
58-73	Till, as above with sand and gravel lenses.
73-90	Clay, silty, light olive gray to olive gray, soft, cohesive, laminated.
90-98	Sand, fine, clayey, olive gray to dark greenish-gray, soft, moderately cohesive, highly lignitic
98-115	Clay, silty, light olive gray to olive gray, moderately soft to slightly hard, smooth, very lightly compacted, highly calcareous.
115-123	Shale, light greenish-gray, slightly hard, smooth, slippery, very tight, shaley cuttings.
123-140	Shale, sandy, light olive gray to brownish-gray, slightly hard and brittle, very lightly compacted, drills fairly easy.

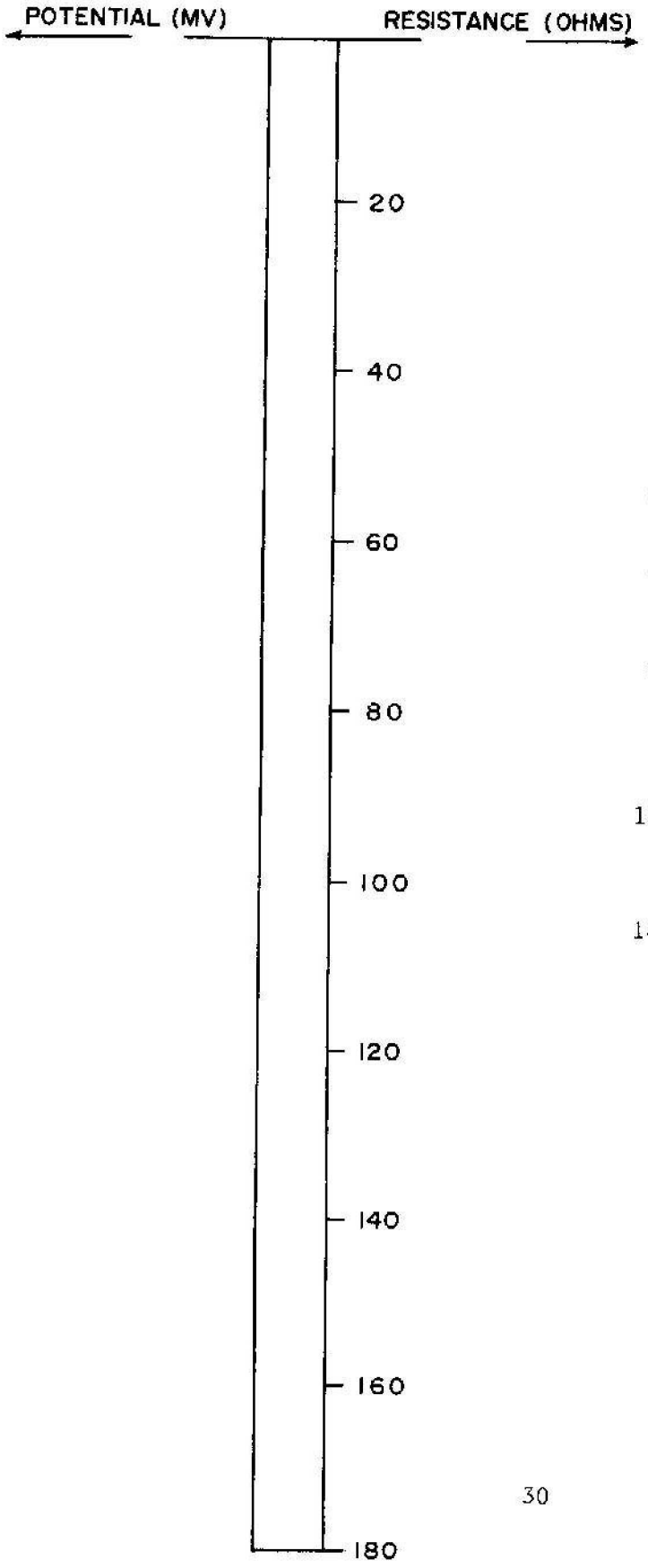
TEST HOLE 3512

LOCATION: 159-93-34BAA

DATE DRILLED: 7/31/67

ELEVATION: 2203
(FT, MSL)

DEPTH: 160
(FT)



DESCRIPTION OF DEPOSITS

0- 8	Clay, silty, moderately olive brown, soft, cohesive, oxidized.
8-17	Clay, silty to sandy, with pebbles, dusky yellow to moderately olive brown, soft, cohesive, oxidized (till).
17-57	Clay, silty and sandy with numerous pebbles and lignite chips, olive gray, medium soft, cohesive, tight (till).
57-67	Gravel, fine and medium, moderately well sorted, subangular and sub-rounded, predominantly limestone with some granitics and shale, appears to be fairly clean.
67-77	Clay, silty to sandy with pebbles, olive gray, moderately soft, cohesive, tight, tough (till).
77-91	Sand, fine to medium gray, very highly lignitic, well sorted, generally subrounded.
91-131	Clay, silty to sandy with numerous pebbles and frequent limestone gravel lenses, moderately soft to slightly hard, very light, moderately rough drilling.
131-145	Shale, silty, light olive gray to light greenish-gray, slightly hard and brittle, smooth, very tight.
145-160	Shale, sandy, light olive gray to brownish-black, moderately soft to slightly hard, laminated, tight.

Observation Well
Depth = 21'
S.T. = 18' to 21'

Water level below land surface

8/10/67	13.30	4/11/68	12.27
9/14/67	13.69	5/14/68	13.42
10/12/67	13.27	6/13/68	12.40
11/07/67	13.22	7/10/68	12.88
12/05/67	13.10	8/01/68	13.30
1/10/68	13.16	9/05/68	12.86
2/07/68	13.22	10/03/68	12.78
3/12/68	12.76	11/05.68	12.75

