

Addendum To
North Dakota Geological Survey
BULLETIN 49

North Dakota State Water Commission
COUNTY GROUND-WATER STUDIES I
GEOLOGY AND GROUND-WATER RESOURCES OF KIDDER COUNTY, NORTH DAKOTA

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EXPLANATION

Glacial drift aquifers in Kidder County, North Dakota, offer considerable potential for the future development of irrigation in this area. Irrigation development is directly related to the availability of ground water in Kidder County. Therefore, it is necessary that an accurate determination of aquifer thickness, lithology, areal extent, and the chemical quality of ground water be made to insure the proper utilization of this resource.

When the original ground-water study was made in Kidder County, small diameter observation wells were not installed as part of the field procedure. As a result, very few water-level and chemical quality data were collected. In 1970 supplementary test drilling was initiated to gather additional data on water levels, aquifer characteristics, and water quality.

Parts I, II, and III of Geology and Ground-Water Resources of Kidder County, North Dakota should serve as text material to explain the glacial geology and hydrology of Kidder County. The following tables list data collected during the recent ground-water investigation and are meant to supplement the main report.

(Analytical results in parts per million except as indicated)

Owner or Description	Location	Depth of Well (Feet)	Screened Interval	Date of Collection	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Manganese (Mn)	Chloride (Cl)
TH 3634	138-71-6ccd ₁	80	77-80	9-23-68	31	0.20	70	18	97	11	407	0	128	1.10	3.9
Virgil Rott	138-71-7aaa	83	68-83	8-28-68	29	0.0	78	10	48	6.3	333	0	73	0.65	4.4
Virgil Rott	138-71-7bba	85	70-85	10-29-68	31	0.0	68	21	101	11	418	0	126	0.95	2.7
TH 5771	138-72-1aaa ₁	113	107-113	8-31-70	27	0.28	68	22	75	6.7	403	0	84	0.88	4.7
	(South Well)														
TH 5771-A	138-72-1aaa ₂	63	57-63	8-31-70	28	0.52	75	20	22	3.9	332	0	48	0.99	1.1
	(North Well)														
TH 5770	138-72-1ccc	78	72-78	8-31-70	28	0.05	77	21	76	7.6	411	0	110	1.00	2.1
Walter Huffnagel	138-72-1dcd	90	----	7-28-70	28	0.28	66	21	68	7.1	359	0	116	0.93	0.9
TH 5774	138-72-7aaa ₁	143	137-143	9- 1-70	25	1.5	69	12	127	6.9	479	0	107	0.31	6.7
	(East Well)														
TH 5774-A	138-72-7aaa ₂	50	47-50	9- 1-70	27	1.6	77	16	110	7.0	430	0	142	0.87	7.4
	(West Well)														
Virgil Rott & Walter Huffnagel	138-72-12abb	---	----	10-13-68	30	0.82	70	22	103	11	429	0	133	0.70	3.3
TH 5916	138-73-8udd	213	207-213	11-30-70	22	4.7	37	16	380	11	653	0	400	0.03	29
Richard DeWitz	139-71-4ulbc	34	----	8-19-70	26	0.18	94	28	17	4.3	354	0	81	0.01	5.6
TH 5772	139-71-29ccc	148	142-148	8-31-70	25	5.5	40	11	254	11	531	0	196	0.30	52
Richard DeWitz	139-72-2abb	106	----	7-28-70	28	0.34	102	18	45	7.0	352	0	113	1.10	15
TH 5760	139-72-24bbb ₁	203	197-203	9- 3-70	24	0.74	67	17	100	8.9	401	0	109	0.84	7.2
	(West Well)														
TH 5760-A	139-72-24bbb ₂	83	77-83	9- 3-70	31	0.12	118	23	57	10	475	0	131	0.84	7.4
	(East Well)														

TABLE 1 - Chemical analyses (Continued)

(Analytical results in parts per million except as indicated)

Owner or Description	Location	Depth of Well (Feet)	Screened Interval	Date of Collection	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Manganese (Mn)	Chloride (Cl)
TH 5776	139-72-31aaa	163	157-163	9- 3-70	32	0.0	51	9.7	91	7.2	397	0	48	0.07	6.9
TH 5775	139-72-31ddd ₁	344	338-344	9- 2-70	34	0.24	27	0.3	271	7.5	572	0	113	0.02	56
	(South Well)														
TH 5775-A	139-72-31ddd ₂	163	157-163	9- 2-70	31	2.10	61	20	107	8.5	417	0	102	0.50	9.8
	(North Well)														
TH 5778	140-71-19ddd	123	117-123	8-21-70	23	0.80	87	25	214	18	605	0	280	0.51	26
Recorder Well	140-71-28bba	60	Perforated	8-25-70	23	0.72	55	18	68	6.3	333	0	86	0.48	7.2
TH 5913	140-71-28daa ₁	68	62-68	11-16-70	23	0.03	70	33	43	4.7	340	0	114	1.50	5.7
	(South Well)														
TH 5913-A	140-71-28daa ₂	33	30-33	11-16-70	22	0.18	68	26	6.6	2.0	239	0	81	0.01	3.0
	(North Well)														
TH 5753	141-70- 6baa	143	137-143	8-19-70	27	1.3	128	38	44	5.3	545	0	109	0.69	8.0
Lawrence Melhoff	141-74-14cbd	30	----	9-25-64	21	0.12	204	88	204	15	289	0	1030	----	26
Patterson Land Co.	142-70-16dbd	107	83-107	10-25-65	30	2.7	73	24	9.1	3.9	300	0	50	----	2.9
Patterson Land Co.	142-70-16dbd	100	----	7-21-70	28	0.0	89	21	9.2	3.4	336	0	59	1.00	3.4
TH 5754	142-71-35ddd	183	177-183	8-20-70	24	4.3	177	48	106	9.6	647	0	293	0.30	11

Flow- ride (F)	Nitrate (NO ₃)	Boron (B)	Total Dissolved Solids	Total Hardness As CaCO ₃	Noncar- bonate	% Sodium	Sodium Adsorption- Ratio	Specific Conductance (Micromhos 25° C)	pH	Irrigation Classification	Remarks
0.2	0.5	0.27	541	251	0	44	2.7	842	7.9	C3-S1	
0.2	5.1	0.24	423	236	0	30	1.4	649	7.7	C2-S1	Pumping Rate 900 gpm
0.1	2.0	0.23	564	255	0	45	2.7	874	7.6	C3-S1	Pumping Rate 895 gpm
0.1	0.2	0.09	477	260	0	38	2.0	741	7.9	C2-S1	
0.1	1.0	0.06	346	271	0	15	0.6	565	8.0	C2-S1	
0.0	1.0	0.18	495	279	0	36	2.0	788	7.9	C3-S1	
0.4	2.5	0.19	451	252	0	36	1.9	726	7.7	C2-S1	Pumping Rate 900 gpm
0.1	1.0	0.12	557	220	0	55	3.7	899	7.8	C3-S1	
0.1	1.0	0.09	586	258	0	47	3.0	892	7.8	C3-S1	
0.1	0.0	0.16	576	267	0	44	2.7	882	7.8	C3-S1	
0.4	3.5	0.90	1170	158	0	83	13	1830	7.9	C3-S3	
0.2	0	0.17	422	352	62	9	0.4	681	8.0	C2-S1	Pumping Rate 300 gpm
0.2	0.6	0.99	884	146	0	78	9.1	1350	7.8	C3-S2	
0.4	1.0	0.26	511	331	42	22	1.1	786	7.5	C3-S1	Pumping Rate 800-900 gpm
0.2	0.1	0.12	538	237	0	47	2.8	833	8.1	C3-S1	
0.2	0	0.30	613	391	1	24	1.3	938	7.9	C3-S1	

Flow- ride (F)	Nitrate (NO ₃)	Boron (B)	Total Dissolved Solids	Total Hardness As CaCO ₃	Noncar- bonate	% Sodium	Sodium Adsorption- Ratio	Specific Conductance (Micromhos 25° C)	pH	Irrigation Classification	Remarks
0.1	1.0	0.16	418	167	0	53	3.1	786	7.9	C3-S1	
0.1	2.5	0.43	781	69	0	88	14	1260	8.0	C3-S3	
0.1	1.0	0.19	539	234	0	49	3.0	833	7.9	C3-S1	
0.2	1.0	0.21	966	321	0	58	5.2	1420	8.2	C3-S2	
0.4	2.5	0.05	392	211	0	40	2.0	762	8.2	C3-S1	Diameter 8 inches
0.2	1.0	0.42	447	310	31	23	1.1	724	8.0	C2-S1	
0.2	1.0	0.35	324	276	80	5	0.2	514	8.1	C2-S1	
0.2	0.3	0.06	632	478	31	16	0.9	967	7.7	C3-S1	
0.3	0.0	0.00	1860	870	634	33	3.0	2140	8.0	C3-S1	Pumping Rate 15 gpm
0.4	0	0.08	344	280	34	6.6	0.2	543	8.0	C2-S1	Pumping Rate 500 gpm
0.4	0	0.33	344	310	34	6	0.2	610	7.7	C2-S1	Pumping Rate 700 gpm
0.1	0	0.18	992	638	108	26	1.8	1450	7.6	C3-S1	

TABLE 2 -- Water Levels in Selected Observation Wells
 Depth to Water, in Feet Below or (+) Above Land Surface

Test Hole 5771 138-72-1aaa₁ (South Well) Depth 113 feet

Date	Water Level	Date	Water Level	Date	Water Level
Aug. 31, 1970	13.90				
Nov. 30	12.75				
Dec. 28	12.69				
Feb. 9, 1971	12.42				
Mar. 8,	12.50				

Test Hole 5771-A 138-72-1aaa₂ (North Well) Depth 63 feet

Date	Water Level	Date	Water Level	Date	Water Level
Aug. 31, 1970	15.62				
Nov. 30	13.71				
Dec. 28	13.64				
Feb. 9, 1971	13.59				
Mar. 8,	13.47				

Test Hole 5770 138-72-1ccc Depth 78 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	48.82				
Nov. 30	45.37				
Dec. 28	45.73				

Test Hole 5774 138-72-7aaa₁ (East Well) Depth 143 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	+ .28				
Nov. 30	+1.53				
Dec. 28	+1.75				
Feb. 9, 1971	+1.74				
Mar. 8	+1.75				

Test Hole 5774-A 138-72-7aaa₂ (West Well) Depth 50 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	8.50				
Nov. 30	7.04				
Dec. 28	7.07				
Feb. 9, 1971	6.74				
Mar. 8	6.64				

Test Hole 5916 138-73-8ddd Depth 213 feet

Date	Water Level	Date	Water Level	Date	Water Level
Mar. 17, 1971	4.90				

Test Hole 5772 139-71-29ccc Depth 148 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	32.33				
Nov. 30	22.62				
Dec. 28	22.74				
Feb. 9, 1971	22.68				
Mar. 8	22.68				

Test Hole 5760 139-72-24bbb₁ (West Well) Depth 203 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	30.40				
Nov. 30	29.33				
Dec. 28	29.52				

Test Hole 5760-A 139-72-24bbb₂ (East Well) Depth 83 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	32.50				
Nov. 30	32.31				
Dec. 28	32.30				

Test Hole 5776 139-72-31aaa Depth 163 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	32.90				
Nov. 30	32.05				
Dec. 28	32.14				
Feb. 9, 1971	31.91				
Mar. 8	31.98				

Test Hole 5775 139-72-31ddd₁ (South Well) Depth 344 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	14.03				
Nov. 30	13.92				
Dec. 28	13.89				
Feb. 9, 1971	13.78				
Mar. 8	13.76				

Test Hole 5775-A 139-72-31ddd₂ (North Well) Depth 163 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	13.50				
Nov. 30	12.97				
Dec. 28	12.92				
Feb. 9, 1971	12.78				
Mar. 8	12.74				

Test Hole 5758 140-71-19ddd Depth 123 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	21.32				
Nov. 30	20.66				
Dec. 28	20.60				

Recorder Well (8-inch diameter) 140-71-28bba Depth 60 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 30	13.46				
Oct. 26	13.66				
Nov. 30	13.98				
Dec. 28	13.02				
Feb. 1, 1971	12.97				
Mar. 1	12.86				

Test Hole 5913. 140-71-28daa₁ (South Well) Depth 68 feet

Date	Water Level	Date	Water Level	Date	Water Level
Mar. 17, 1971	12.52				

Test Hole 5913-A 140-71-28daa₂ (North Well) Depth 33 feet

Date	Water Level	Date	Water Level	Date	Water Level
Mar. 17, 1971	10.30				

Test Hole 5753 141-70-6baa Depth 143 feet

Sept. 3, 1970	43.25
Nov. 30,	42.89
Dec. 28	43.08
Feb. 1, 1971	43.18
Mar. 1	43.20

PL Co. 6 (3-inch diameter) 142-70-9aaa Depth 90 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 30, 1970	67.35				
Oct. 26	67.43				
Nov. 30	67.22				
Dec. 28	67.35				
Feb. 1, 1971	67.45				
Mar. 1	67.52				

PL Co. 5 142-70-16ddd Depth 70 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 30, 1970	21.84				
Oct. 26	21.72				
Nov. 30	21.53				
Dec. 28	21.64				
Feb. 1, 1971	21.70				
Mar. 1	21.44				

Test Hole 5754 142-71-35ddd Depth 183 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	9.75				
Nov. 30	6.42				
Dec. 28	6.52				
Feb. 1, 1971	6.55				
Mar. 1	6.54				

Test Hole 5751 144-70-26ccc Depth 343 feet

Date	Water Level	Date	Water Level	Date	Water Level
Sept. 3, 1970	+ .5				
Mar. 17, 1971	+1.3				

FIGURE 1 -- MAP OF KIDDER COUNTY SHOWING LOCATION
OF SELECTED TEST HOLES AND WELLS



TABLE 3 -- LOGS OF TEST HOLES

Explanation of Lithologic Symbols

	Gravel or sand and gravel
	Boulder clay (till)
	Silty clay (glaciofluvial sediment)
	Shale

The following test hole logs are a summary of data from the driller's logs, geologist's sample descriptions and the resistivity and potential electric logs.

Grain size classification is C. K. Wentworth's scale from Pettijohn (1957).

Elevations are based on mean sea level datum as represented on and interpreted from the Dawson, Steele, Steele Northeast, Steele Northwest, Tappen North, Tappen South, Tappen Northeast and Tappen Southeast, U. S. Geological Survey, topographic maps.

Test holes are called observation wells when they have been completed as wells with 1 $\frac{1}{4}$ -inch diameter plastic casing.

