THE WATER SUPPLY AT MOUND CITY, CAMPBELL COUNTY, SO. DAK.

BY

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CONTENTS

ILLUSTRATIONS

FIGURE

TABLE

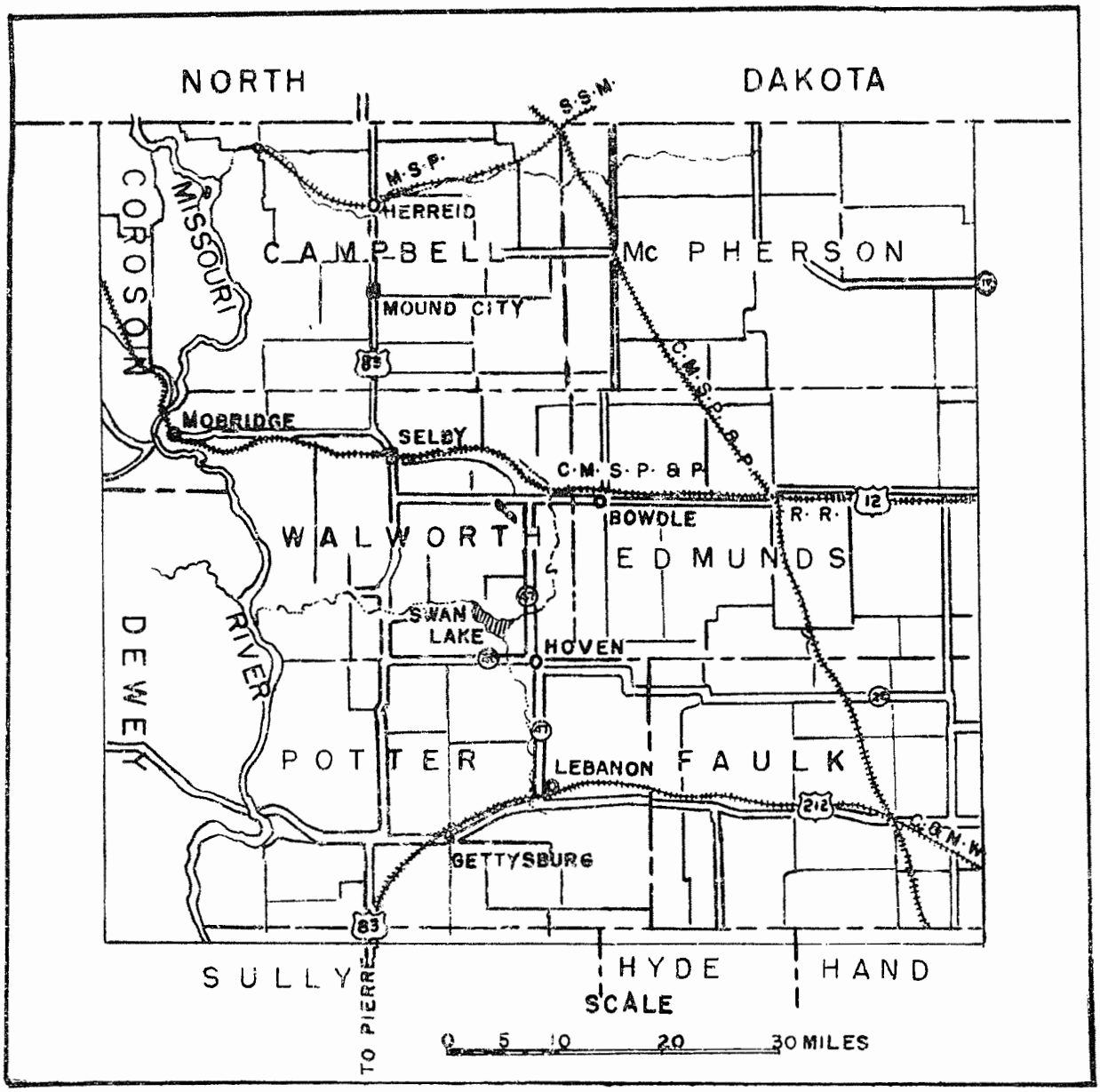


FIG. 1 INDEX MAP

THE WATER SUPPLY AT MOUND CITY, SOUTH DAKOTA

K. Y. Lee

INTRODUCTION

Mound City (Fig. 1, Index Map) is the county seat of Campbell County. It has a population of about one hundred and twenty and is situated near the center of the county. It lies one hundred and seven miles from the State capitol, Pierre, and thirty-one miles northeast of Mobridge. U. S. Highway 83 passes through the center of the city.