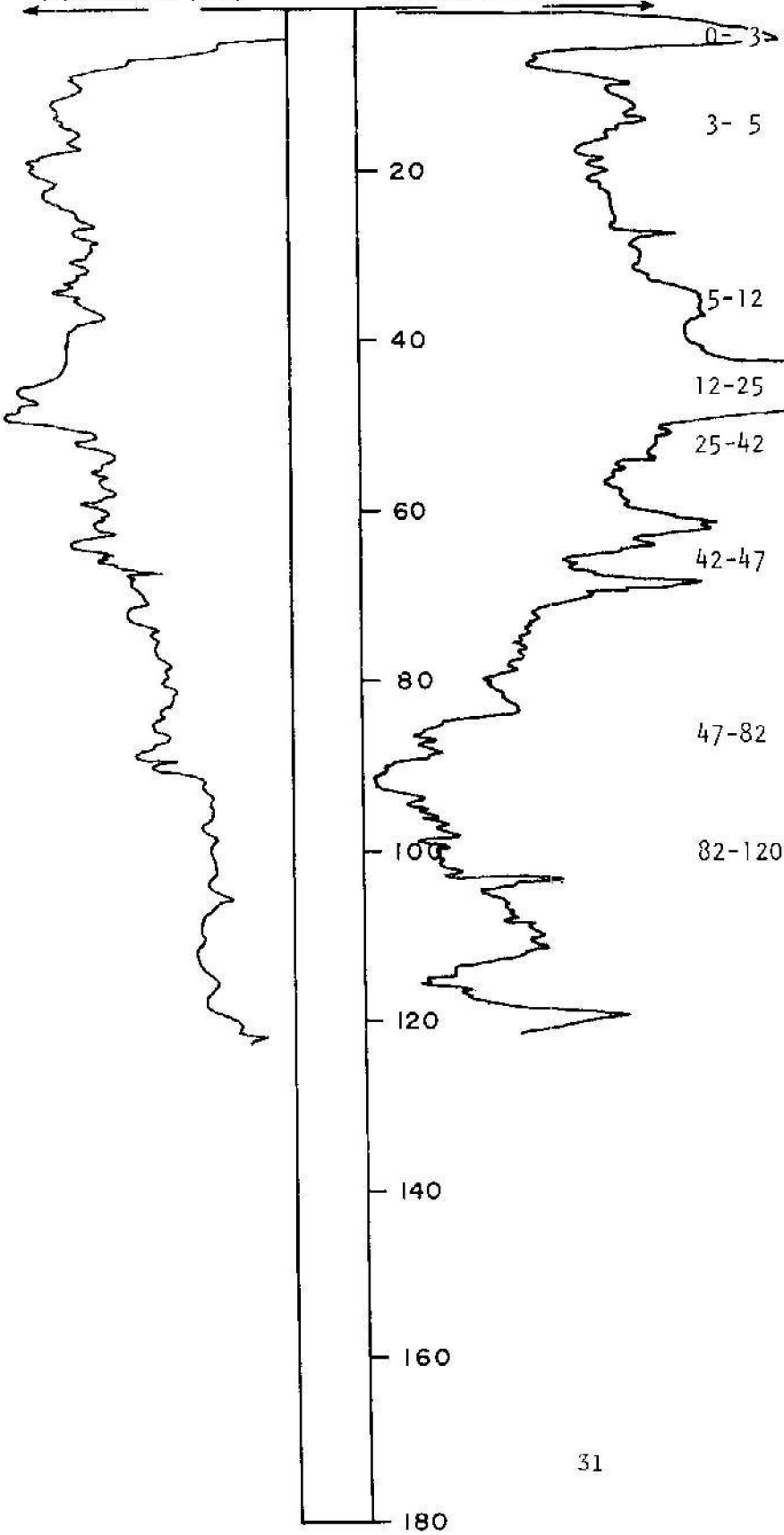
TEST HOLE 10096

LOCATION: 159-93-35bbd

DATE DRILLED: 6/7/78

ELEVATION: 2189
(FT, MSL)

DEPTH: 120
(FT)



DESCRIPTION OF DEPOSITS

0-3	Clay, silty, sandy, yellow-brown, very sticky clay, 30% silt, 20% very fine sand.
3-5	Gravel, sandy, fine to medium gravel, coarse sand, predominantly fine gravel, well sorted, subrounded to subangular, predominantly carbonates and shale, quartz, oxidized.
5-12	Clay, silty, sandy, gravelly, yellow-brown, moderately plastic and cohesive clay, oxidized (till).
12-25	Clay (as above), dark green-gray, unoxidized (till).
25-42	Clay, sandy, pebbly, very sandy, poorly compact, dark gray clay with 40-50% sand and pebbles (till).
42-47	Gravel, sandy, fine to medium gravel, fine to coarse sand, predominantly fine gravel, fairly well sorted, subrounded, predominantly carbonates (35%), shale (30%), quartz (20%).
47-82	Clay, silty, sandy, pebbly, dark gray, poorly to moderately plastic and cohesive, 30% lignite sand (till).
82-120	Clay, sandy, light gray-green, very compact, 40% very fine sand interbedded with beds of lignite.

Observation Well
Depth = 46'
S. I. = 43'- 46'

TEST HOLE 10103

LOCATION: 159-92-31CBB

DATE DRILLED: 6-13-78

ELEVATION: 2216
(FT, MSL)

DEPTH: 60'
(FT)

DESCRIPTION OF DEPOSITS

0- 8 Gravel, sandy, very fine to very coarse, predominantly fine gravel (50%), fairly well sorted, subrounded to rounded, gravel predominantly carbonates, shale, sand predominantly quartz carbonates and shale, oxidized.

8-30 Clay, sandy, silty, pebbly, oxidized, olive green to dark gray green (unoxidized), cohesive and plastic clay, not too compact very sandy, slightly silty (till).

30-46 Sand, very fine to coarse, predominantly fine sand (80%), very well sorted, subrounded, predominantly quartz (40%), carbonates (30%), shale.

46-60 Lignite interbedded with medium gray compact clay and very fine clayey sand.

Observation Well
Depth = 42'
S.I. = 36'- 42'

Water level below land surface
6/14/78 17.68'

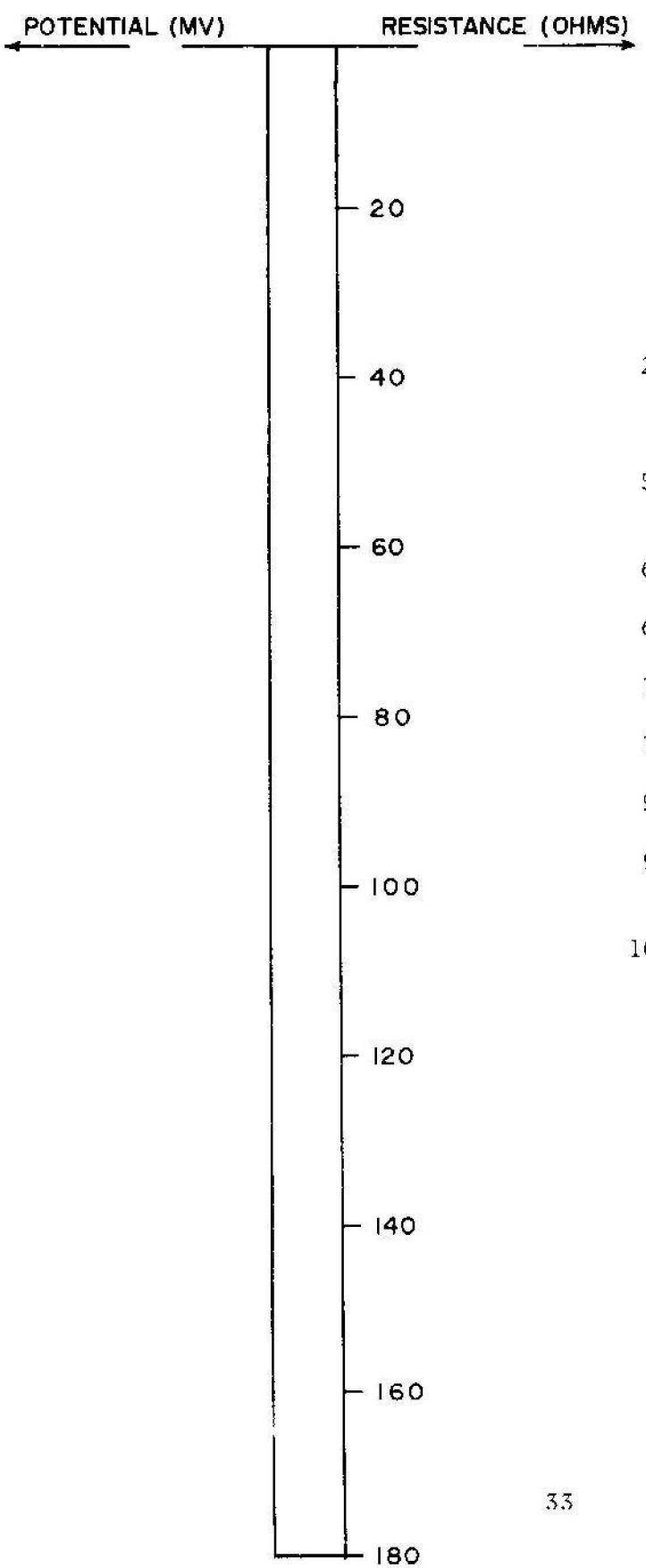
TEST HOLE 3384

LOCATION: 159-093-36AAA

DATE DRILLED: 8/12/66

ELEVATION: 2258
(FT, MSL)