138-71-6ccd
Test Hole 5634
Elevation 1812 feet

DATE DRILLED: 9-18-68

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Sand, fine- to coarse-grained oxidized -----	30	30
	Silt, clayey, olive gray, laminated -----	20	50
	Gravel, sandy, fine to coarse, predominantly limestone and granitics, some shale -----	30	80
	Clay, (till) -----	10	90

Observation Well
Depth 80 feet
Screened interval 77-80 feet
Chemical Analysis
Electric Log

138-71-7bba
Test Hole 3635
Elevation 1811 feet

DATE DRILLED: 9-18-68

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Sand, coarse-grained, well-sorted -----	30	30
	Clay, silty, olive gray -----	5	35
	Sand, gravelly, fine- to very coarse-grained, angular to rounded, poorly sorted -----	48	83
	Clay, silty, pebbly, olive gray ---	7	90

Observation Well
Depth 80 feet
Screened Interval 77-80 feet
Chemical Analysis
Electric Log

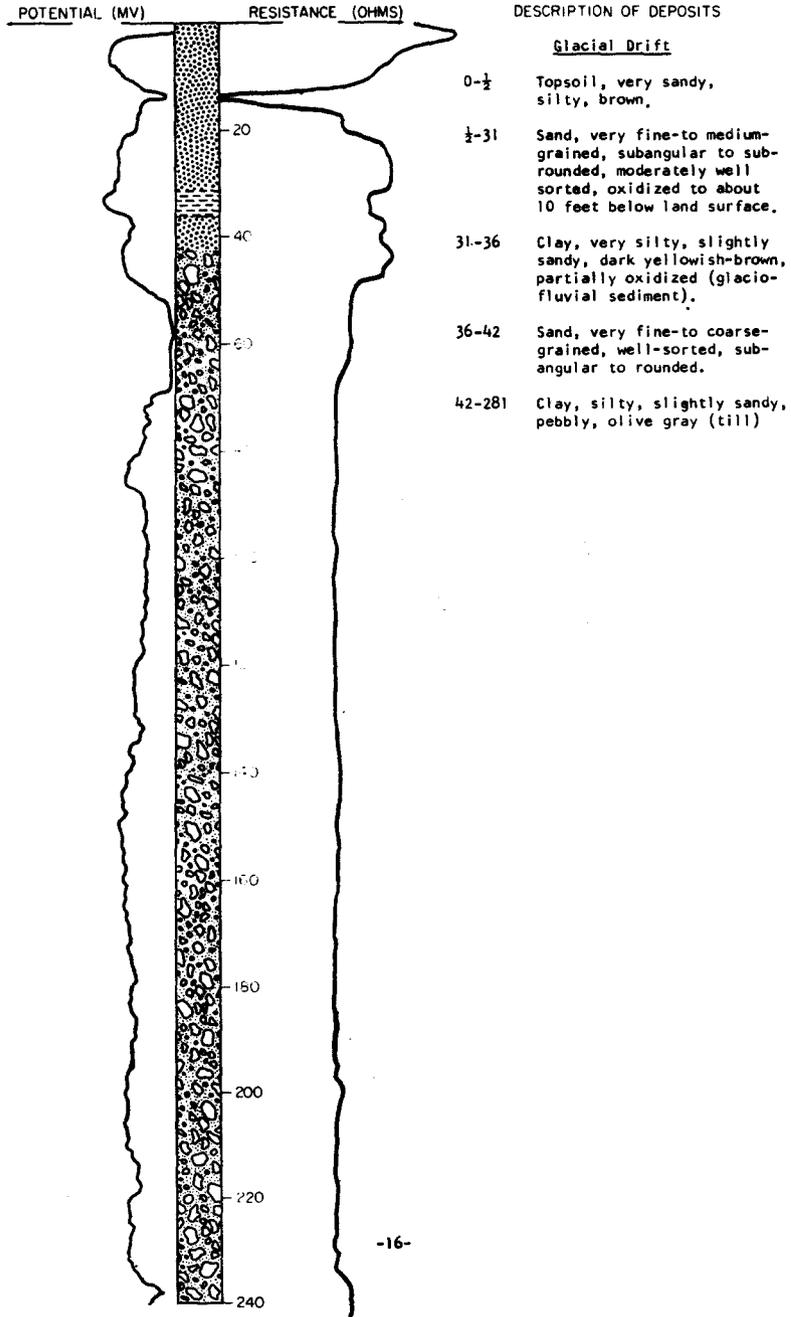
TEST HOLE 5773

LOCATION: 138-71-18ccc

DATE DRILLED: August 31, 1970

ELEVATION: 1810
(FT, MSL)

DEPTH: 380
(FT)



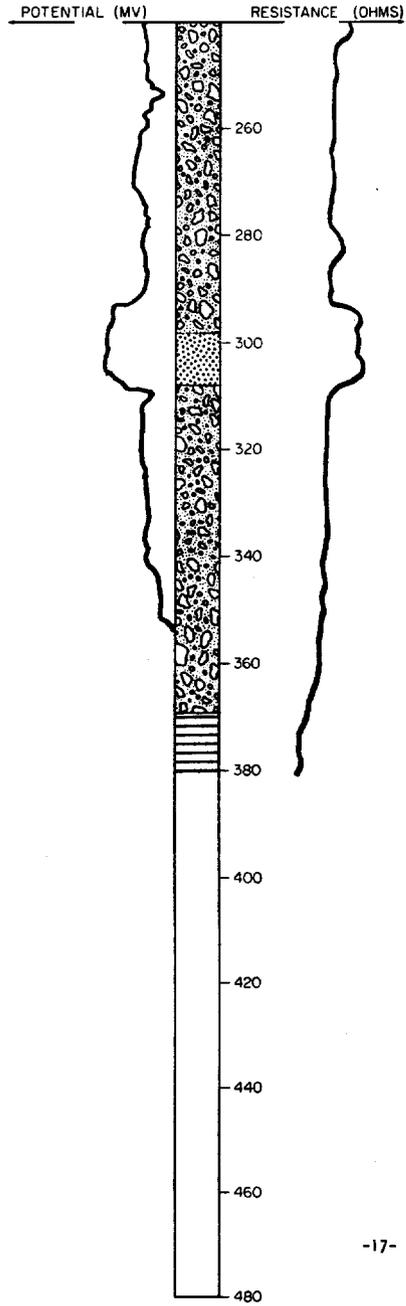
TEST HOLE 5773 continued

LOCATION: 138-71-18ccc

DATE DRILLED: August 31, 1970

ELEVATION: 1810
(FT, MSL)

DEPTH: 380
(FT)



DESCRIPTION OF DEPOSITS

281-298 Clay, silty, sandy, pebbly, very gravelly, olive gray (till).

298-308 Sand, fine-to very coarse-grained, subangular to rounded, moderately well-sorted.

308-369 Clay, silty, moderately sandy, pebbly, olive gray (till).

Pierre Formation

369-380 Shale, siliceous, grayish-black to black, indurated, bedded, non-calcareous.

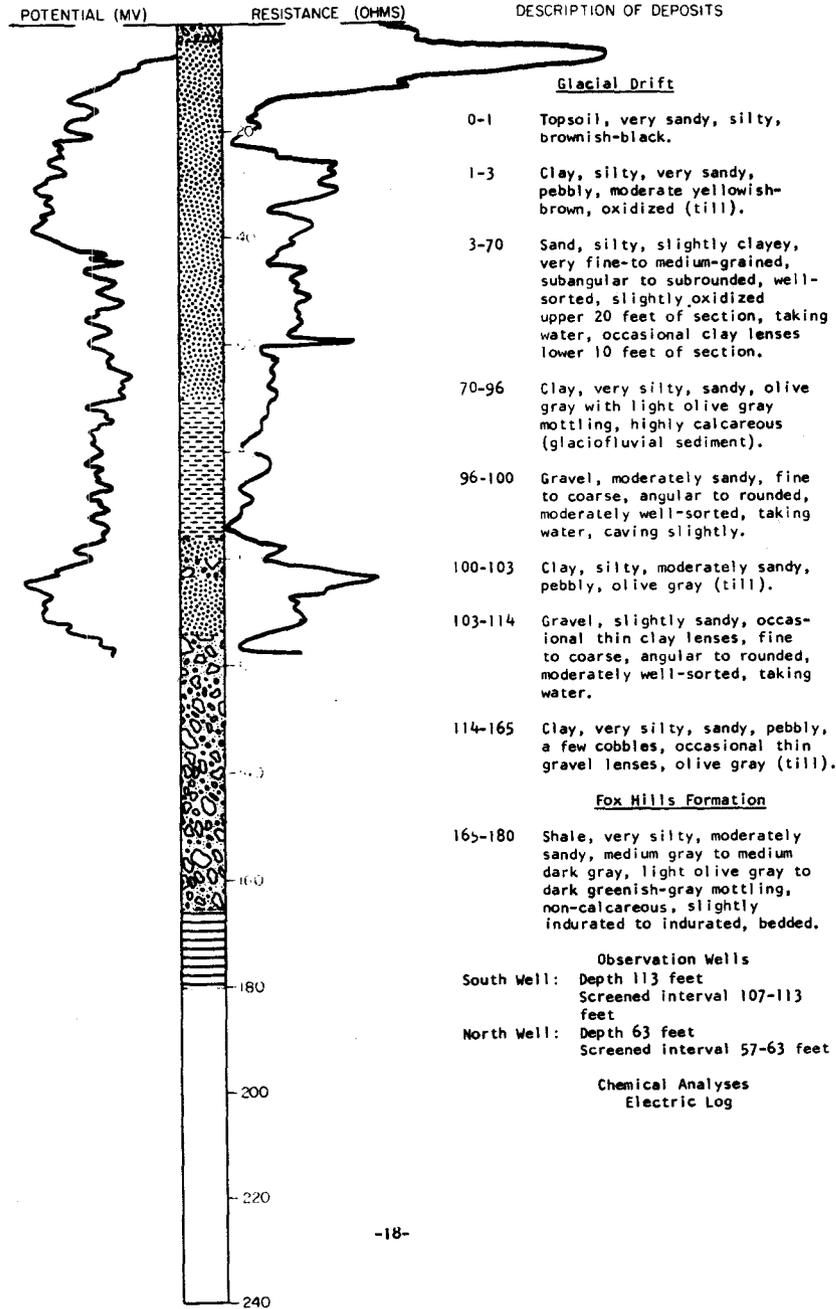
Electric Log

LOCATION: 138-72-1aaa

DATE DRILLED: August 28, 1970

ELEVATION: 1765
(FT, MSL)

DEPTH: 180
(FT)



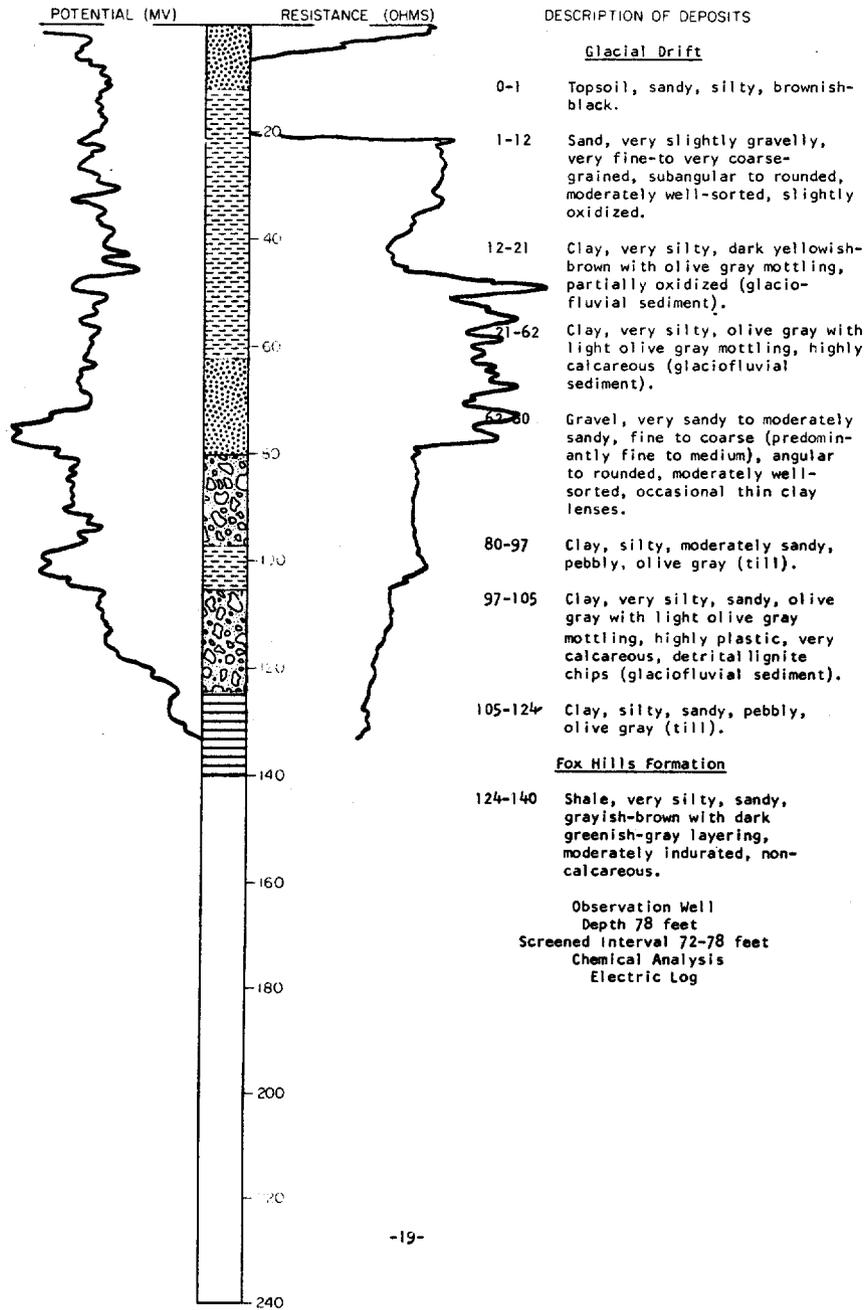
LOCATION: 138-72-1ccc

TEST HOLE 5770

DATE DRILLED: August 28, 1970

ELEVATION: 1790
(FT, MSL)

DEPTH: 140
(FT)



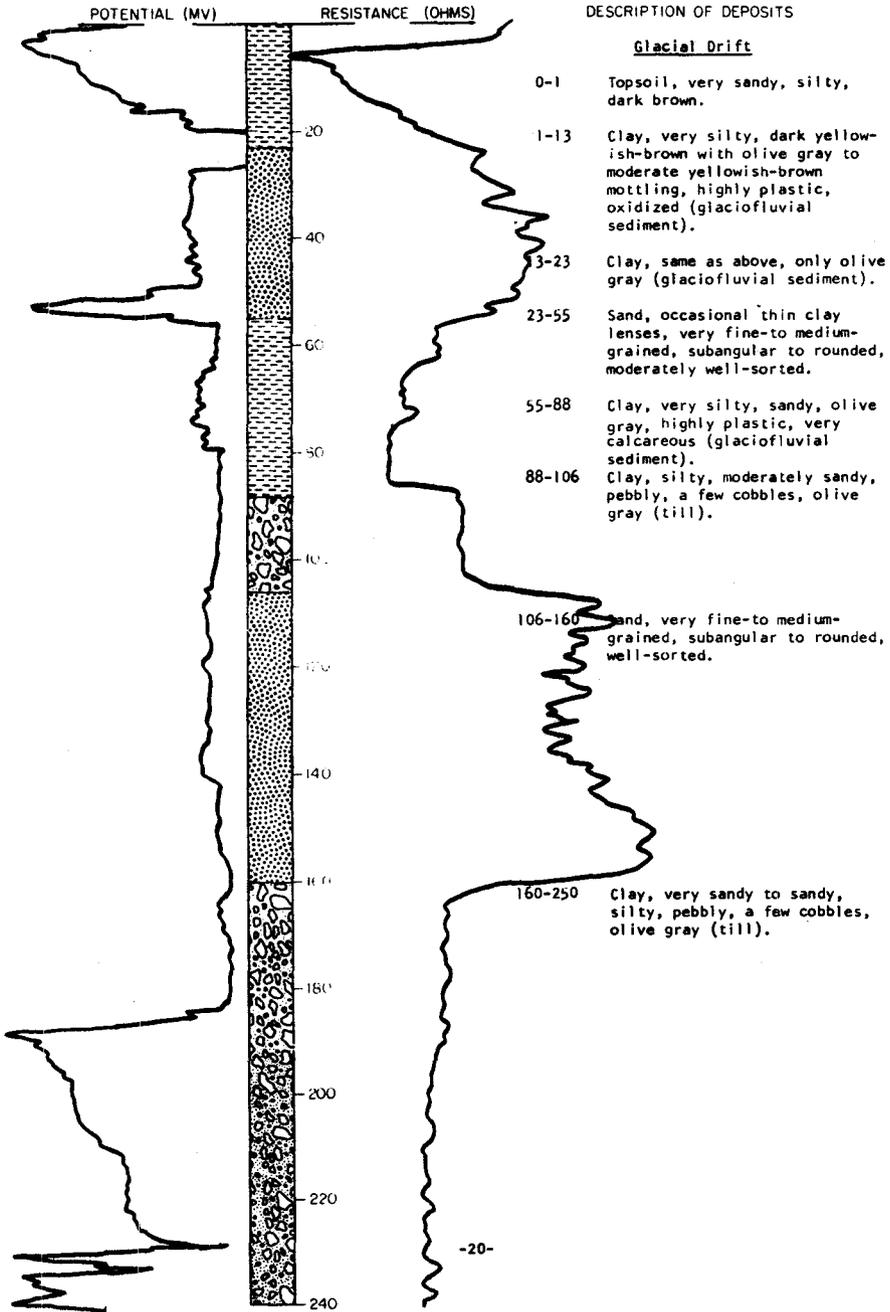
TEST HOLE 5774

LOCATION: 138-72-7aaa

DATE DRILLED: August 31, 1970

ELEVATION: 1730
(FT, MSL)