With the increase in population, a problem has arisen because of the installation of a sewage disposal plant which requires more water for its operation than the city has been able to furnish.

The Geological Survey was approached with a request for assistance in determining the amount of water that could be developed near the city. At the request of the city officials, therefore, the writer was dispatched by the State Geologist to make an investigation of the situation.

During the last part of August, 1956, more than three days were spent at Mound City carrying out the investigation. Following the suggestion of city board members, eleven sites for electric soundings were selected. A Carl A. Bays and Associates' Earth Resistivity Instrument ER-7 (1953 Model) was used to determine the apparent resistances of subsurface sediments. On the basis of these electric soundings, two sites for test holes were tentatively located, and subsequent drilling tests were carried out by a professional driller.

Samples were taken from the test holes at five feet intervals, and mechanical analyses to obtain textural data were made at the laboratory of the State Geological Survey.

GEOLOGY

Geologic environment plays a major role in controlling the supply of groundwater. In the vicinity and at the site of Mound City, the Wisconsin glacial drift is spread over an eroded surface of Pierre shale. On the basis of physical characters two substages of this drift, Iowan and Late Cary, were tentatively defined (Fig. 2).

Iowan Drift: This drift consists of "boulder clay" and

STRATIFIED SAND AND GRAVEL. IT OCCURS AT THE WESTERN PORTION OF MOUND CITY. THE "BOULDER CLAY" IS GENERALLY MEDIUM GRAY ON THE WEATHERED SURFACE, AND BLACKISH GRAY SOMEWHAT OLIVINE-GREEN AND GRAYISH BUFF, WHEN IT IS MOIST. A ONE FOOT LEACHED ZONE OCCURS AT THE TOP OF THIS TILL. STRATIFIED DRIFT COMPOSED OF SAND AND GRAVEL IS CONTEMPORANEOUS WITH THE "BOULDER CLAY", AND OCCURS AT DIFFERENT DEPTHS RANGING FROM 25 FEET TO 45 FEET.

SCATTERED COARSE SAND AND GRAVEL, TYPICAL OUTWASH PRODUCTS OF IOWAN DRIFT, APPEAR AS SMALL APRON-SHAPED FANS, AND ARE EXPOSED ONLY NEAR THE NORTHWESTERN PART OF THE CITY OUTSIDE THE CITY LIMITS

LATE CARY DRIFT: AT MOUND CITY THIS DRIFT IS MADE OF OUTWASH PRODUCTS, SAND AND GRAVEL. THE OUTWASH (FIG. 2, AND APPENDIX: TEST HOLES 1 AND 2) OCCURS AT THE EASTERN PART OF THE CITY, AND CONSISTS CHIEFLY OF FINE-, MEDIUM- TO COARSE-GRAINED SANDS, AND SOME GRAVULES OF ROUNDED PIERRE SHALE FRAGMENTS. BLUISH GRAY CLAY WITH SOME PEBBLES AND GRANULES ARE PRESENT AT A DEPTH RANGING FROM TWENTY FEET TO TWENTY-FIVE FEET IN TEST HOLE NUMBER ONE. OBVIOUSLY THESE MATERIALS WERE DERIVED FROM THE IOWAN DRIFT TO THE WEST, AND WERE CARRIED DOWN BY LATE CARY MELT WATER. THIS LAYER GRADUALLY THINS OUT EASTWARD WITHIN A DISTANCE OF ABOUT FIVE HUNDRED FEET, AS WAS PROVED BY TEST HOLE NUMBER TWO.