DEPTH: 120
(FT)



	DESCRIPTION OF DEPOSITS
0- 1	Topsoil, very fine sandy loam, black.
1- 9	Sand, very fine, clayey and silty with pebbles, yellowish gray, soft, slightly to moderately cohesive, oxidized (till).
9-29	Clay, silty and sandy with pebbles and rocks, moderately olive brown, soft to moderately soft, cohesive, oxidizes (till).
29-55	Clay, silty, and sandy with pebbles and rocks, olive green, moderately soft, moderately cohesive, tight (till).
55-61	Sand, fine to medium, greenish gray, moderately well sorted, subrounded.
61-66	Clay, medium bluish gray, soft, cohesive, moderately plastic.
66-73	Sand, medium greenish-gray, well sorted, subrounded.
73-76	Clay, medium bluish gray, silty, soft, cohesive.
76-90	Sand, medium, greenish-gray, well sorted, subrounded, clean.
90-99	Shale, medium gray, slightly hard, moderately brittle, very tight.
99-107	Lignite, black, fractured.
107-120	Shale, medium gray to greenish-gray, slightly hard, brittle, smooth, tight.

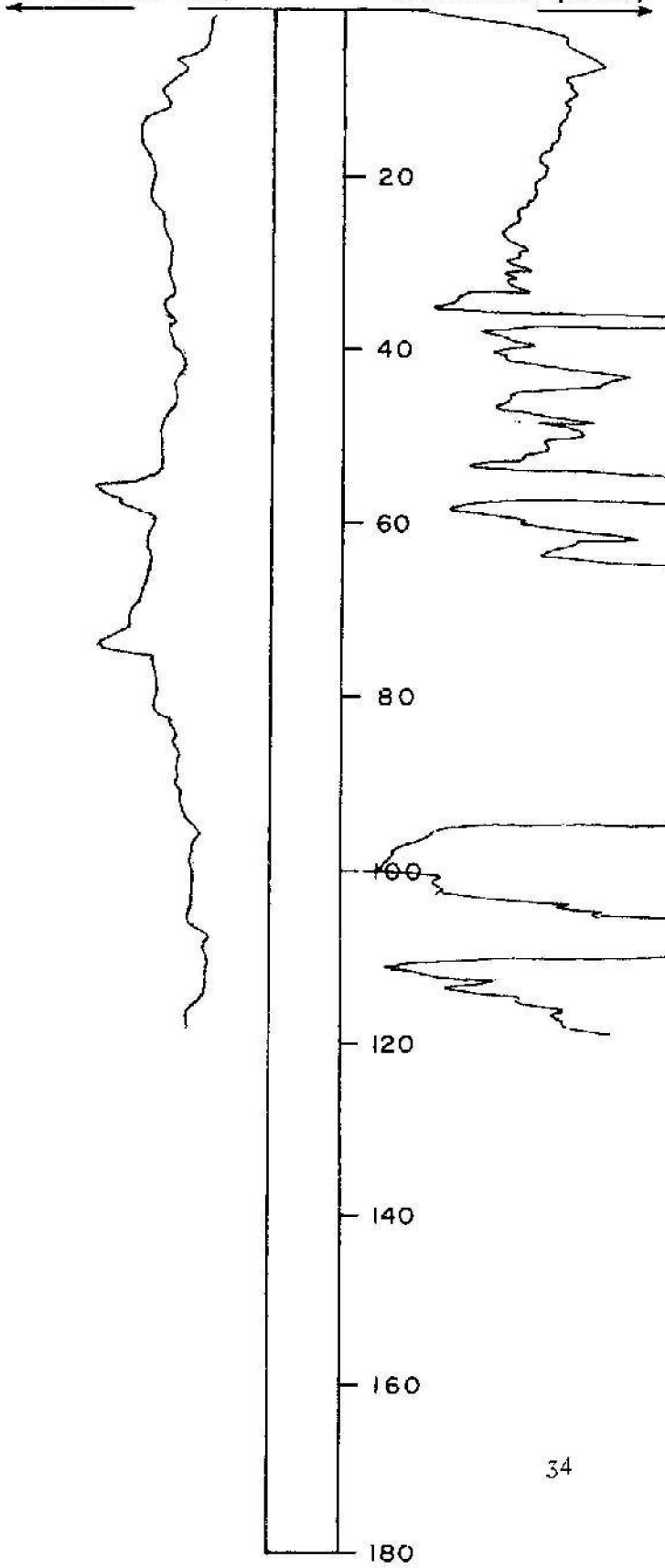
TEST HOLE 10090

LOCATION: 159-93-36AAA$_2$

DATE DRILLED: 6/6/78

ELEVATION: 2255
(FT, MSL)

DEPTH: 120
(FT)



DESCRIPTION OF DEPOSITS

0-16 Clay, sandy, silty, pebbly, moderately yellow-brown, moderately compact and plastic, oxidized, very sandy (till).

16-41 Clay, sandy, silty, pebbly, medium gray-green clay, compact and plastic sandy gravel lense 36'- 38' oxidized (till).

41-54 Clay, sandy, silty, pebbly, dark gray, green, very compact clay, plastic, very sandy and silty, oxidized (till).

54-57 Sand, silty, very fine to coarse, predominantly fine sand, 30% silt, predominantly quartz carbonates with 20% coarse lignite sand.

57-64 Clay, silty, light gray, very plastic and moderately compact clay.

64-94 Sand, silty, very fine to coarse with 30% silt, predominantly fine sand, fairly well sorted, predominantly quartz carbonates, shale, moderately well rounded.

94-120 Lignite interbedded with gray sandy silty clay, lignite bed 94'- 97', dark gray clay, very compact and plastic 97'- 104', lignite 104' - 109', dark gray sandy clay, very compact, fine sand.