DEPTH: 300
(FT)



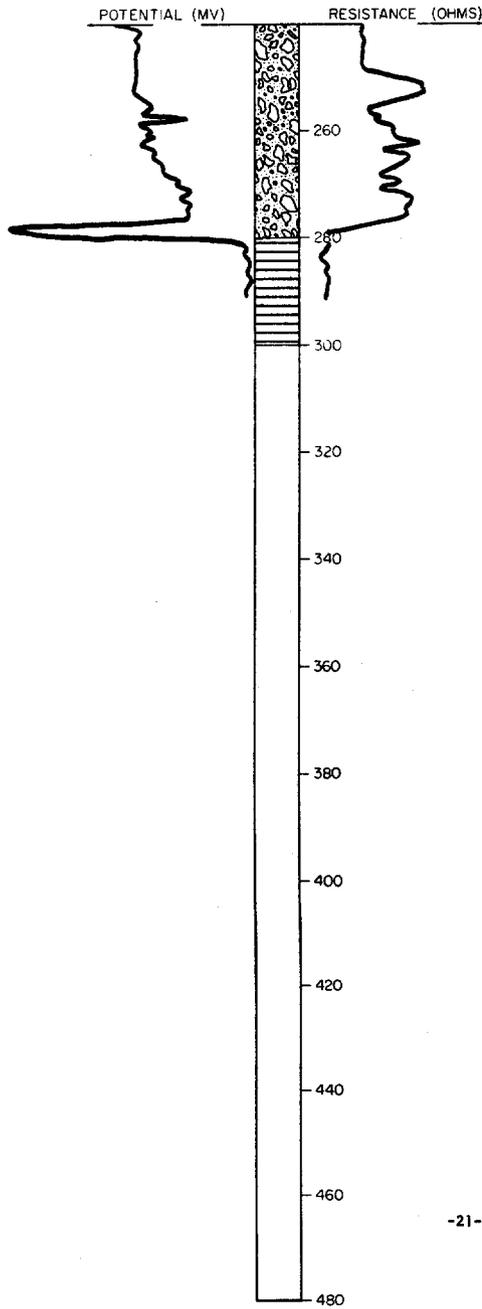
TEST HOLE 5774 continued

LOCATION: 138-72-7aaa

DATE DRILLED: August 31, 1970

ELEVATION: 1730
(FT, MSL)

DEPTH: 300
(FT)



DESCRIPTION OF DEPOSITS

250-280 Clay, silty, sandy, pebbly, gravelly, olive gray (till).

Pierre Formation

280-300 Shale, siliceous, grayish-black, indurated, non-calcareous, bedded.

Observation Wells
East Well: Depth 143 feet
Screened Interval 137-143 feet
West Well: Depth 50 feet
Screened interval 47-50 feet
Chemical Analyses
Electric Log

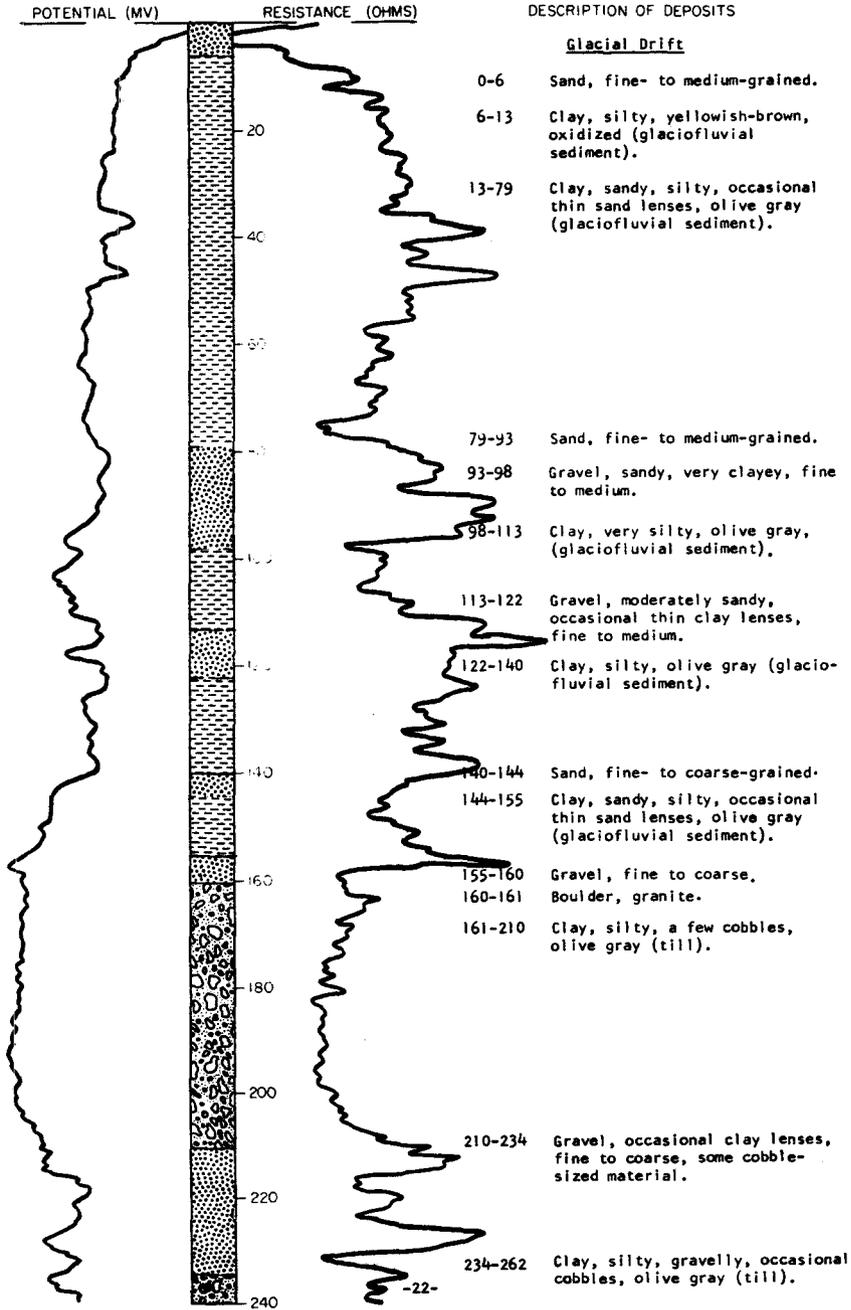
TEST HOLE 5916

LOCATION: 138-73-8ddd

DATE DRILLED: October 17, 1970

ELEVATION: 1,730
(FT, MSL)

DEPTH: 280
(FT)



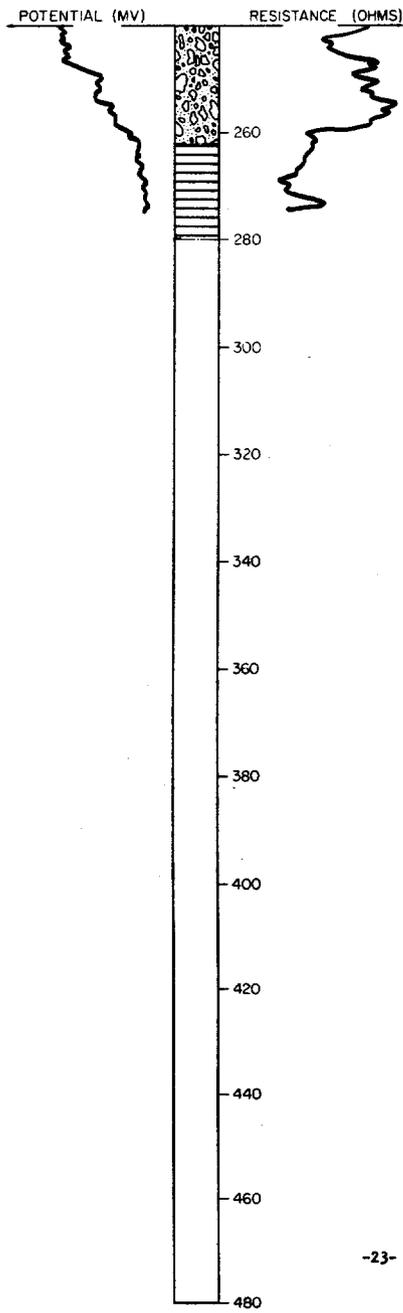
TEST HOLE 5916 continued

LOCATION: 138-73-8ddd

DATE DRILLED: October 17, 1970

ELEVATION: 1,730
(FT, MSL)

DEPTH: 280
(FT)



DESCRIPTION OF DEPOSITS

Pierre Formation

262-280 Shale, siliceous, brownish-black.

Observation Well

Depth 213

Screened Interval 207-213 feet

Chemical Analysis

Electric Log

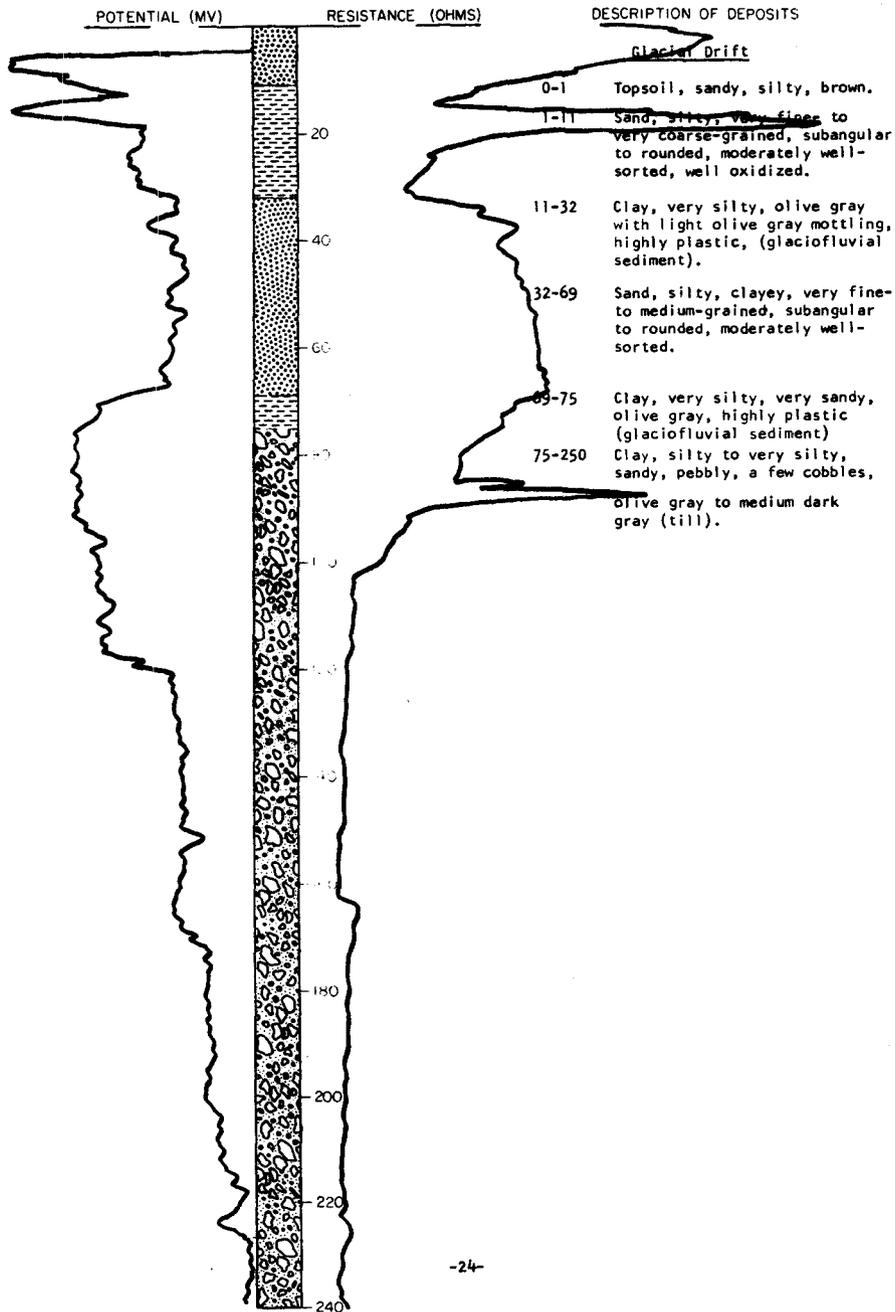
TEST HOLE 5759

LOCATION: 139-71-20bbb

DATE DRILLED: August 20, 1970

ELEVATION: 1745
(FT, MSL)

DEPTH: 280
(FT)



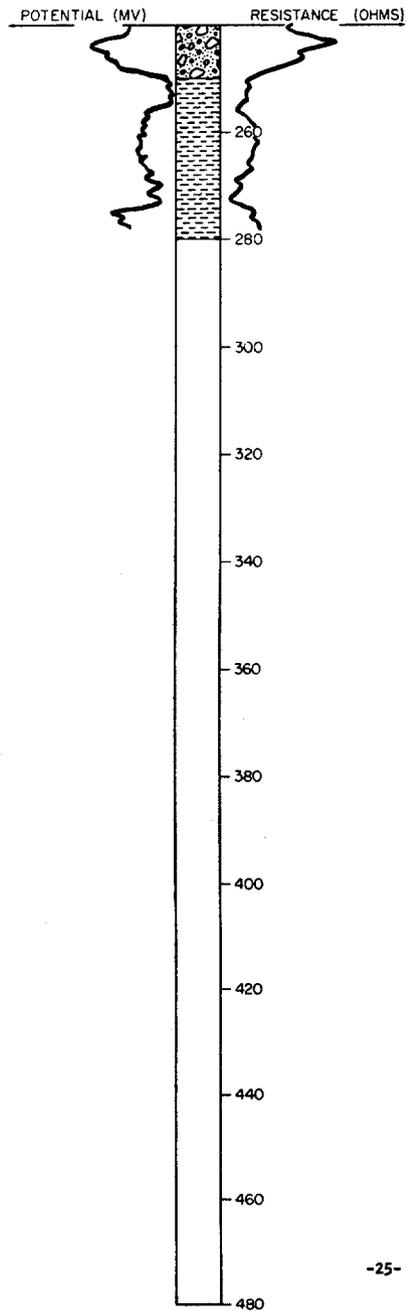
TEST HOLE 5759 continued

LOCATION: 139-71-20bbb

DATE DRILLED: August 20, 1970

ELEVATION: 1745
(FT, MSL)

DEPTH: 280
(FT)