DISCUSSION OF SEDIMENTARY ENVIRONMENTS OF LATE CARY OUTWASH: IN ORDER TO GET THE GENERAL PICTURE OF THE RELATIONSHIP BETWEEN THE TEXTURAL PROPERTIES OF LATE CARY OUTWASH AND ITS STORAGE CAPACITY FOR GROUNDWATER, TEXTURAL PROPERTIES OF THE OUTWASH WERE DETERMINED BY MECHANICAL ANALYSES (TABLES 1 AND 2) ON THE BASIS OF WENTWORTH'S GRADE SCALE, FROM WHICH THE SEDIMENTARY ENVIRONMENTS ARE TENTATIVELY DEDUCED.

DURING THE PERIOD OF LATE CARY TIME, OUTWASH MATERIALS WERE CARRIED BY THE MELT WATER DOWN TO A VALLEY, WHICH TRENDED NEARLY DUE NORTH-SOUTH, AND DRAINED IN A NORTHWEST DIRECTION. TEXTURAL DATA SHOW THESE SANDS WERE FORMED UNDER A SERIES OF DIFFERENT CONDITIONS, WHICH HEREWITH ARE DEFINED CHIEFLY ON THE PRINCIPAL GEOLOGICAL AGENT RESPONSIBLE FOR THE DEPOSITION OF THE SEDIMENT. GENERALLY THE SIZE COMPOSITION OF A SEDIMENT IS CONTROLLED BY THE CONDITIONS PREVAILING DURING DEPOSITION OF THE SEDIMENT.

IN CONNECTION WITH THE SIZE COMPOSITION OF A SEDIMENT THREE CHIEF PARAMETERS ON THE TEXTURAL STUDY, NAMELY MEAN, QUARTILES, AND COEFFICIENT OF SORTING SHOULD BE MENTIONED AS BELOW. MEAN IS THE MEDIAN DIAMETER OF CLASTIC SEDIMENTS, AND IS CONTROLLED BY THE STRENGTH OF THE CURRENT THAT MOVED THE MATERIAL TO THE SITE OF DEPOSITION. THE QUARTILES REPRESENT THE GRAINS ONE-FOURTH AND THREE-FOURTHS OF THE WAY ALONG THE RANGE OF A CUMULATIVE CURVE,

TABLE 1

TEXTURAL DATA ON GLACIAL OUTWASH FROM THE TEST HOLE 1, MOUND CITY, CAMPBELL CO.

SAMPLE NO.	DEPTH (FEET)	MECHANICAL ANALYSIS* (DIAMETER IN MM)							TOTAL WEIGHT	TEXTURAL PARAMETERS			
		4-2	2-1	1-1/2	1/2-1/4	1/4-1/8	1/8-1/16	1/16-	%	Q1	M	Q3	SO
1	3-5	0.006	1.04	10.55	68.42	19.69	0.22	0.04	99.96	0.480	0.390	0.280	1.414
2	5-10		0.47	7.78	83.34	8.27	0.11	0.004	99.97	0.500	0.460	0.360	1.000
3	25-30		0.006	0.24	7.84	89.10	2.74	0.05	99.97	0.245	0.230	0.190	1.000
4	30-35	0.33	0.10	0.24	12.11	81.77	4.45	0.84	99.84	0.250	0.245	0.190	1.000
5	35-40	0.02	0.11	0.26	9.53	77.46	11.41	1.17	99.96	0.240	0.205	0.155	1.414
6	40-45		0.01	0.02	6.07	85.53	8.11	0.22	99.96	0.245	0.220	0.170	1.000
7	45-50			0.12	17.53	75.70	6.44	0.18	99.97	0.250	0.235	0.185	1.000
8	50-55			0.66	40.46	55.24	3.34	0.27	99.97	0.315	0.255	0.195	1.414
9	55-60		0.06	1.49	60.63	34.36	2.99	0.44	99.97	0.420	0.315	0.210	1.414
10	60-65		0.10	0.62	31.98	62.68	4.51	0.07	99.96	0.280	0.225	0.175	1.414
11	65-70		0.19	4.51	77.14	16.99	0.96	0.19	99.98	0.485	0.420	0.280	1.414
12	70-75	0.13	0.26	18.25	79.92	1.22	0.10	0.09	99.97	0.500	0.450	0.365	1.414
13	75-80	0.21	1.13	27.98	63.36	6.28	0.78	0.22	99.96	0.540	0.435	0.340	1.414
14	80-85	1.33	4.82	53.39	35.36	4.58	0.37	0.11	99.96	0.840	0.600	0.400	1.414
15	85-90	0.16	10.47	77.71	10.14	1.27	0.16	0.05	99.96	0.980	0.880	0.660	1.000
16	90-95	0.94	33.99	59.59	4.48	0.76	0.15	0.06	99.97	1.150	0.945	0.740	1.414