Observation Well
Depth = 91'
S.I. = 85'- 91'
Water Level Below Land Surface
6/14/78 46.85

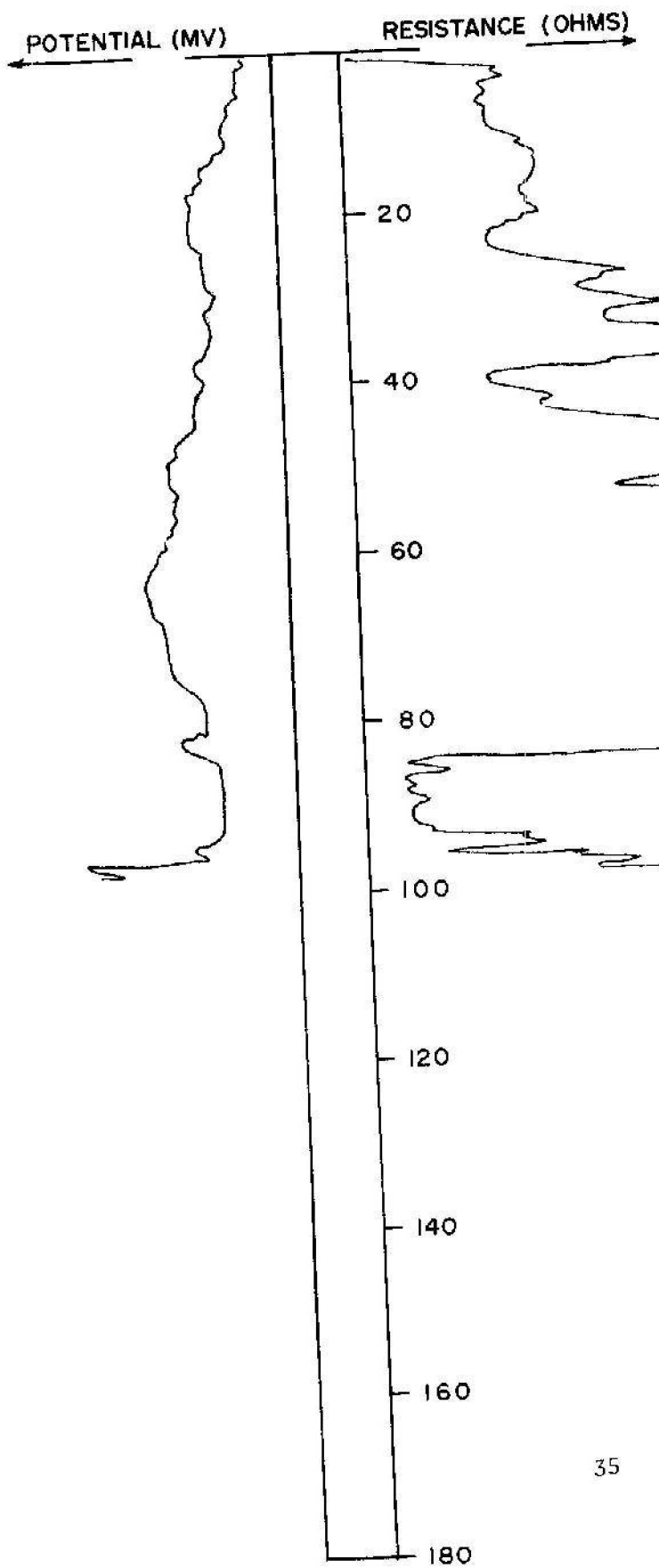
TEST HOLE 10102

LOCATION: 159-93-36AAD

DATE DRILLED: 6/13/78

ELEVATION: 2231
(FT, MSL)

DEPTH: 100
(FT)



DESCRIPTION OF DEPOSITS

0-21 Clay, silty, sandy, pebbly, yellow-green, cohesive compact, oxidized, very plastic, gravel lense at 14' and 24' (till).

21-39 Clay, sandy, silty, olive-green, very fine sand (40%), moderately compact, not too plastic, moderately cohesive, oxidized, gravel lense at 27' to 28' (till).

39-44 Clay, sandy, silty, olive-green, sand, very fine to coarse (30%), poorly plastic and poorly cohesive, oxidized.

44-82 Sand, silty, clayey, very fine to coarse sand, predominantly fine sand (50-60%), 10-20% silt, approximately 30% clay, poorly sorted, predominantly carbonates, shale, and quartz.

82-100 Lignite interbedded with compact, very cohesive and brittle silty clay, lignite 82-83', 94-100'.

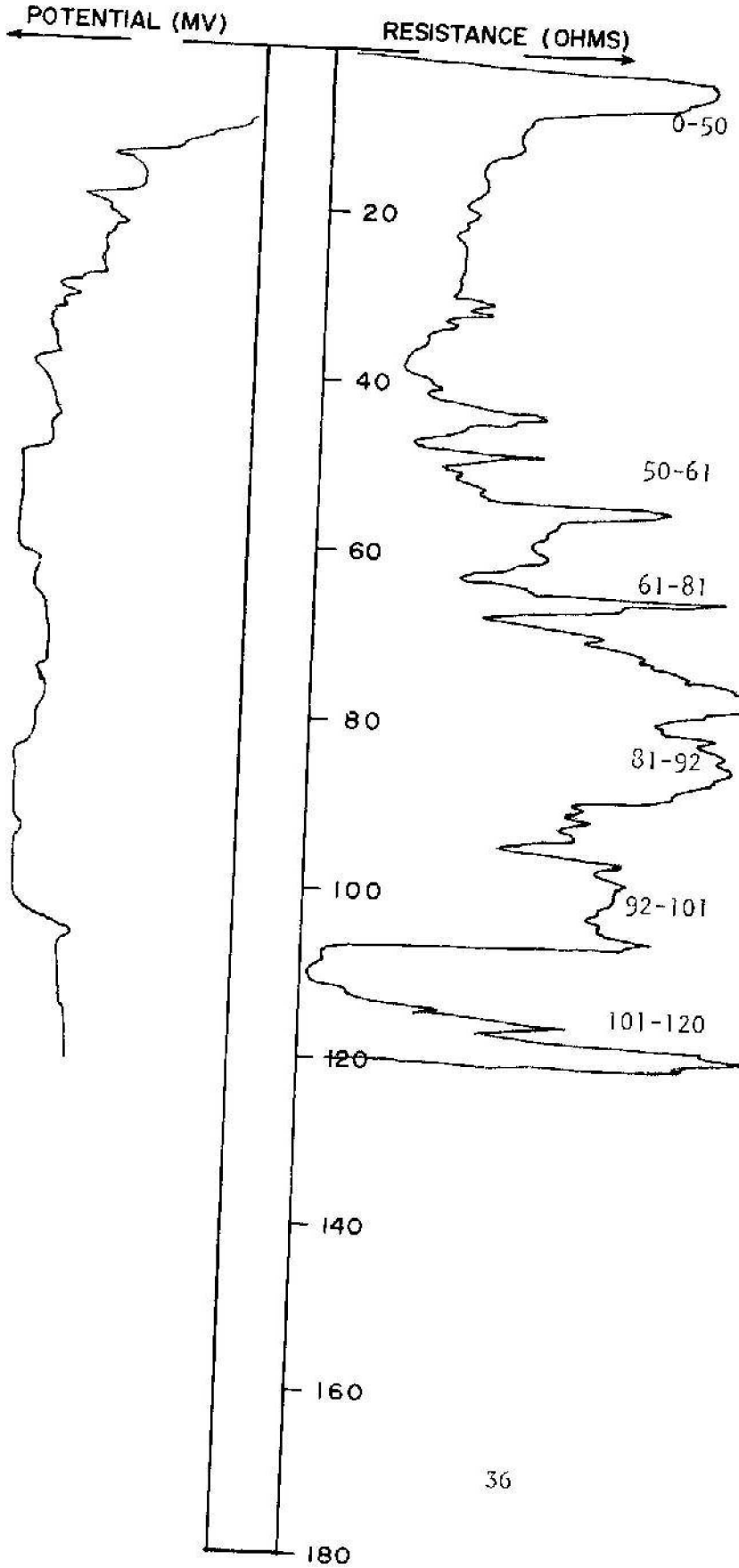
TEST HOLE 10101

LOCATION: 159-93-36ABA

ELEVATION: 2252
(FT, MSL)

DATE DRILLED: 6-12-78

DEPTH: 120
(FT)



DESCRIPTION OF DEPOSITS

0-50 Clay, silty, sandy, pebbly, yellow-green, oxidized, poorly to mederately cohesive, boulder at 1' and 19' (till).