DESCRIPTION OF DEPOSITS

Pierre Formation

250-280 Shale, siliceous, grayish-black to black, indurated, non-calcareous

Electric Log

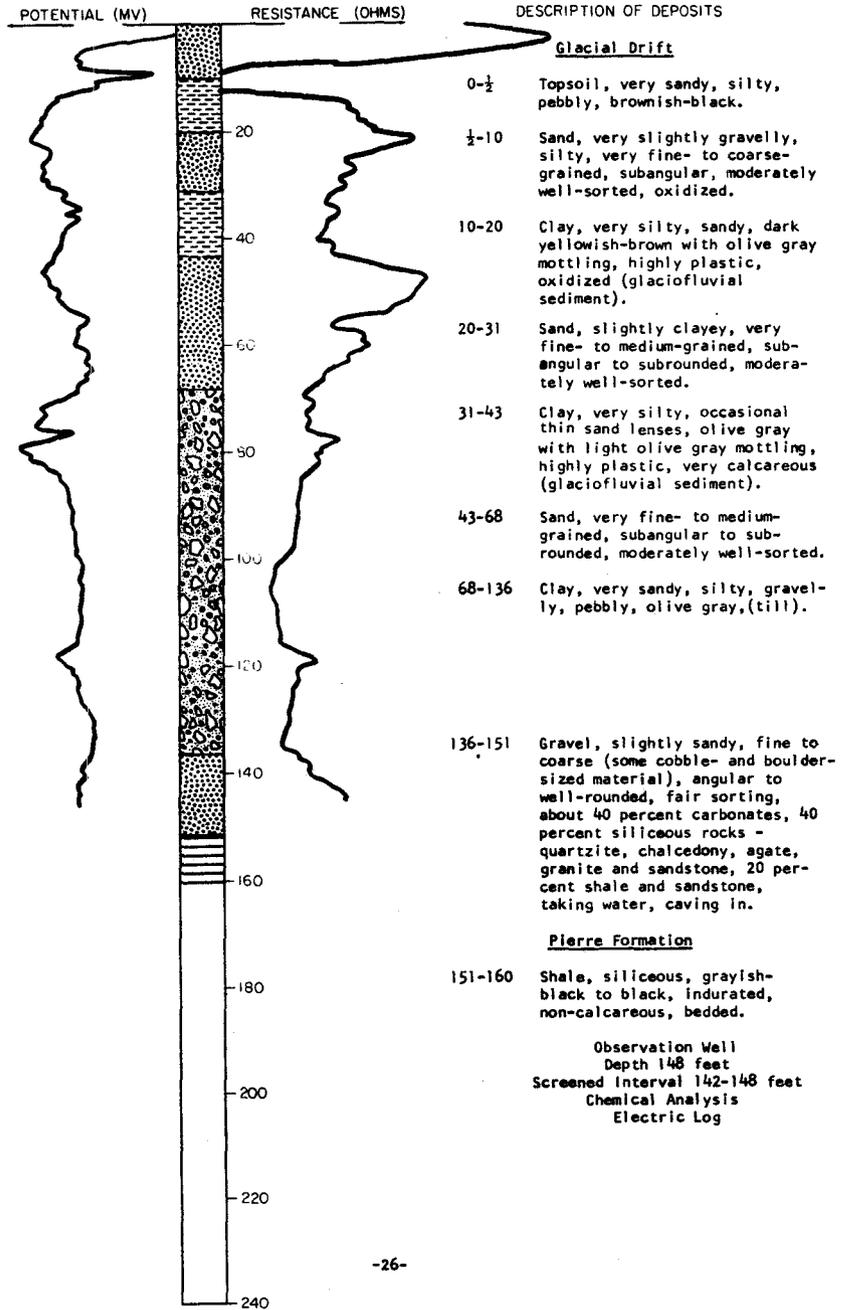
TEST HOLE 5772

LOCATION: 139-71-29ccc

DATE DRILLED: August 28, 1970

ELEVATION: 1,775
(FT, MSL)

DEPTH: 160
(FT)



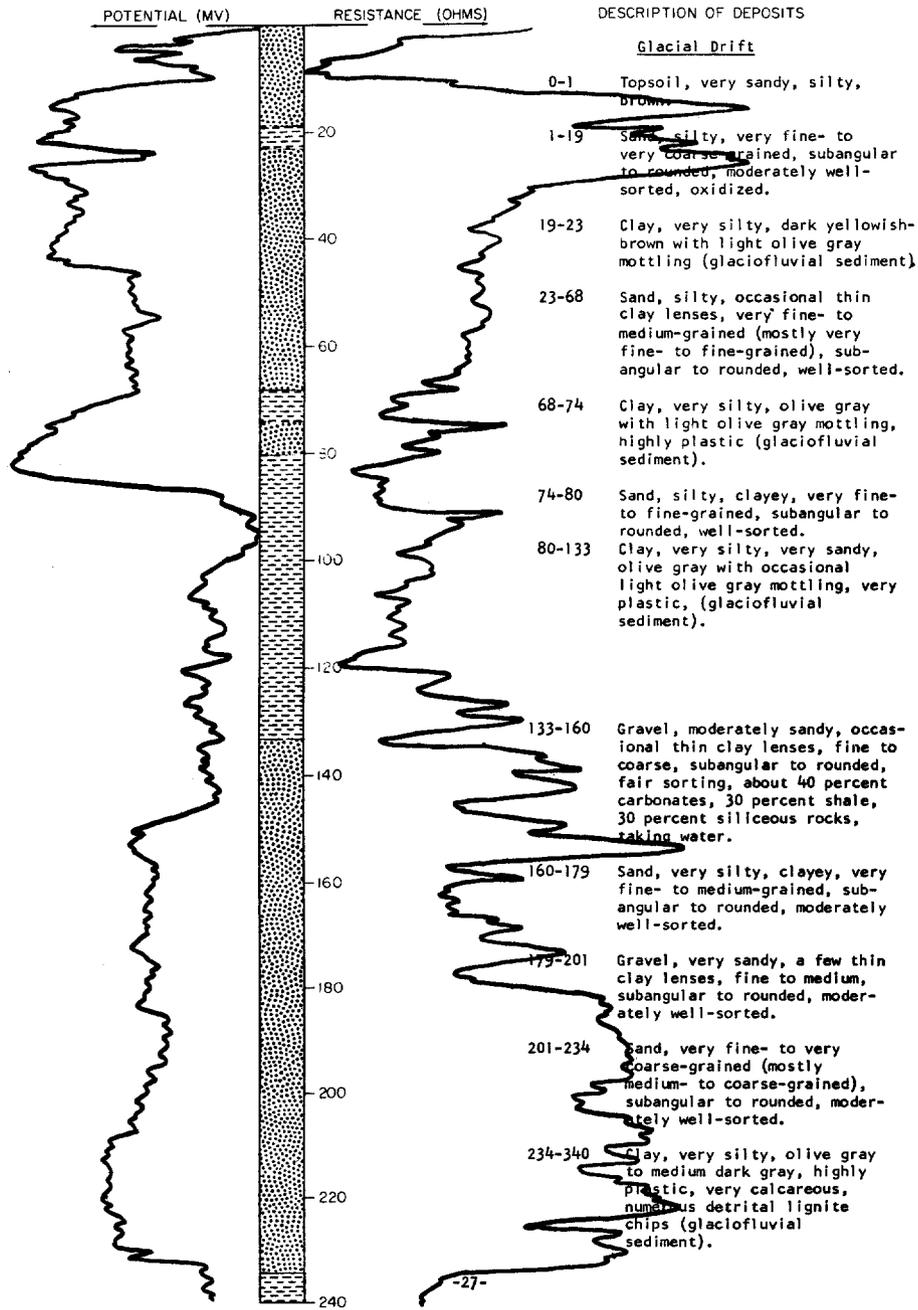
TEST HOLE 5760

LOCATION: 139-72-24bbb

DATE DRILLED: August 21, 1970

ELEVATION: 1768
(FT, MSL)

DEPTH: 360
(FT)



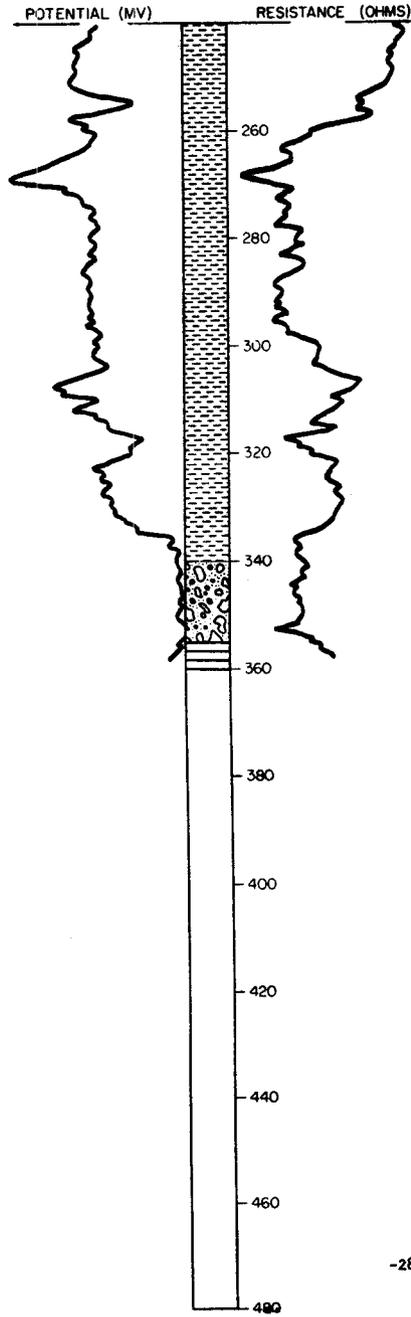
TEST HOLE 5760 continued

LOCATION: 139-72-24bbb

DATE DRILLED: August 21, 1970

ELEVATION: 1768
(FT, MSL)

DEPTH: 360
(FT)



DESCRIPTION OF DEPOSITS

340-355 Clay, silty, sandy, pebbly, olive gray (till).

Pierre Formation

355-360 Shale, siliceous, grayish-black to black, indurated, non-calcareous.

Observation Wells
West Well: Depth 203 feet
Screened Interval 197-203 feet
East Well: Depth 83 feet
Screened Interval 77-83 feet
Chemical Analyses
Electric Log

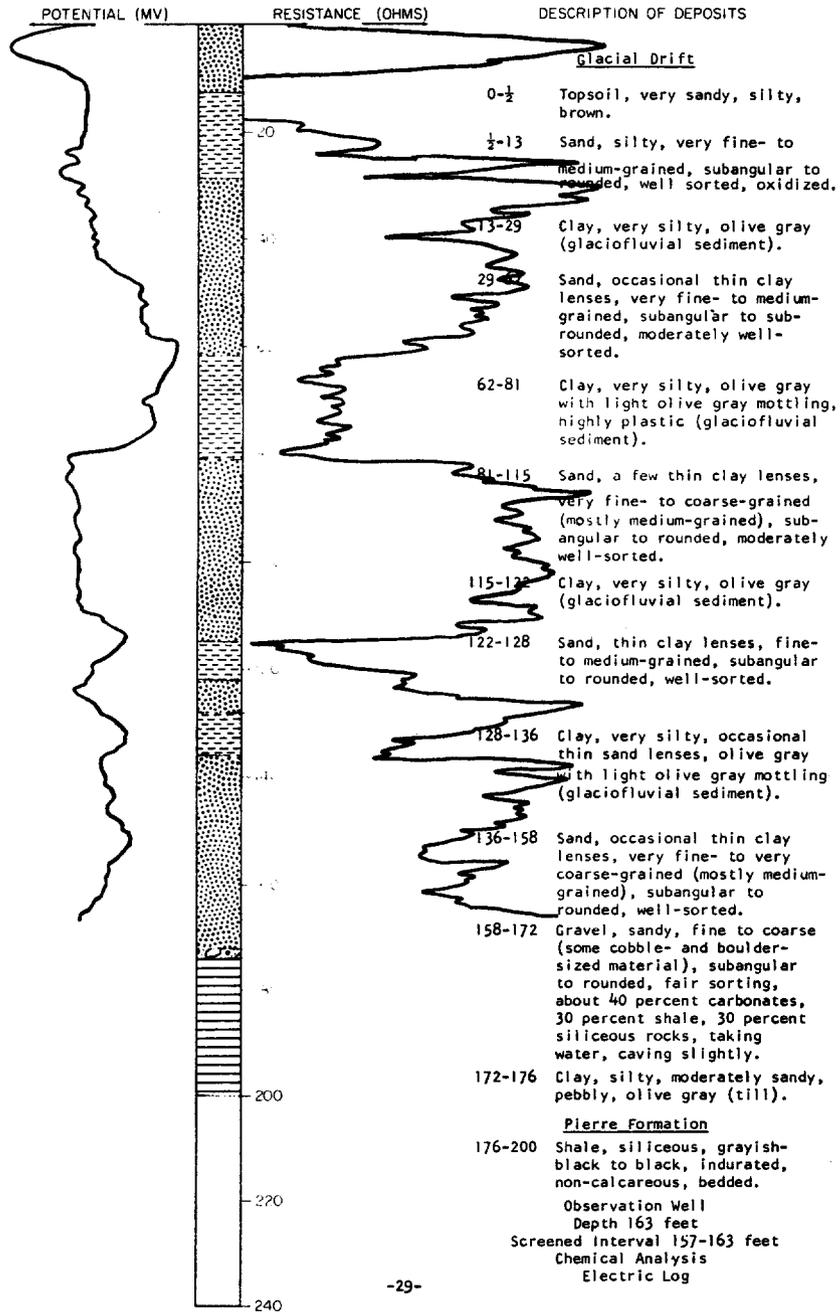
TEST HOLE 5776

LOCATION: 139-72-31aaa

DATE DRILLED: September 2, 1970

ELEVATION: 1765
(FT, MSL)

DEPTH: 200
(FT)



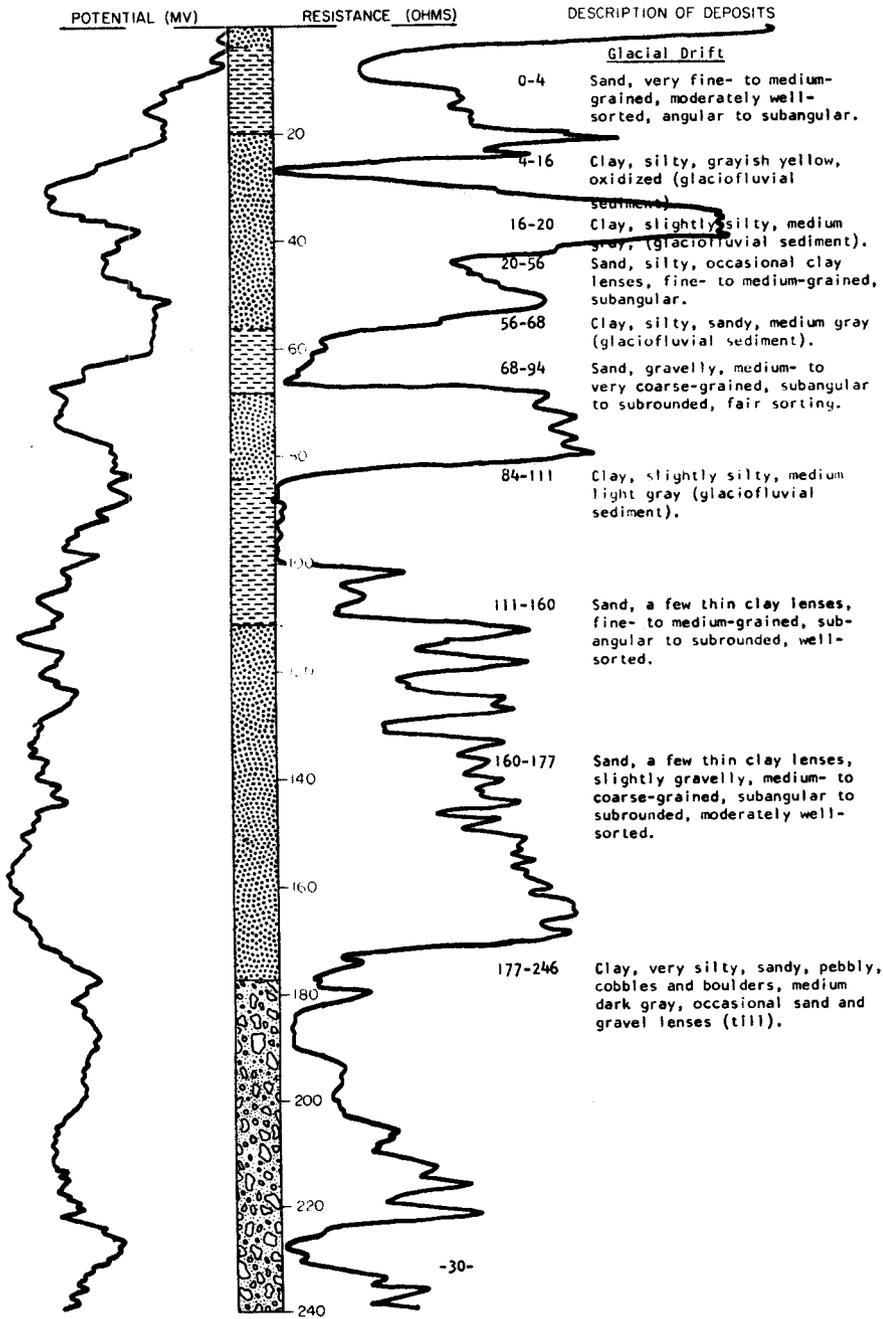
TEST HOLE 5775

LOCATION: 139-72-31ddd

DATE DRILLED: September 1, 1970

ELEVATION: 1740
(FT, MSL)