* WENTWORTH'S GRADE LIMITS

M MEDIAN DIAMETER

Q1 1ST QUARTILE (25%)

Q3 3RD QUARTILE (75%)

$SO = \sqrt{Q1/Q3}$ SORTING COEFFICIENT

TABLE 2

TEXTURAL DATA ON GLACIAL OUTWASH FROM THE TEST HOLE 2, MOUND CITY, CAMPBELL CO.

SAMPLE NO.	DEPTH (FEET)	MECHANICAL ANALYSIS* (DIAMETER IN MM)							TOTAL WEIGHT %	TEXTURAL PARAMETERS			
		4-2	2-1	1-1/2	1/2-1/4	1/4-1/8	1/8-1/16	1/16-		Q1	M	Q3	SO
101	2.5-5		0.08	2.01	47.30	42.40	7.37	0.83	99.99	0.330	0.250	0.200	1.414
102	5-10	0.74	10.11	26.73	46.23	14.28	1.30	0.46	99.85	0.640	0.455	0.300	1.414
103	10-15	0.09	0.33	4.42	58.40	33.12	3.13	0.47	99.96	0.430	0.320	0.210	1.414
104	15-20	0.08	1.06	19.70	65.36	13.07	0.53	0.17	99.97	0.500	0.455	0.330	1.414
105	20-25	0.57	6.25	59.66	28.11	4.79	0.36	0.21	99.95	0.880	0.670	0.450	1.414
106	25-30	1.74	16.25	63.34	13.07	4.90	0.54	0.14	99.98	0.985	0.840	0.580	1.414
107	30-35	1.57	17.50	64.95	11.09	4.36	0.40	0.09	99.96	0.985	0.840	0.605	1.414
108	35-40	3.81	30.99	46.43	11.56	6.17	0.77	0.24	100.00	1.200	0.880	0.590	1.414
109	40-45	0.48	9.43	48.37	21.59	18.09	1.77	0.24	99.97	0.885	0.605	0.310	1.732
110	45-50	1.44	20.20	34.52	20.52	19.45	3.50	0.31	99.94	0.950	0.600	0.275	1.732
111	50-55	0.55	10.71	27.42	32.83	25.27	2.95	0.23	99.96	0.680	0.410	0.230	1.732
112	60-65	1.37	5.52	16.41	46.47	28.34	1.78	0.09	99.98	0.485	0.320	0.230	1.412
113	65-70	0.15	7.50	33.91	31.99	22.77	3.52	0.10	99.94	0.660	0.430	0.240	1.732
114	70-75	0.12	5.65	26.35	32.75	30.40	4.50	0.21	99.98	0.580	0.330	0.210	1.732
115	75-80		0.86	11.04	35.62	44.88	7.25	0.32	99.97	0.355	0.250	0.185	1.414
116	85-90	0.12	6.20	50.77	35.68	6.91	0.28	0.01	99.97	0.730	0.525	0.400	1.414
117	95-100	0.29	2.31	12.23	54.27	28.81	1.92	0.13	99.96	0.450	0.300	0.240	1.414
118	105-110	1.95	23.34	43.92	25.64	4.79	0.25	0.07	99.96	1.000	0.620	0.460	1.414
119	115-120	9.98	41.91	28.40	15.36	4.09	0.19	0.02	99.95	1.400	1.000	0.620	1.414

* WENTWORTH'S GRADE LIMITS

$SO \sqrt{Q1/Q3}$ SORTING COEFFICIENT

Q1 1ST QUARTILE (25%)