50-61 Clay, silty, dark gray, very silty (40-50%) cohesive and moderately plastic, not too compact, unoxidized.

61-81 Sand, clayey, silty, light green, very fine to medium, 20-30% clay, 20% brownish-black silt, predominantly very fine sand, poorly sorted, fairly moderately cohesive.

81-92 Sand, silty, light brown, very fine to medium, 20-30% silt, predominantly fine sand, well sorted, rounded, predominantly quartz, carbonates, and shale.

92-101 Clay, silty, medium to dark gray, cohesive, very plastic, 20-30% black silt, not too compact, sticky.

101-120 Lignite interbedded with dark gray, compact and very cohesive silty clay, lignite at 101'- 103', 106'- 107', 115'- 120'.

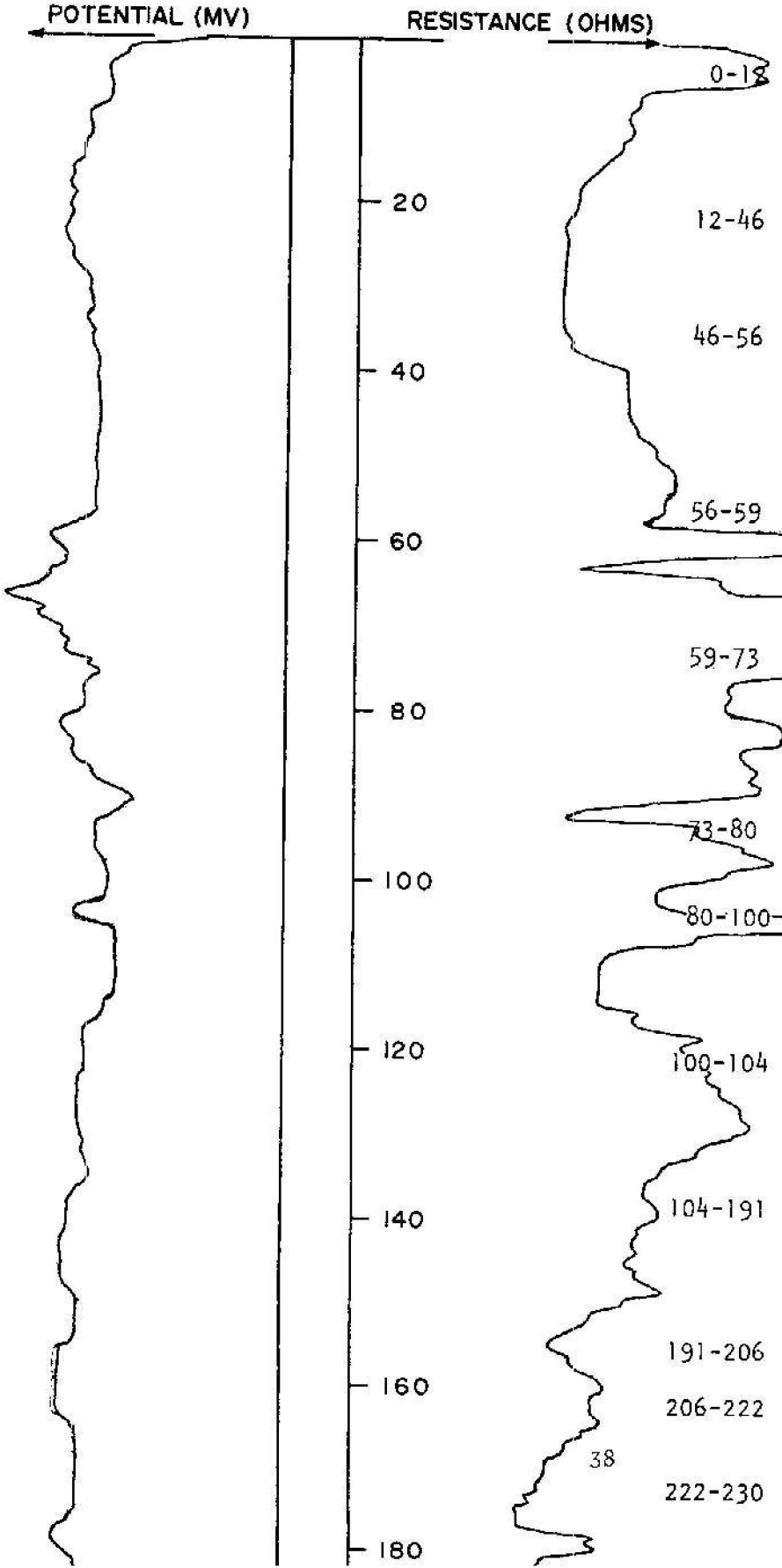
TEST HOLE 10105

LOCATION: 159-93-36BAA

DATE DRILLED: 6/20/78

ELEVATION: 2212
(FT, MSL.)

DEPTH: 240
(FT)



DESCRIPTION OF DEPOSITS

0-12	Clay, silty, sandy, pebbly, light olive-green, moderately compact and cohesive, moderately plastic, oxidized, gravel (lenses at 5', 8', 12' (till).
12-46	Clay (as above), dark gray-green, unoxidized, moderately compact, gravel lenses at 17', 23', 49' (till).
46-56	Silt, sandy, dark brown-gray, silt, 30% very fine, light gray sand.
56-59	Sand, very fine to medium, well sorted, predominantly fine sand, subrounded to rounded, predominantly quartz, carbonates and shale.
59-73	Gravel, sandy, fine granular gravel, 10% medium and coarse sand, predominantly fine gravel, well sorted, subangular to rounded, predominantly carbonates (40%), shale (30%).
73-80	Clay, sandy, silty, light gray, 30-40% very fine sand, 20-30% silt.
80-100	Clay, sandy, pebbly, dark gray to black, moderately compact and cohesive, interbedded fine gravel-sandy, predominantly coarse sand.
100-104	Gravel, fine to medium, predominantly fine, fairly well sorted, predominantly carbonates and shale, subrounded to rounded.
104-191	Clay, silty, sandy, pebbly, dark gray, compact, cohesive and moderately plastic, very sandy, detrital lignite and sand lense at 116'- 119' (till).
191-206	Sand, silty, clayey, dark brown, 30-40% silt, 20-30% clay.
206-222	Clay, silty, sandy, pebbly, dark gray, compact, interbedded detrital lignite.
222-230	Lignite

(continued)