DEPTH: 400
(FT)



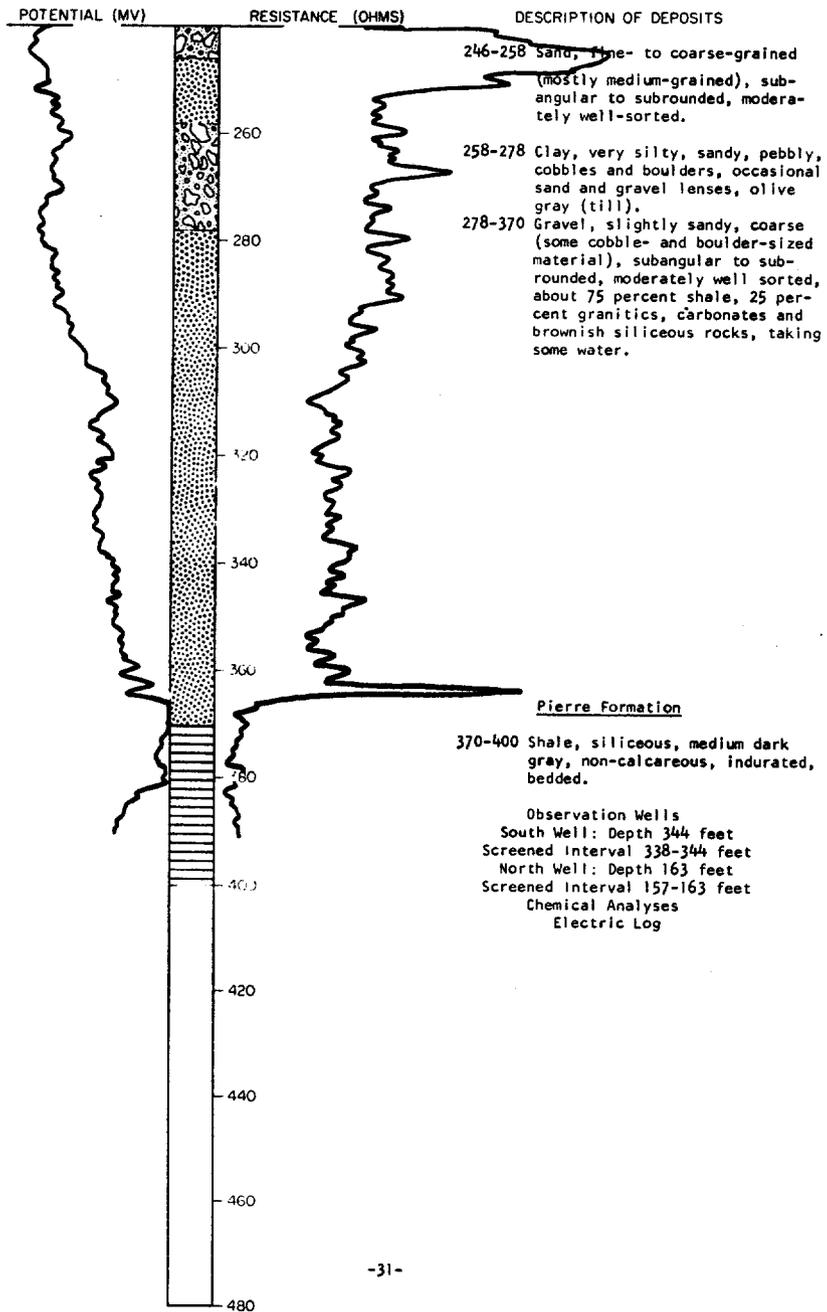
TEST HOLE 5775 continued

LOCATION: 139-72-31ddd

DATE DRILLED: September 1, 1970

ELEVATION: 1740
(FT, MSL)

DEPTH: 400
(FT)



139-73-13ddd
 Test Hole 5914
 Elevation 1815 feet

DATE DRILLED: 11-12-70

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, silty, moderately sandy, pebbly, brownish-black -----	1	1
	Clay, very silty, moderately sandy, pebbly, dusky yellow to moderate yellowish-brown, oxidized (till)--	28	29
Fox Hills Formation:			
	Sandstone, very fine-to fine-grained, dark reddish-brown to yellowish-brown, slightly cemented to well cemented, well oxidized and iron-stained, upper 5-10 feet of section highly calcareous, otherwise non-calcareous, bedded -----	26	55
	Sandstone, interbedded with shale, fine-grained, moderately clayey, moderately sandy, medium bluish-gray to dark greenish-gray, slightly cemented to well cemented, non-calcareous, slightly micaceous, bedded -----	25	80

139-73-15ddd
Test Hole 5915
Elevation 1875 feet

DATE DRILLED: 11-12-70

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, clayey, moderately sandy, pebbly, brownish-black -----	1	1
	Clay, silty, moderately sandy, occasional cobbles, dark yellowish- brown, oxidized (till) -----	50	51
Fox Hills Formation:			
	Sandstone, very fine-to fine-grained, interbedded with moderately clayey, sandy shale, dark reddish-brown to dark yellowish-brown with medium dark gray to greenish-gray mottling, partially oxidized to oxidized, moderately indurated, well cemented, non-calcareous -----	29	80

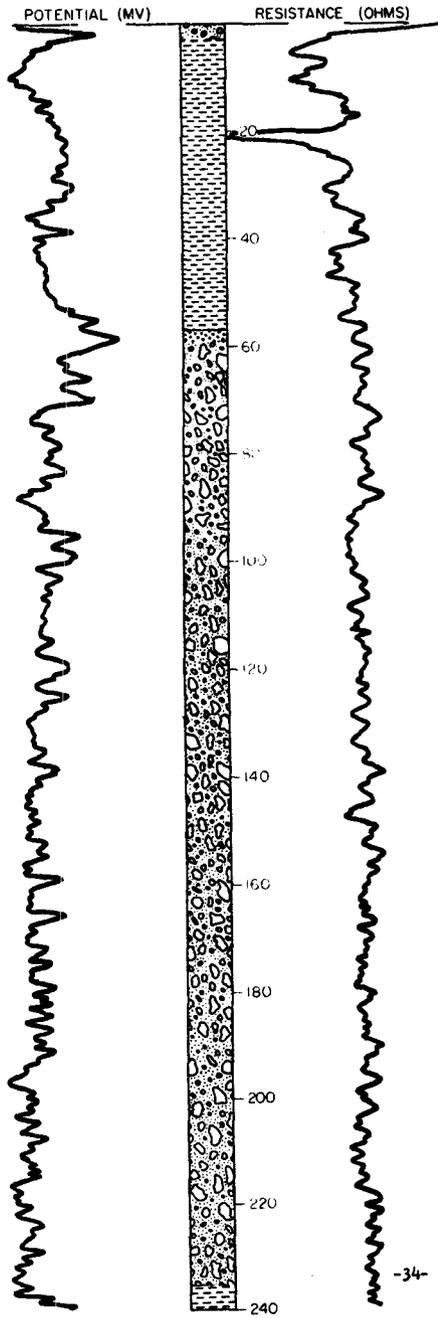
TEST HOLE 5756

LOCATION: 140-71-2bbb

DATE DRILLED: August 19, 1970

ELEVATION: 1910
(FT, MSL)

DEPTH: 400
(FT)



- DESCRIPTION OF DEPOSITS**
- Glacial Drift**
 - 0-1 Topsoil, silty, pebbly, cobbles, boulders, grayish-black.
 - 1-3 Clay, silty, moderately sandy, pebbly, cobbles, boulders, moderate yellowish-brown, oxidized (till).
 - 3-31 Clay, very silty, dark yellowish-brown with light olive gray to dark gray mottling, highly plastic, very calcareous, partially oxidized (glaciofluvial sediment).
 - 31-57 Clay, very silty, olive gray with light olive gray mottling, highly plastic, very calcareous (glaciofluvial sediment).
 - 57-59 Sand, very fine-to medium-grained, subangular, moderately well-sorted.
 - 59-235 Clay, very silty, pebbly, olive gray to medium dark gray (till).
 - 235-286 Clay, very silty, olive gray with light olive gray mottling, highly plastic, very calcareous, numerous detrital lignite fragments (glaciofluvial sediment).
 - 286-395 Clay, silty, moderately sandy, cobbles (numerous cobbles and boulders lower 40 feet of section), medium dark gray (till).

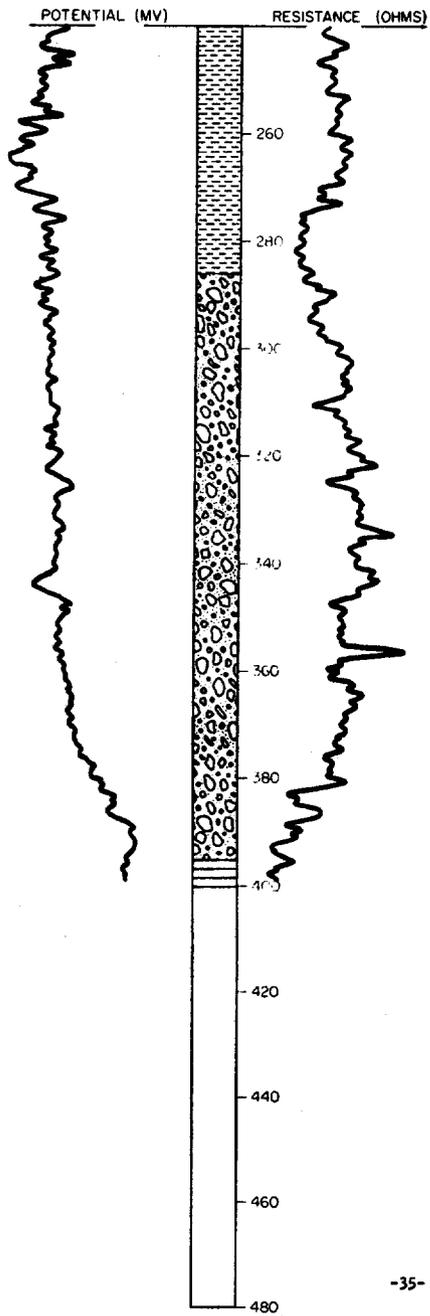
TEST HOLE 5756 Continued

LOCATION: 140-71-2bbb

DATE DRILLED: August 19, 1970

ELEVATION: 1910
(FT, MSL)

DEPTH: 400
(FT)



DESCRIPTION OF DEPOSITS

Pierre Formation

395-400 Shale, siliceous, grayish-black to black, indurated, non-calcareous.

Electric log

140-71-5aaa
 Test Hole 5757
 Elevation 1754 feet

DATE DRILLED: 8-20-70

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, sandy, silty, pebbly, brownish-black -----	1	1
	Clay, very silty, sandy, pebbly, moderate yellowish-brown, oxidized (till) -----	4	5
	Sand, silty, slightly clayey, very fine-to coarse-grained, subangular to rounded, moderately well-sorted, oxidized -----	8	13
	Clay, silty, slightly sandy, pebbly, a few cobbles, olive gray (till)--	49	62
	Sand, slightly gravelly, very fine-to very coarse-grained (mostly medium-to coarse-grained), subangular, moderately well-sorted, slightly oxidized -----	13	75
	Clay, silty to very silty, slightly sandy, occasional cobbles and boulders, olive gray to medium dark gray (till) -----	185	260
Pierre Formation:			
	Shale, siliceous, grayish-black to black, indurated, non-calcareous -----	20	280

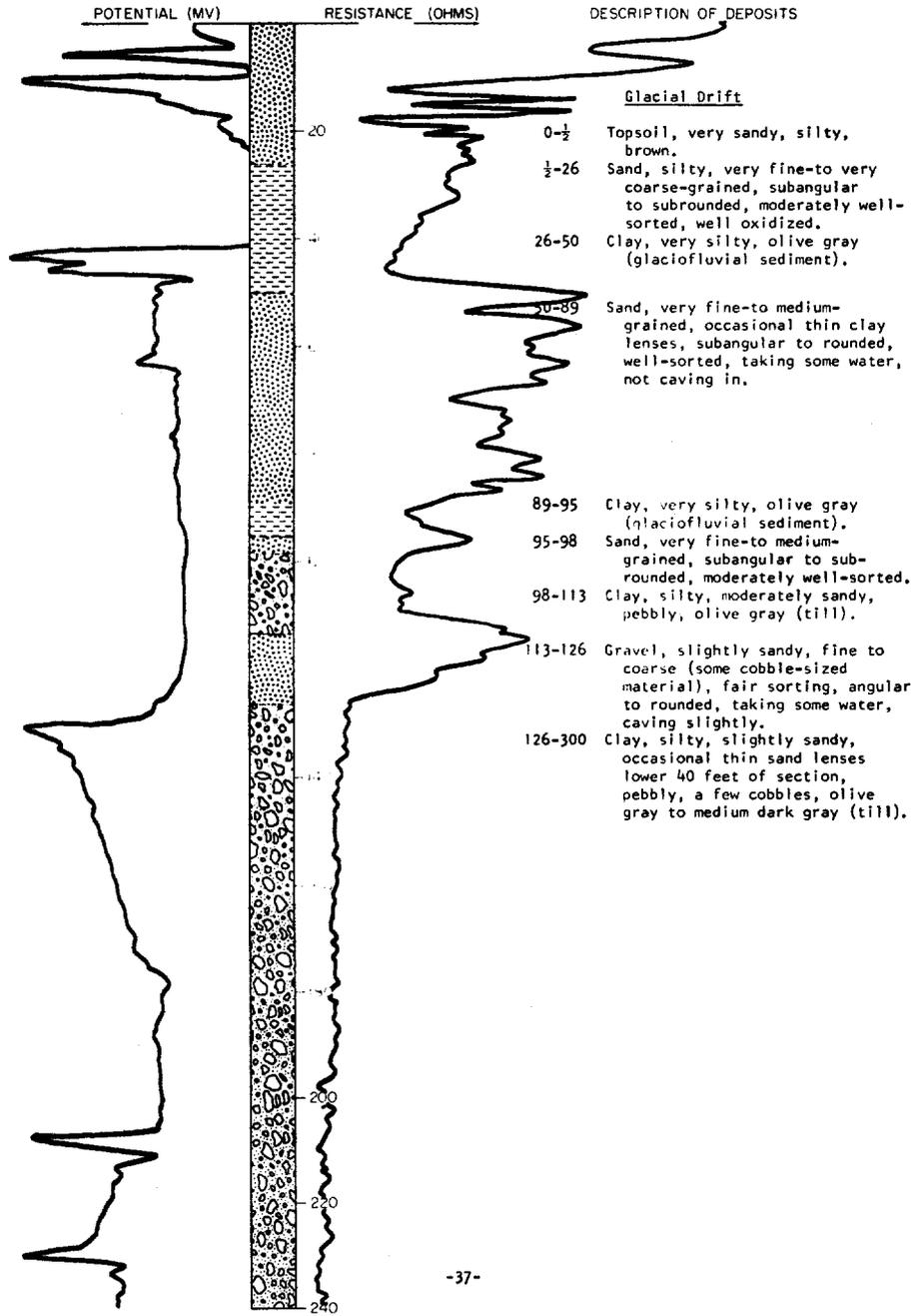
TEST HOLE 5758

LOCATION: 14n-71-19ddd

DATE DRILLED: August 20, 1970

ELEVATION: 1760
(FT, MSL)