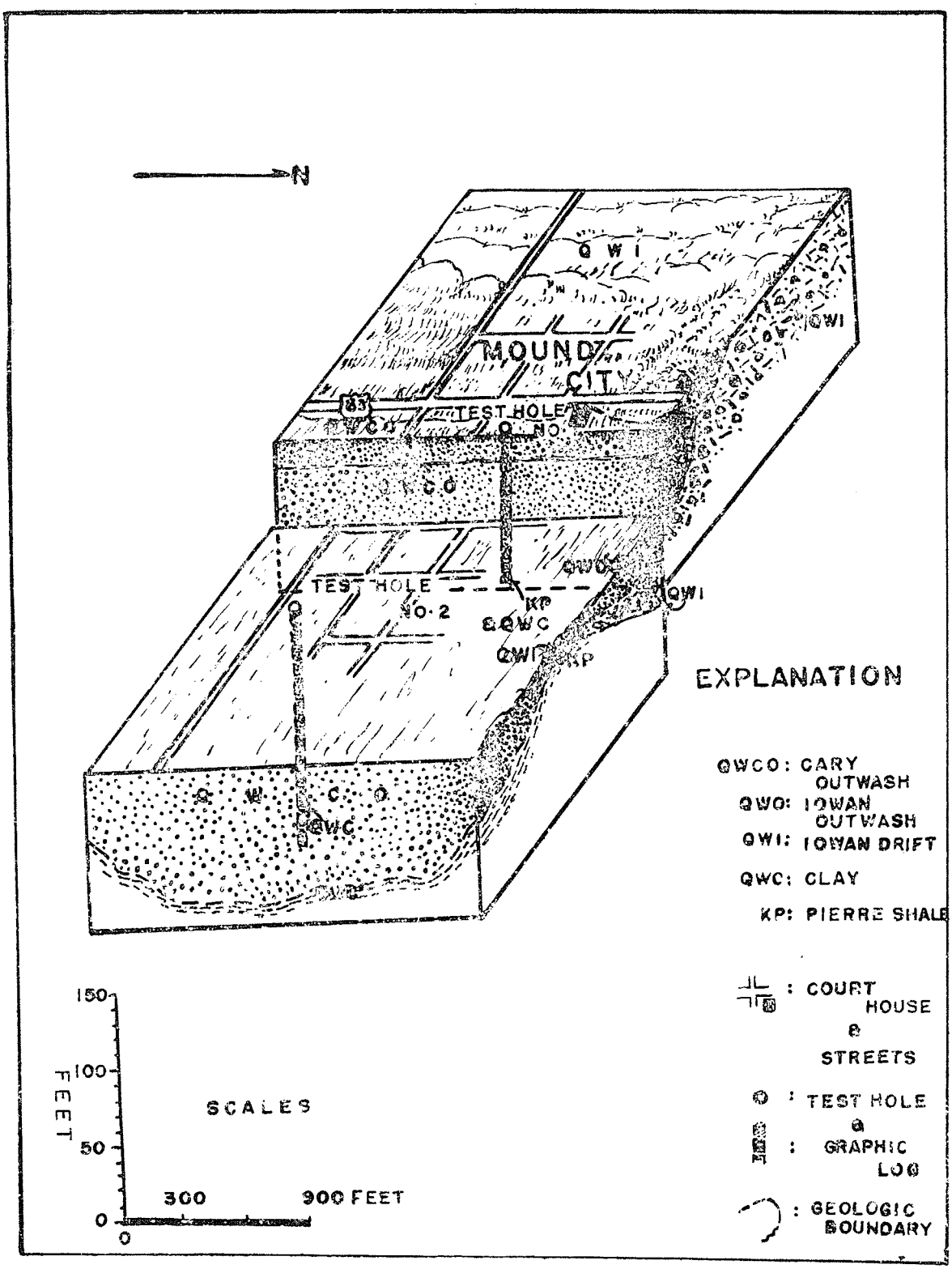
Q3 3RD QUARTILE (75%)