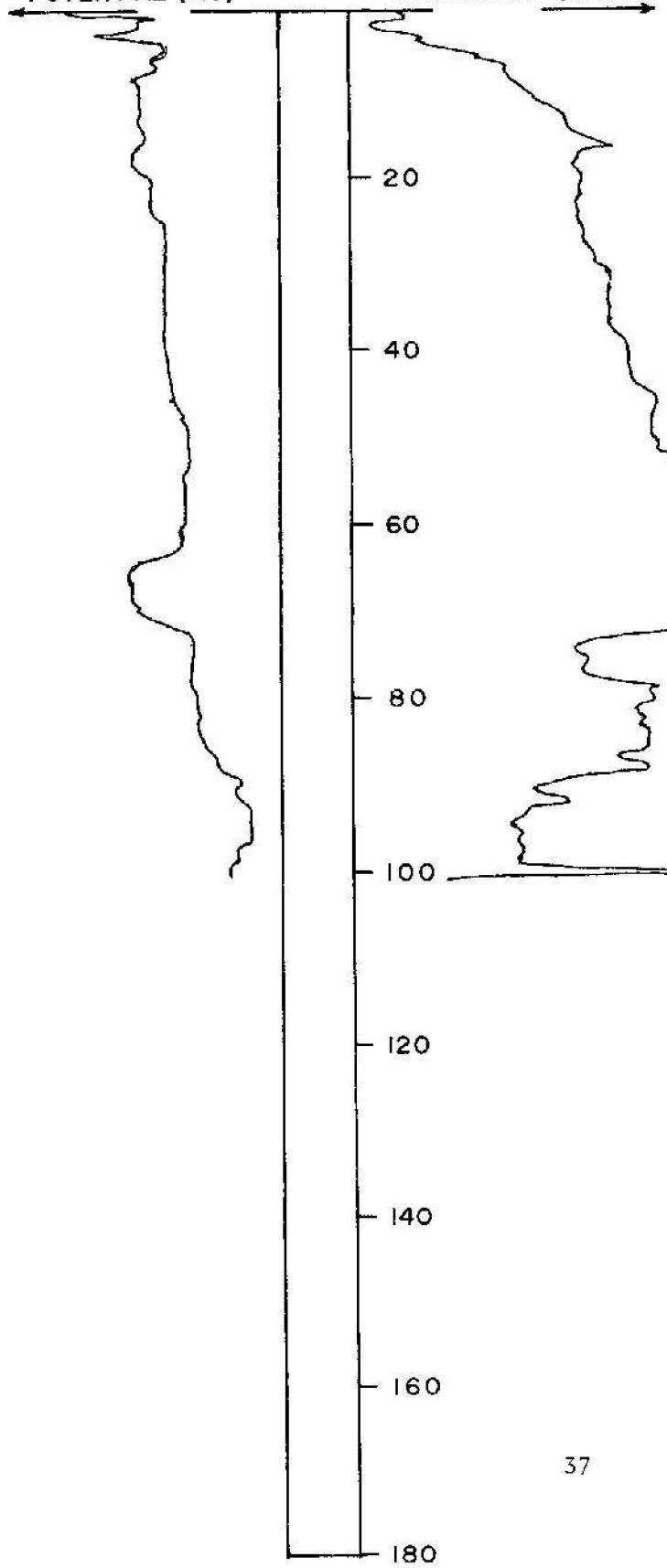
TEST HOLE 10104

LOCATION: 159-93-36ABC

DATE DRILLED: 6/13/78

ELEVATION: 2200
(FT, MSL)

DEPTH: 100
(FT)

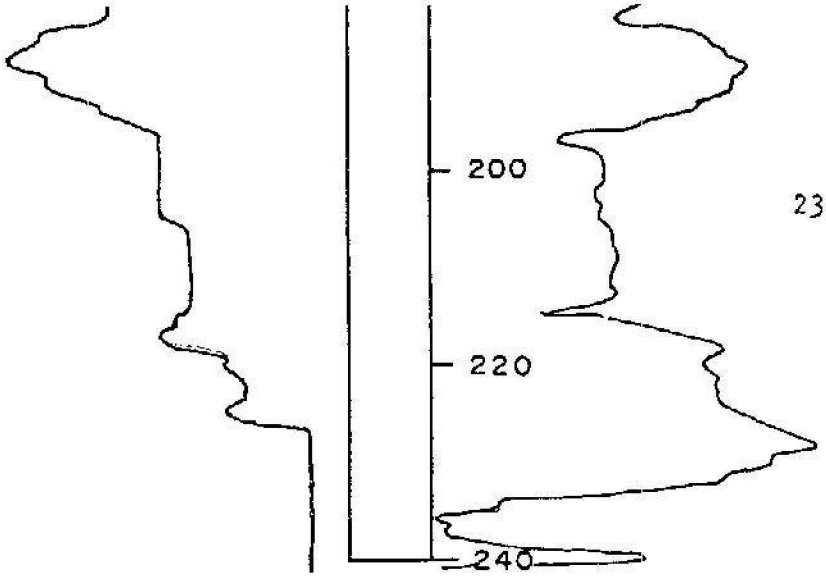


DESCRIPTION OF DEPOSITS

0-13	Clay, sandy, silty, gravelly, olive gray, compact, cohesive, moderately plastic, oxidized, thin gravel lense at 12' (till).
13-60	Clay (as above), dark gray, unoxidized, silty, sandy, gravelly, thin gravel lenses at 25' and 49' (till).
60-69	Gravel, sandy, fine to coarse gravel, very coarse sand, predominantly fine gravel, well-sorted, subangular to rounded, predominantly carbonates and shale, quartz.
69-76	Clay, silty, sandy, medium gray, cohesive and moderately plastic, 20-30% silt.
76-86	Sand, silty, clayey, light green, very fine sand, 20% silt, 20% clay, fairly cohesive.
86-100	Clay, silty, medium dark gray, very compact and nearly brittle.

Observation Well
Depth = 65'
S.I. = 62'- 65'

Water level below land surface
6/13/78 2.55'



10105 continued

230-240 Clay, dark gray, very compact, and brittle, interbedded lignite.

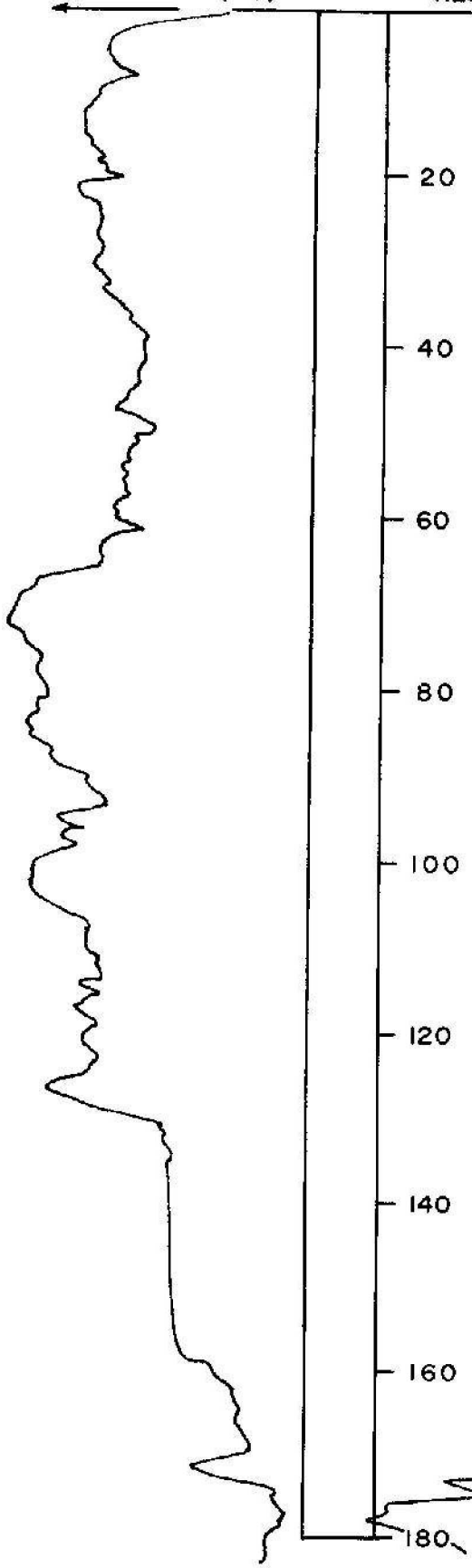
TEST HOLE 10100

LOCATION: 159-93-36BAB

DATE DRILLED: 6/9/78

ELEVATION: 2200
(FT, MSL)