DEPTH: 400
(FT)

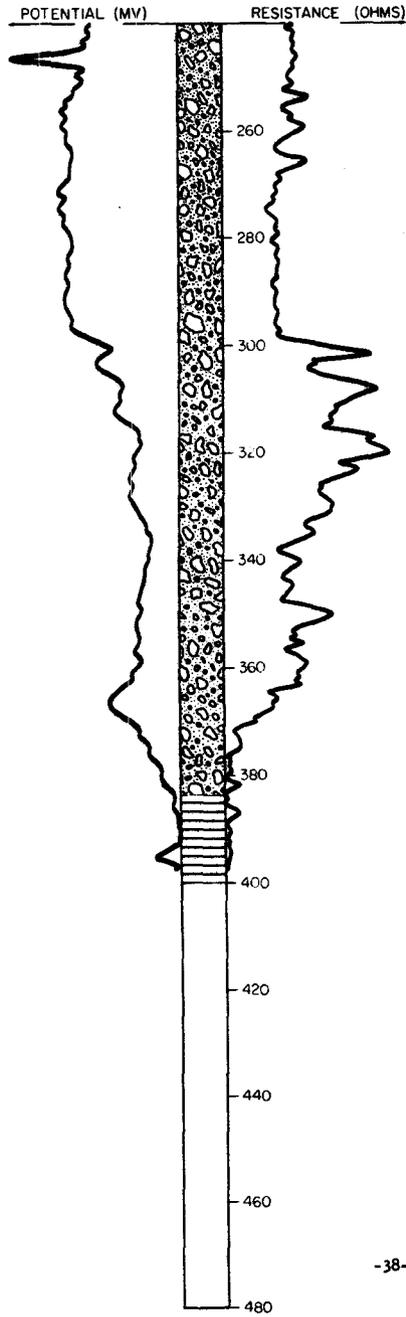


LOCATION: 140-71-19ddd

DATE DRILLED: August 20, 1970

ELEVATION: 1760
(FT, MSL)

DEPTH: 400
(FT)



DESCRIPTION OF DEPOSITS

300-383 Clay, silty, sandy, numerous thin sand lenses, cobbles, olive gray to medium dark gray (till).

Pierre Formation

383-400 Shale, siliceous, grayish-black to black, indurated, bentonitic mottling, non-calcareous.

Observation well
Depth 123 feet
Screened interval 117-123 feet
Chemical analysis
Electric log

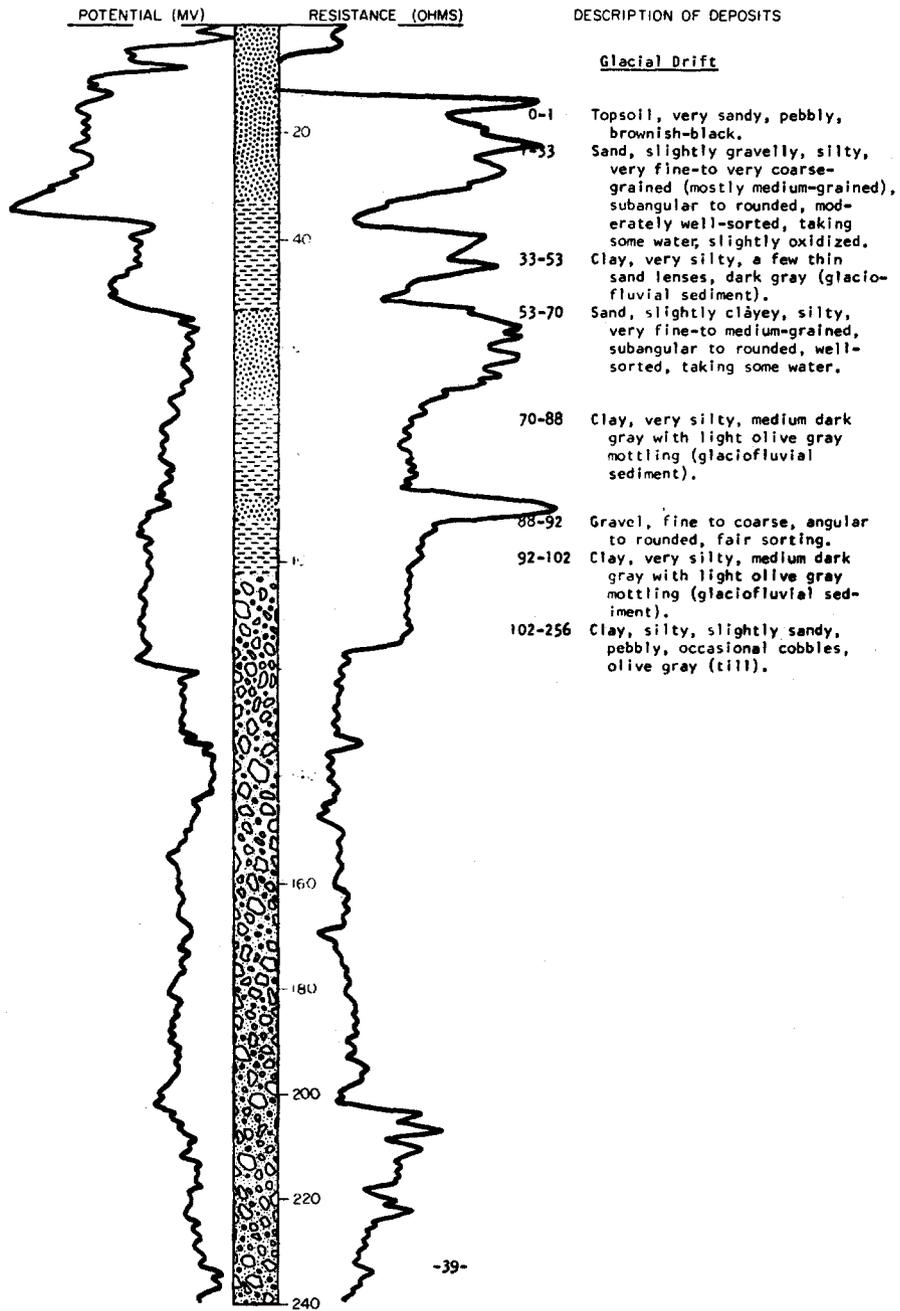
TEST HOLE 5913

LOCATION: 140-71-28daa

DATE DRILLED: October 12, 1970

ELEVATION: 1765
(FT, MSL)

DEPTH: 280
(FT)



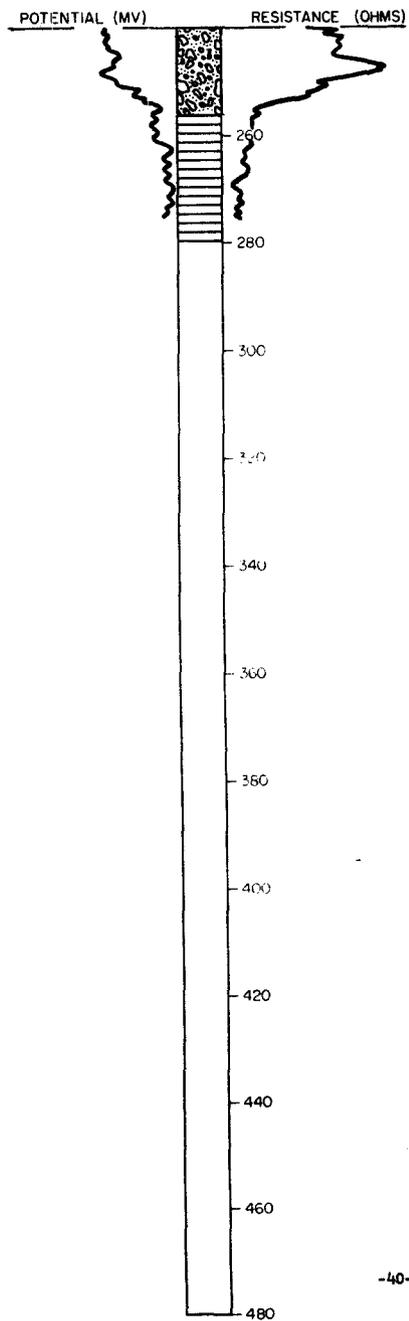
TEST HOLE 5913 Continued

LOCATION: 140-71-28daa

DATE DRILLED: October 12, 1970

ELEVATION: 1765
(FT, MSL)

DEPTH: 280
(FT)



DESCRIPTION OF DEPOSITS

Pierre Formation

256-280 Shale, siliceous, grayish-black, indurated, non-calcareous, bedded.

Observation wells
South well: depth 68 feet
North well: depth 33 feet
Screened interval 62-68 feet
Screened interval 30-33 feet
Chemical analyses
Electric log

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, very sandy, silty, brown --	1	1
	Sand, slightly gravelly, very fine- to very coarse-grained (mostly medium-grained), subangular to subrounded, moderately well- sorted, taking water rapidly, mixed 100 lbs. bentonite, oxidized -----	23 ¹	24
	Gravel, sandy, fine to coarse (some cobble-sized material), subangular to rounded, fair sorting, taking water, caving slightly -----	15	39
	Clay, silty, moderately sandy, pebbly, olive gray (till) -----	10	49
	Gravel, sandy, cobbles and boulders, fine to coarse, subangular to rounded, poorly sorted, caving in, mixed 50 lbs. bentonite -----	8	57
	Clay, silty, slightly sandy, pebbly, occasional cobbles, olive gray (till) -----	34	91
	Gravel, sandy, clayey, fine to coarse (some cobble-sized material), fair to poor sorting, subangular to rounded, taking water -----	11	102
	Clay, silty, sandy, pebbly, very gravelly, cobbles, olive gray (till) -----	13	115
	Sand, moderately clayey, slightly gravelly, very fine-to very coarse- grained (mostly fine-to medium- grained), subangular to rounded, moderately well-sorted -----	39	154
	Clay, very silty, sandy, pebbly, occasional thin sand lenses, olive gray (till) -----	19	173
	Sand, silty, clayey, very fine-to medium-grained, subangular to rounded, moderately well-sorted --	13	186
	Clay, very silty, slightly sandy, pebbly, a few cobbles, medium dark gray (till) -----	86	272

141-70-6baa (Cont.)
Test Hole 5753

DATE DRILLED: 8-18-70

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Pierre Formation:	Shale, siliceous, grayish-black to black, indurated, bentonitic, non-calcareous -----	8	280
	Observation well Depth 143 feet Screened interval 137-143 feet Chemical analysis		

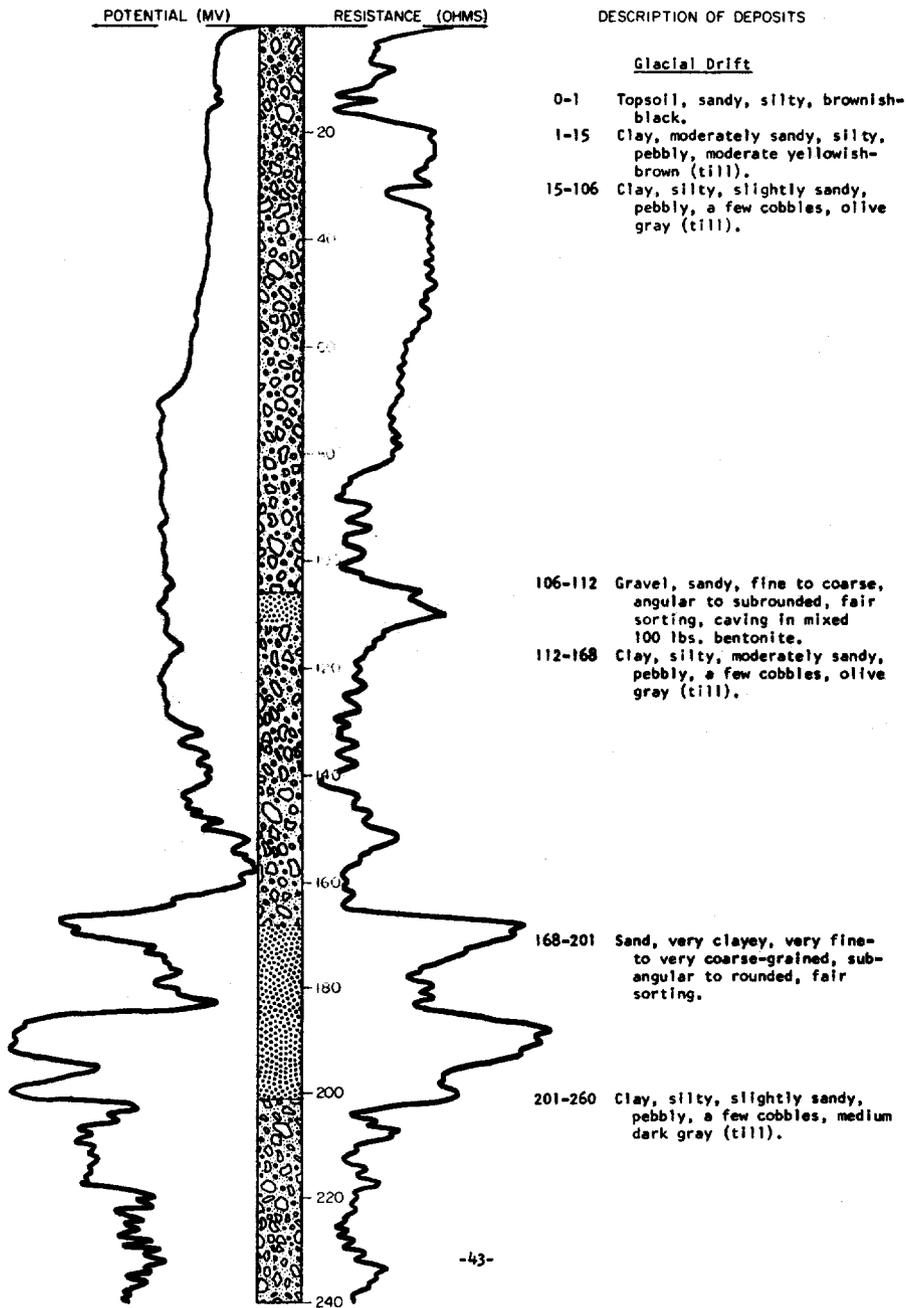
TEST HOLE 5752

LOCATION: 141-70-8aaa

DATE DRILLED: August 17, 1970

ELEVATION:
(FT, MSL)