DEPTH: 180'
(FT)



DESCRIPTION OF DEPOSITS

0- 15	Clay, silty, sandy, pebbly, moderately cohesive and plastic, yellow-green clay, very silty, sandy with pebbles common to only slightly pebbly, oxidized (till).
15-63	Clay (as above), dark gray to gray-brown (till).
63-74	Gravel, sandy, fine to coarse gravel, fine to coarse sand, predominantly fine gravel (60%) well sorted subrounded predominantly carbonates, shale, quartz.
74-86	Clay, silty, dark brown, silty clay, moderately plastic and cohesive.
86-90	Silt, clayey, dark brown silt, only slightly clayey, poor sample return, poorly cohesive.
90-103	Gravel, sandy, fine to coarse gravel, well sorted, angular to rounded, predominantly medium gravel, predominantly shale, carbonates, quartz.
103-125	Silt, clayey, dark brown silt, only slightly clayey to moderately clayey with a layer of lignite 116'- 117' and a few very thin beds of gravel, poor return, poorly cohesive, coarse gravel 122'- 125'.
125-131	Clay, silty, sandy, dark brown clay, 30-40% silt only slightly sandy, moderately plastic and cohesive (till).
131-170	Clay, silty, sandy, pebbly, dark gray, fairly moderately plastic and cohesive, very silty and sandy, sand and gravel lenses 164'- 170', and detrital lignite.
170-180	Clay, sandy, silty, light green clay, moderately plastic with 40% very fine sand interbedded with clayey silt, dark brown, poorly cohesive, and very carbonaceous ranging to a medium gray, very cohesive clay.

Observation Well
Depth = 71'
S.I. = 68' - 71'

Water level below land surface

6/13/78	6.14

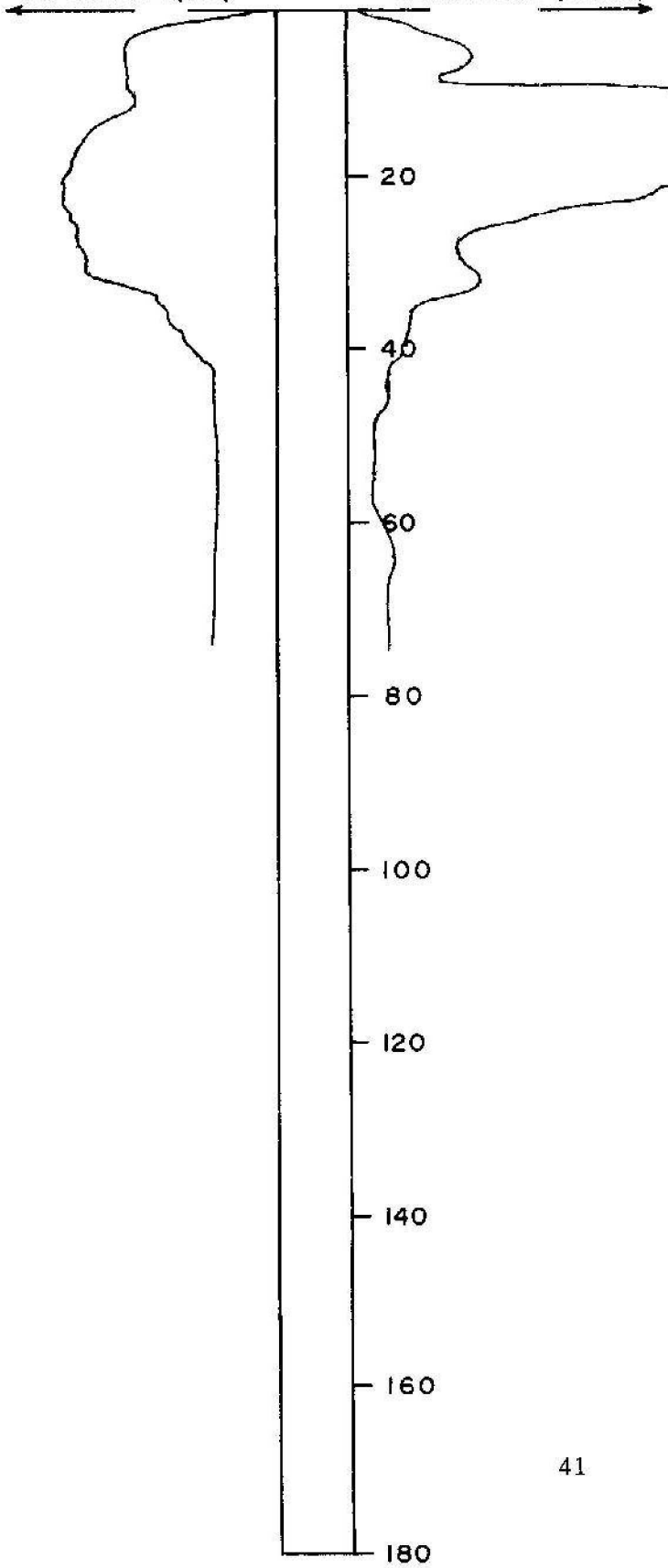
TEST HOLE 10106

LOCATION: 159-93-36BBA

DATE DRILLED: 6/20/78

ELEVATION: 2217
(FT, MSL)

DEPTH: 80
(FT)



DESCRIPTION OF DEPOSITS

0- 9	Clay, silty, sandy, pebbly, light olive green-yellow, oxidized, moderately compact and cohesive gravel lense 3'- 6' (till).
9-15	Sand, fine to coarse, predominantly coarse sand, well sorted, oxidized, subrounded to rounded, predominantly carbonates, shale, and quartz.
15-26	Gravel, sandy, fine to coarse, sand, fine to medium gravel, predominantly fine granular gravel, well sorted, subrounded to rounded.
26-28	Clay (as above), oxidized, light olive-green.
28-32	Sand, very fine to coarse, predominantly medium sand, unoxidized, well sorted, subrounded to rounded, predominantly quartz, shale.

TABLE 2 -- CHEMICAL ANALYSES
(Analytical results are in milligrams per liter except where indicated)

AQUIFERS _ Owner or Designation	Location	Depth of Well (feet)	Temp (°F)	Date of Collection 1978	(SiO_2)	(Fe)	(Mn)	(Ca)	(Mg)	(Na)	(K)	(HCO_3)	(CO_3)	(SO_4)	(Cl)	(F)	(NO_3)	(B)	Total Dissolved Solids	Total Hardness as $CaCO_3$	Total Hardness Noncarbonate	Percent Sodium	SAR	Specific Conductance	pH
10090	159-93-36caa2	91		6/14	20	.51	.22	67	30	250	5.5	666	0	280	10	[illegible]	1.0	.20	1020	290	0	65	6.4	1590	7.9
10091	159-93-26aad	54		6/14	13	.04	.12	95	47	160	2.7	410	0	420	15	.3	20.	.49	997	440	100	44	3.3	1420	8.0
10092	159-93-26dda	97		6/14	26	.49	.04	16	17	440	10.0	751	0	450	7.2	.4	1.0	.44	1380	110	0	89	18.0	2040	8.1
10092A	159-93-26daa2	26		6/14	45	.16	.12	46	52	270	6.0	681	0	360	5.9	.1	1.0	.24	1140	330	0	64	6.5	1640	8.0
10096A	159-93-35bbd2	46		6/13	25	1.9	.46	89	46	230	6.9	689	0	340	6.1	.1	1.0	.39	1030	410	0	54	4.9	1560	[illegible]
10098	159-93-26bcb	21		6/13	21	.40	.54	110	60	240	6.9	676	0	480	5.8	.2	2.0	.34	1260	520	0	50	4.6	1780	8.0
10100	159-93-36bad	71		6/13	21	.02	.54	100	49	160	[illegible]	598	0	290	3.5	.1	1.0	.29	863	450	0	43	3.3	1360	7.8
10103	159-92-31cbb	42		6/14	15	.08	.06	76	32	170	6.7	469	0	170	4.6	.2	38.	.24	854	320	0	53	4.1	1230	7.9
10104	159-93-36abc	65		6/13	19	.12	.40	80	41	240	6.3	566	0	400	4.1	[illegible]	1.0	.34	1070	370	0	58	[illegible]	1560	7.9
owers Lake Well #1	159-93-25cca	103		6/13	29	1.7	.10	34	28	430	11.0	732	0	530	7.0	.3	1.0	.24	1480	200	0	* [illegible]	13.0	2100	7.5
owers Lake Well #2	159-93-35aaa	[illegible]		6/13	33	.12	.12	42	35	390	10.0	734	0	480	3.4	.4	0.4	.33	1420	250	0	76	11.0	2010	7.8
C. E. Hubbard	159-93-36aac	38		6/15	16	.00	.00	2.0	3.9	360	2.0	622	0	310	2.6	.2	1.0	.00	1020	21	0	97	36.0	1570	7.5
nderson	159-92-31bcb4	80?		6/15	21	.71	.34	65	29	5.4	5.4	656	0	270	2.9	.2	[illegible]	.39	1010	280	0	65	6.2	1480	7.5
ris Engel	159-93-27cad	50		6/15	27	5.8	.46	72	49	380	11	758	0	550	10.0	.3	0.5	.34	1520	380	0	68	8.5	2110	7.6
en Moore	159-93-34aac	50		6/15	21	6.7	.30	57	31	310	5.5	764	0	310	3.4	[illegible]	1.0	.54	1120	270	0	71	8.2	1670	7.5
ower Lake High Sch.				6/15	17	13.0	.40	87	50	200	5.7	616	0	300	3.4	.2	1.0	.20	1030	410	0	51	4.3	1440	7.5
en Luey	159-92-31cbc	35		6/14	18	.04	.09	73	40	56	2.8	425	0	61	4.4	.3	76.	.10	590	360	1	25	[illegible]	874	7.6

* Water Softener

Table 3 -- Dissolved chemical constituents in water -- their effects upon usability and recommended concentration limits for domestic and municipal water supplies in North Dakota.

Constituent or Parameter	Effects of dissolved constituents on water use	Suggested limits for drinking water in North Dakota[1]	U.S. Public Health Service recommended limits for drinking water[2]
Silica (SiO_2)	No physiological significance		
Iron (Fe)	Concentrations over 0.1 mg/l will cause staining of fixtures. Over 0.5 mg/l may impart taste and colors to food and drink.		0.3 mg/l
Manganese (Mn)	Produces black staining when present in amounts exceeding 0.05 mg/l		0.05 mg/l
Calcium(Ca) and Magnesium (Mg)	Calcium and magnesium are the primary causes of hardness. High concentrations may have a laxative effect on persons not accustomed to this type of water.		
Sodium (Na)	No physiological significance except for people on salt-free diets. Does have an effect on the irrigation usage of water.		
Potassium (K)	Small amounts of potassium are essential to plant and animal nutrition.		
Bicarbonate (HCO_3) and Carbonate (CO_3)	No definite significance, but high bicarbonate content will impart a flat taste to water.		
Sulfate (SO_4)	Combines with Calcium to form scale. More than 500 mg/l tastes bitter and may be a laxative	0-300 mg/l - low 300-700 mg/l - high over-700 mg/l - very high	250 mg/l
Percent Sodium and Sodium Adsorption Ratio (SAR)	Indicate the sodium hazard of irrigation water.		
Chloride (cl)	Over 250 mg/l may impart a salty taste, greatly excessive concentrations may be physiologically harmful. Humans and animals may adapt to higher concentrations.		250 mg/l
Flouride (F)	Flouride helps prevent tooth decay within specified limits. Higher concentrations cause mottled teeth.	Limits of 0.9 mg/l to 1.5 mg/l	Recommended limits depend on average of daily temperatures. Limits range from 0.6 mg/l at 32°C. to 1.7 mg/l at 10°C.
Nitrate (NO_3)	Over 45 mg/l can be toxic to infants. Larger Concentrations can be tolerated by adults. More than 200 mg/l may have a deleterious effect on livestock health		45 mg/l
Boron (B)	No physiological significance. Greater than 2.0 mg/l may be detrimental to many plants		
Total dissolved solids	Persons may become accustomed to water containing 2,000 mg/l or more dissolved solids.	0-500 mg/l - low 500-1400 mg/l average 1400-2500 mg/l high over 2500 mg/l very high	500 mg/l
Hardness (as $CaCO_3$)	Increases soap consumption, but can be removed by a water-softening system.	0-200 mg/l - low 200-300 mg/l average 300-450 mg/l high over 450 mg/l very high	
pH	Should be between 6.0 and 9.0 for domestic consumption		
Specific Conductance	An electrical indication of total dissolved solids measured in micromhos per Centimeter at 25°C. Used primarily for irrigation analyses.		

1. Schmid, R. W., 1965, Water Quality Explanation: North Dakota State Water Commission, unpublished report, File No. 989.
2. U.S. Public Health Service, 1962, Public Health Service Drinking Water Standards: U.S. Public Health Service, Pub. No. 956, 61 p.

References

Armstrong, C. A., 1971, Ground Water Resources of Burke and Mountrail Counties, North Dakota, Part III, North Dakota County Ground Water Study No. 14.

Brookhart, J. W., and Powell, J. E., 1961, Reconnaissance of Geology and Ground Water of Selected Areas in North Dakota, North Dakota Ground Water Studies No. 28.

Paulson, Quentin F., 1954, Geology and Occurrence of Ground Water in the Stanley Area, Mountrail County, North Dakota, North Dakota Ground Water Studies No. 23.

Simpson, Howard E., 1929, Geology and Ground-Water Resources of North Dakota. United States Geological Survey Water Supply Paper No. 598.