DEPTH: 380
(FT)



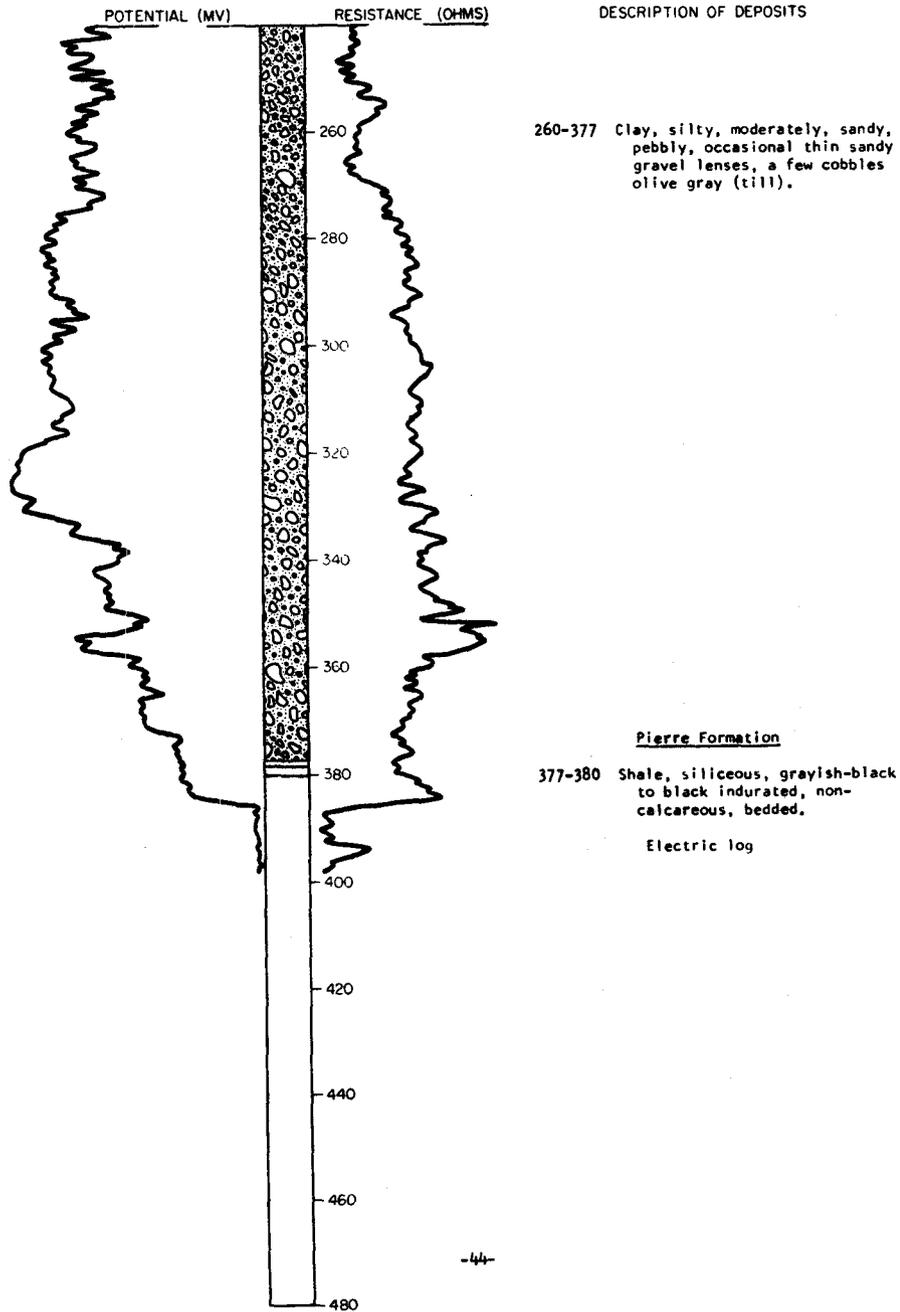
TEST HOLE 5752 Continued

LOCATION: 141-70-8aaa

DATE DRILLED: August 17, 1970

ELEVATION:
(FT, MSL)

DEPTH: 380
(FT)



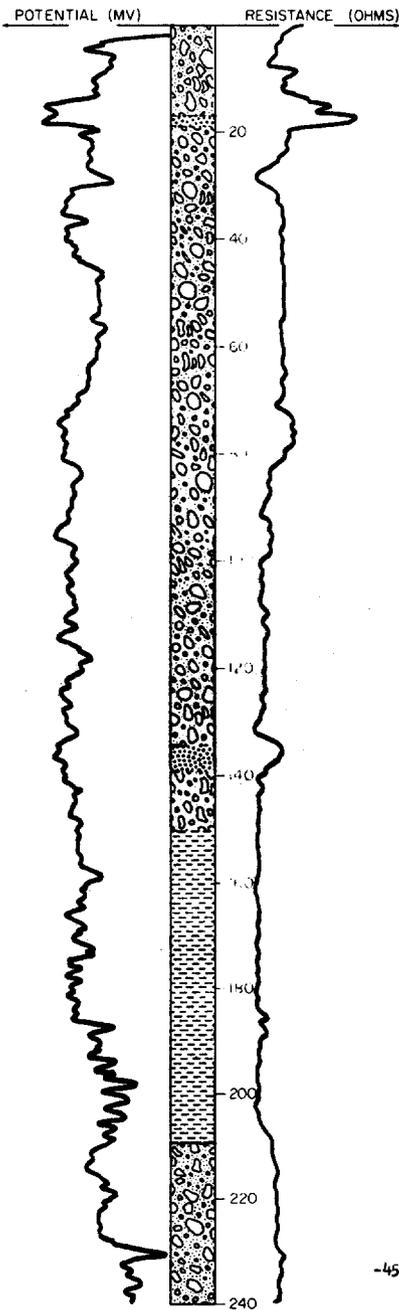
TEST HOLE 5755

LOCATION: 141-70-22aaa

DATE DRILLED: August 18, 1970

ELEVATION:
(FT, MSL)

DEPTH: 360
(FT)



DESCRIPTION OF DEPOSITS

Glacial Drift

- 0-1 Topsoil, sandy, silty, pebbly, brownish-black.
- 1-15 Clay, silty, moderately sandy, pebbly, moderate yellowish-brown, oxidized (till).
- 15-17 Clay, silty, slightly sandy, pebbly, olive gray (till).
- 17-19 Gravel, clayey, sandy, fine to coarse, subangular, poorly sorted.
- 19-134 Clay, silty to very silty, slightly sandy, pebbly, olive gray to medium dark gray (till).

- 134-139 Sand, slightly clayey, very fine- to medium-grained subangular, fair sorting.
- 139-150 Clay, silty, slightly sandy, pebbly, medium dark gray (till).
- 150-209 Clay, very silty, olive gray with light olive gray to dark gray mottling, occasional detrital lignite fragments (glaciofluvial sediment).

- 209-336 Clay, silty, moderately sandy, pebbly, a few cobbles, gravelly, medium dark gray (till).

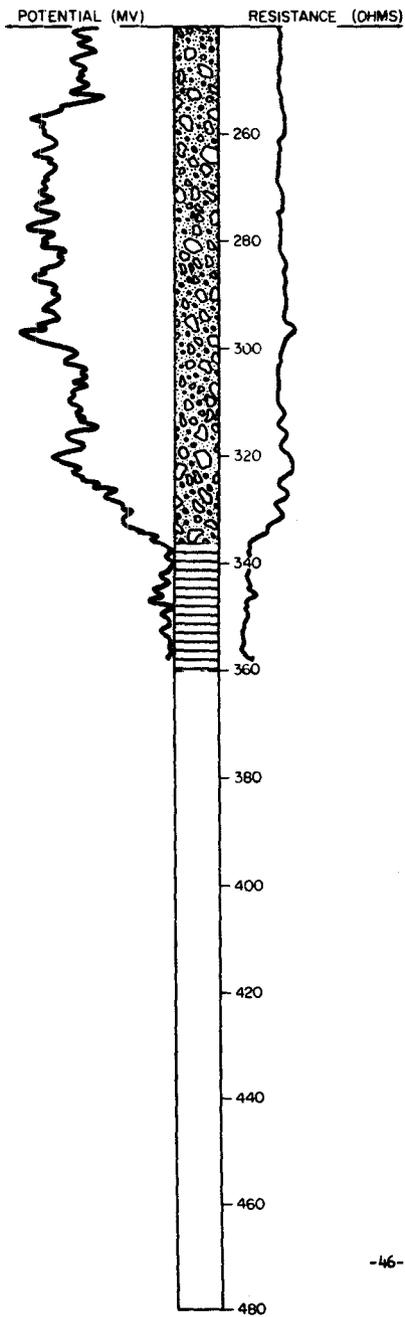
TEST HOLE 5755 Continued

LOCATION: 141-70-22aaa

DATE DRILLED: August 18, 1970

ELEVATION:
(FT, MSL)

DEPTH: 360
(FT)



DESCRIPTION OF DEPOSITS

Pierre Formation

336-360 Shale, siliceous, grayish-black to black, indurated, non-calcareous.

Electric log

<u>Geologic Source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Sand, gravelly, poorly sorted, sub-angular to subrounded, oxidized ---	61	61
	Silt, dusky yellow, slightly cohesive, oxidized -----	4	65
	Clay, silty, sandy, pebbly, moderate olive brown, oxidized (till) -----	4	69
	Clay, silty, sandy, pebbly, olive gray (till) -----	4	73
	Sand, gravelly, thin clay lenses, medium- to coarse-grained, well-sorted, lignitic, taking water ----	51	124
	Clay, silty, sandy, light olive gray to olive gray, calcareous -----	67	191
	Sand, clayey, fine-grained, dark greenish-gray -----	33	224
	Gravel, sandy, fine to coarse, moderately well-sorted, subangular to subrounded -----	13	237
	Clay, sandy, olive gray -----	5	242
	Gravel, sandy, fine to coarse, moderately well-sorted, subangular to subrounded -----	8	250
	Clay, silty, sandy, olive gray to light olive gray, lignitic, poor samples -----	68	318
Pierre Formation:			
	Shale, olive black, hard, non-calcareous -----	10	328

Observation well
 Depth 90 feet
 Slotted interval 70-90 feet
 Electric log

142-70-16ddd
PL Co. 5

DATE DRILLED: 10-4-65

<u>Geologic Source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Sand, gravelly, fine- to coarse-grained, moderately well-sorted, subrounded, oxidized -----	26	26
	Clay, silty, sandy, pebbly, gravelly, olive gray (till) -----	15	41
	Sand, gravelly, medium- to very coarse-grained, subrounded -----	21	62
	Clay, silty, pebbly, olive gray (till) -----	17	79
	Clay, olive gray -----	5	84
	Observation well		
	Depth 70 feet		
	Screened interval 67-70 feet		

<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, very sandy, silty, brown --	½	½
	Sand, moderately gravelly, very fine- to very coarse-grained, subangular to rounded, moderately well-sorted, well oxidized, taking water, mixed 100 lbs. bentonite -----	26½	27
	Clay, silty, moderately sandy, pebbly, olive gray (till) -----	12	39
	Sand, silty, slightly clayey, very fine-to very coarse-grained (mostly medium-grained), subangular to rounded, moderately well-sorted --	18	57
	Clay, very silty, sandy, olive gray with light olive gray mottling (glaciofluvial sediment) -----	22	79
	Clay, silty, slightly sandy, pebbly, a few cobbles, olive gray (till)--	35	114
	Sand, very fine-to very coarse-grained (mostly fine-to medium-grained), sub- angular to rounded, well-sorted, taking water -----	56	170
	Gravel, very sandy, fine to medium, subangular to rounded, moderately well-sorted, taking water -----	19	189
	Clay, very silty, olive gray with light olive gray mottling, highly plastic, very calcareous (glaciofluvial sedi- ment) -----	33	222
	Clay, silty, slightly sandy, pebbly, olive gray (till) -----	24	246
Pierre Formation:			
	Shale, siliceous, grayish-black to black, moderately indurated, non- calcareous -----	14	260
	Observation well Depth 183 feet Screened interval 177-183 feet Chemical analysis		

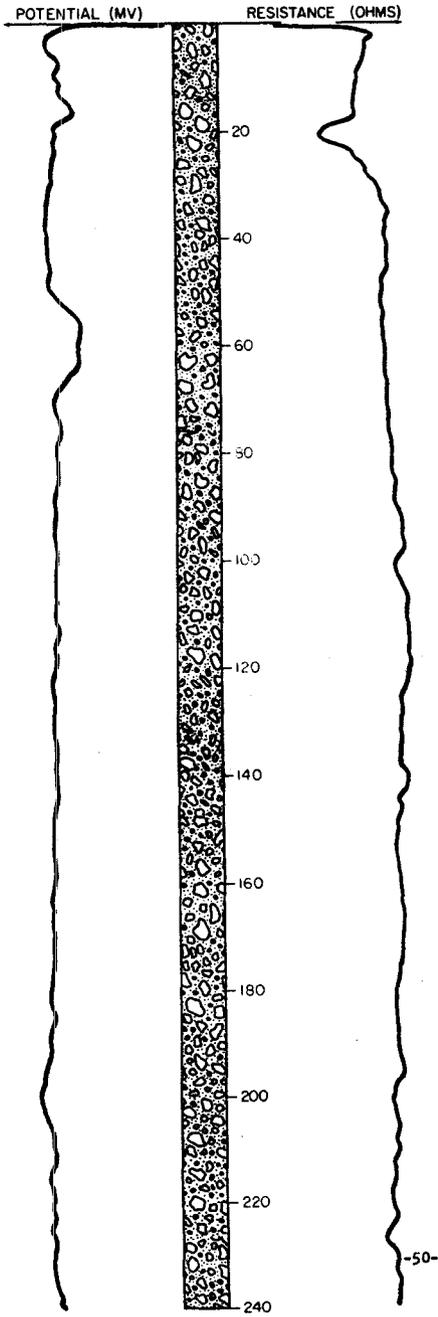
TEST HOLE 5749

LOCATION: 143-70-10ddd

DATE DRILLED: August 4, 1970

ELEVATION:
(FT, MSL)

DEPTH: 580
(FT)



DESCRIPTION OF DEPOSITS

Glacial Drift

- 0-1 Topsoil, silty, clayey, sandy, brownish-black.
- 1-51 Clay, silty, moderately sandy, pebbly, a few cobbles, moderate yellowish-brown, oxidized (till).
- 51-360 Clay, silty, slightly sandy, pebbly, a few cobbles, olive gray, losing circulation to surface cracks and crevasses, mixed 200 lbs. bentonite (till).

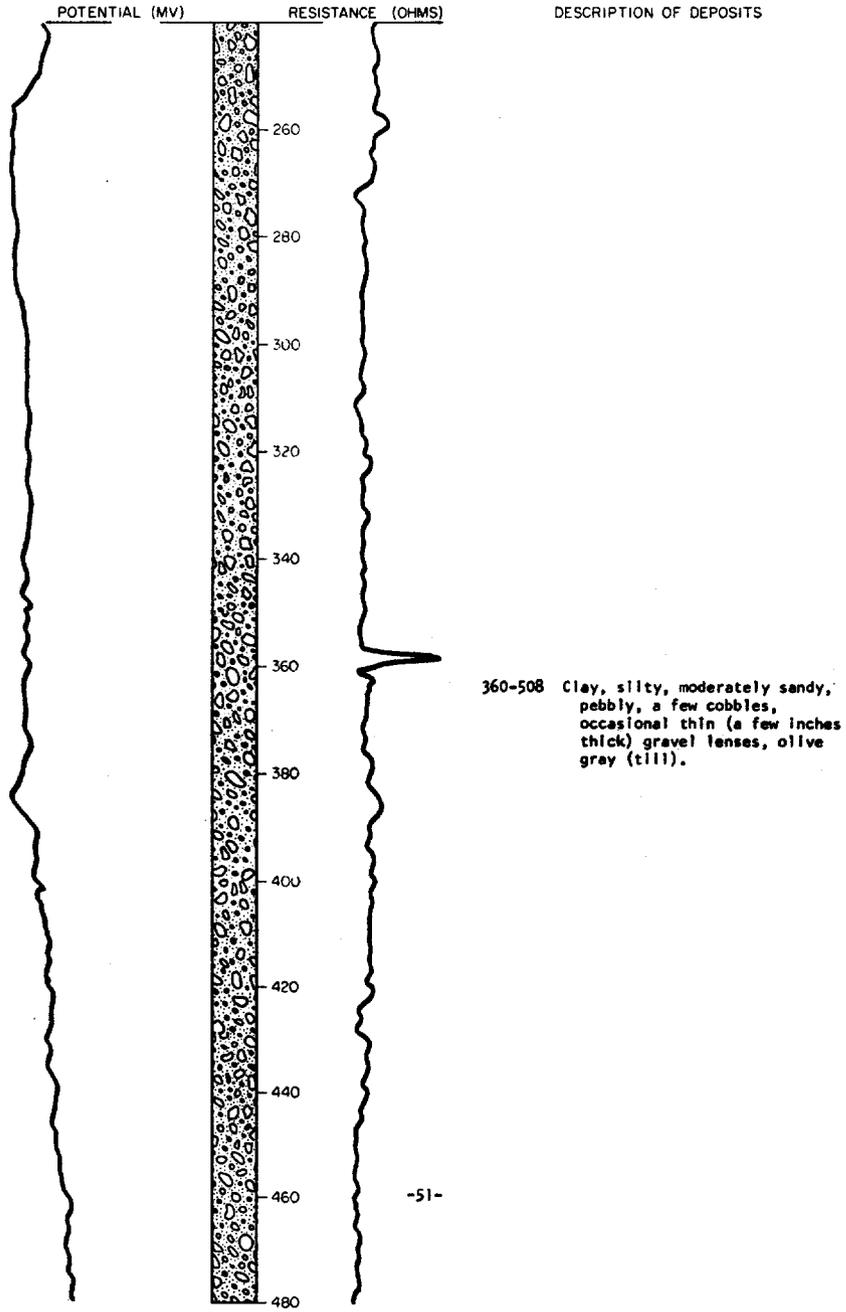
TEST HOLE 5749 Continued

LOCATION: 143-70-10ddd

DATE DRILLED: August 4, 1970

ELEVATION:
(FT, MSL)

DEPTH: 580
(FT)



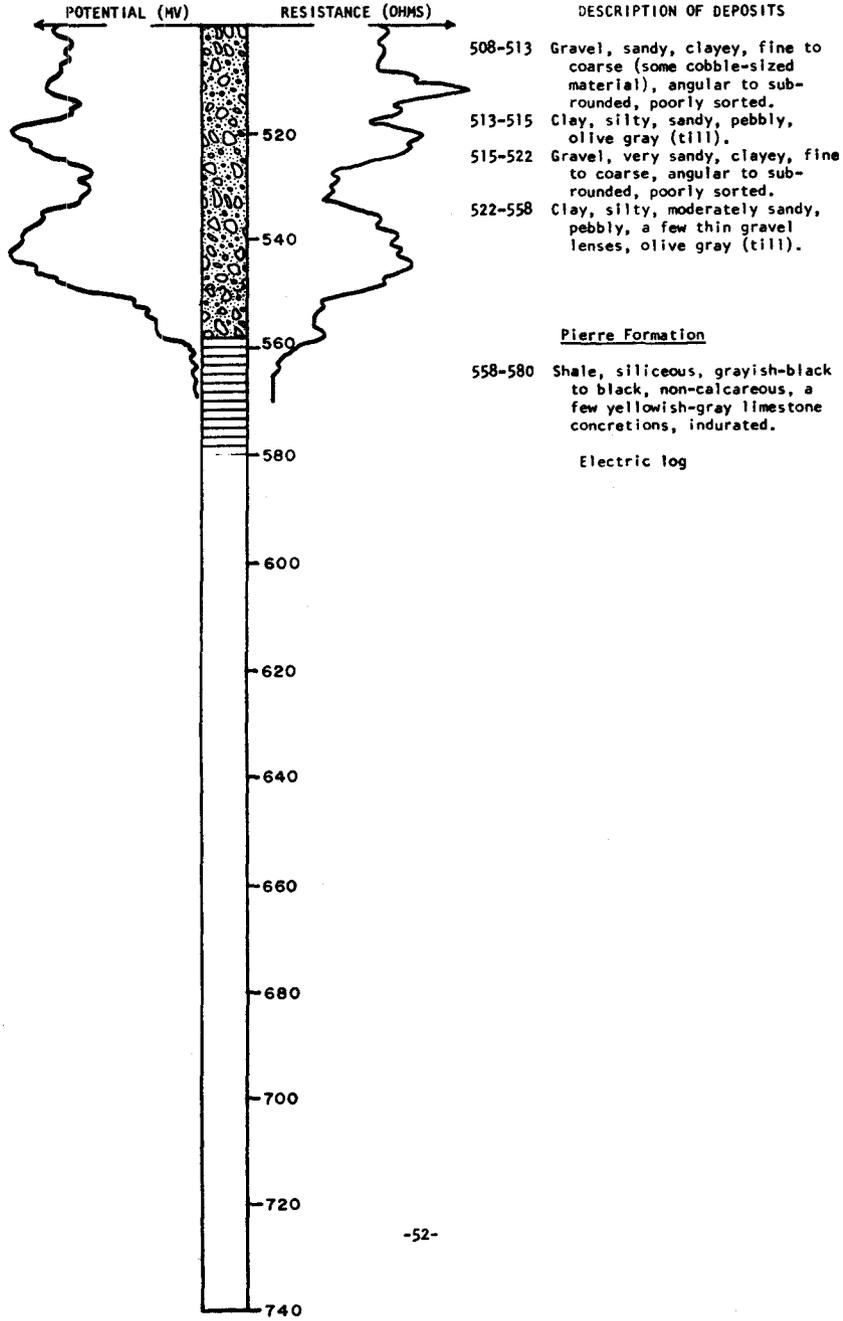
TEST HOLE 5749 Continued

LOCATION: 143-70-10ddd

DATE DRILLED: August 4, 1970

ELEVATION:
(FT, MSL)

DEPTH: 580
(FT)



<u>Geologic source</u>	<u>Material</u>	<u>Thickness (feet)</u>	<u>Depth (feet)</u>
Glacial Drift:			
	Topsoil, sandy, pebbly, cobbles, boulders, brown -----	½	½
	Gravel, very sandy, silty, clayey, fine to coarse (some cobble-sized material), angular to subrounded, fair sorting, well oxidized, taking water, caving slightly, mixed 150 lbs. bentonite -----	19½	20
	Clay, silty, moderately sandy, pebbly, a few cobbles and boulders, olive gray (till) -----	21	41
	Clay, very silty, moderately sandy, olive gray, occasional detrital lignite fragments (glaciofluvial sediment) -----	77	118
	Clay, silty, slightly sandy, pebbly, a few cobbles and boulders, olive gray (till) -----	21	139
	Sand, fine-to very coarse-grained, angular to subrounded, moderately well-sorted -----	7	146
	Clay, silty, sandy, pebbly, a few sand lenses, olive gray (till) ---	9	155
	Sand, silty, clayey, fine-to medium-grained, moderately well-sorted, subangular to rounded -----	3	158
	Clay, silty, moderately sandy to sandy, pebbly, a few cobbles, olive gray -----	22	180
	Sand, very silty, interbedded with clay lenses, fine-to very coarse-grained, subangular to rounded, moderately well-sorted -----	51	231
	Clay, very silty, slightly sandy, occasional thin sand lenses from 231-245 feet, medium gray (glaciolacustrine sediment) -----	47	278
	Clay, silty, slightly sandy, pebbly, occasional cobbles and boulders, olive gray (till) -----	22	320
Pierre Formation:			
	Shale, siliceous, grayish-black to black, moderately indurated, non-calcareous -----	20	340

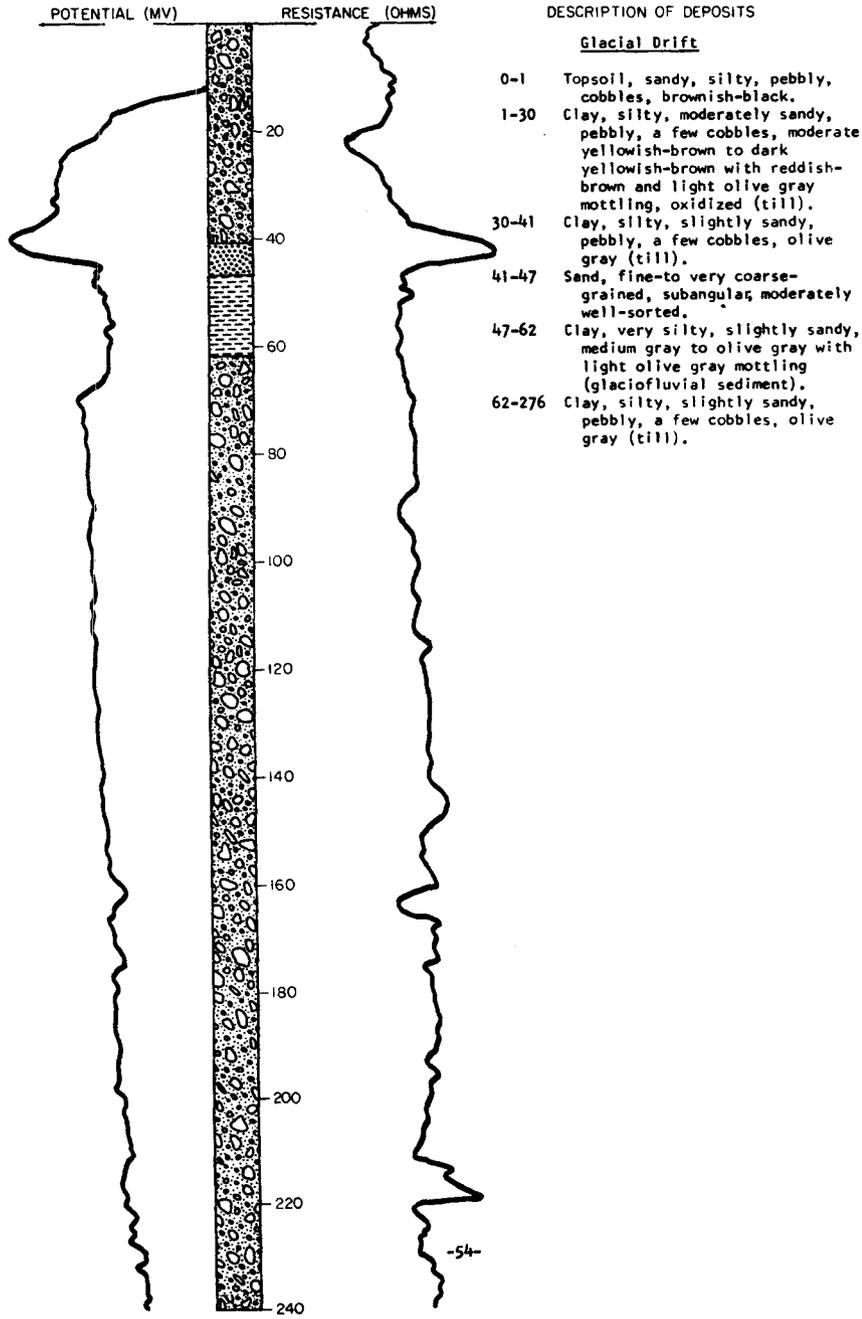
TEST HOLE 5751

LOCATION: 144-70-26ccc

DATE DRILLED: August 11, 1970

ELEVATION:
(FT, MSL)

DEPTH: 680
(FT)



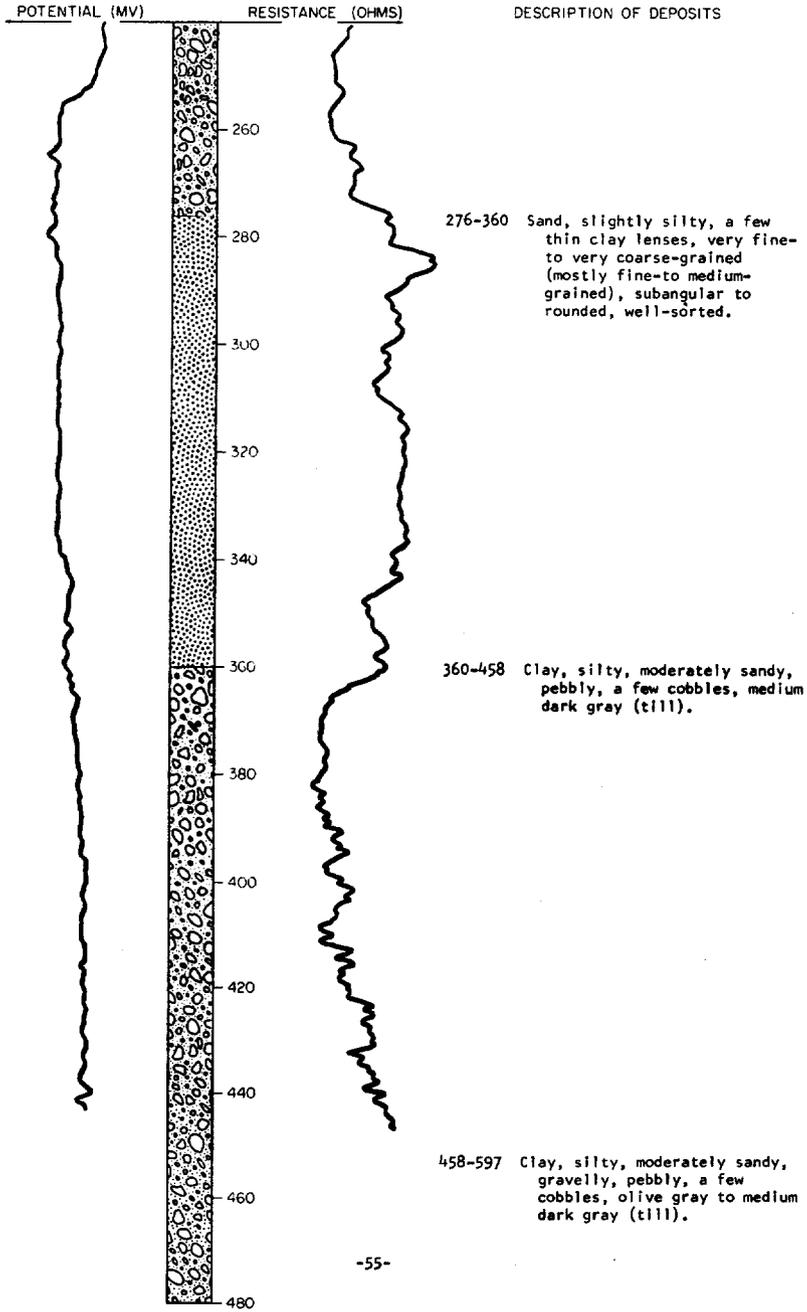
TEST HOLE 5751 Continued

LOCATION: 144-70-26ccc

DATE DRILLED: August 11, 1970

ELEVATION:
(FT, MSL)

DEPTH: 680
(FT)



TEST HOLE 5751 Continued

LOCATION: 144-70-26ccc

DATE DRILLED: August 11, 1970

ELEVATION:
(FT, MSL)

DEPTH: 680
(FT)