WHICH IS CONSTRUCTED ACCORDING TO THE CUMULATIVE WEIGHT PERCENTAGE OF EACH SAMPLE (TABLES 1 AND 2) PLOTTED ON A SEMI-LOGARITHMIC GRAPH. IN FACT, BOTH THE MEDIAN AND QUARTILE ARE READ DIRECTLY FROM THE CUMULATIVE CURVE. THE COEFFICIENT OF SORTING IS DEFINED AS THE SQUARE ROOT OF THE RATIO OF THE ONE-FOURTH QUARTILE TO THE THREE-FOURTHS QUARTILE, WHICH IS OBTAINED GRAPHICALLY FROM THE CUMULATIVE CURVE. GENERALLY SPEAKING THE SORTING COEFFICIENT IS AN INDEX OF THE RANGE OF CONDITIONS PRESENT IN THE TRANSPORTING FLUID, WHICH IS REGARDED AS TO THE RANGE OF VELOCITIES, AND DEGREES OF TURBULENCE, AND TO SOME EXTENT REFLECTS THE DISTANCE OF TRANSPORTATION.

AS SHOWN ON TABLES 1 AND 2, SANDS ARE CLASSIFIED AS COARSE-GRAINED NEAR THE BASAL PART OF THE TEST HOLE NUMBER ONE AT THE DEPTHS RANGING FROM EIGHTY FEET TO NINETY-FIVE FEET, THE VALUES OF MEDIAN DIAMETER RANGE FROM 0.600 MM TO 0.945 MM. IN TEST HOLE NUMBER TWO, SANDS DEFINED AS COARSE-GRAINED SHOW THE VALUES OF MEDIAN DIAMETER RANGING FROM 0.600 MM TO 0.880 MM BETWEEN THE DEPTH INTERVAL FROM TWENTY FEET TO FIFTY FEET, AND ALSO INDICATE THE VALUES OF MEDIAN DIAMETER RANGING FROM 0.62 MM TO 1.00 MM IN THE DEPTH INTERVAL BETWEEN ONE HUNDRED FIVE FEET AND ONE HUNDRED TWENTY FEET. SANDS SHOWN ON THE TWO TABLES HAVE VALUES OF MEDIAN DIAMETER RANGING FROM 0.205 MM TO 0.460 MM, AND ARE CLASSIFIED AS FINE- TO MEDIUM-GRAINED. THESE DATA CLEARLY INDICATE THE STRENGTH OF CURRENT MOVING THE COARSE-GRAINED SANDS WAS COMPARATIVELY STRONGER THAN THAT OF THE CURRENT MOVING THE FINE- TO MEDIUM-GRAINED SANDS. THE SEDIMENTARY ENVIRONMENTS ARE THEREFORE PRESUMED TO HAVE STARTED WITH GLACIAL CONDITIONS, THEN TRANSITIONAL GLACIAL AND ALLUVIAL CONDITIONS MIGHT HAVE BEEN PRESENT. GRADUALLY THE FOREGOING CONDITIONS CHANGED INTO THE ALTERNATING CONDITIONS OF LAGOONAL AND LITTORAL TYPES, WHICH ARE CLEARLY SHOWN IN THE UPPER PART OF THE OUTWASH (APPENDIX TEST HOLES 1 AND 2; TABLES 1 AND 2). AS A WHOLE, THE VALUES OF THE SORTING COEFFICIENT OF THE OUTWASH RANGE FROM 1 TO 1.732, AND INDICATE THAT THE OUTWASH IS VERY WELL-SORTED; IN OTHER WORDS THE TRANSPORTING AGENTS GENERALLY HAD A COMPARATIVELY LOW VELOCITY, AND A RATHER STREAMLINED CURRENT, WHICH CARRIED THESE MATERIALS MORE THAN FIVE MILES FROM THE EAST. IN SHORT, THE CHANGES OF SEDIMENTARY ENVIRONMENT WERE PROBABLY MAINLY CONTROLLED BY THE CHANGES OF ENERGY OF THE TRANSPORTING MEDIUM.

SHALLOW WATER

AT MOUND CITY, THE AMOUNT, CAPACITY AND MOVEMENT OF SHALLOW WATER MAINLY DEPEND ON THE MEAN VALUES OF THE ANNUAL PRECIPITATION, THE CHARACTER OF THE WISCONSIN DRIFT, AND THE TOPOGRAPHY OF BOTH THE DRIFT SURFACE AND THE BOTTOM OF THE RESERVOIR. OF THESE THE TOPOGRAPHIC CONDITIONS OF BOTH THE DRIFT SURFACE AND THE BOTTOM



FIG·2 BLOCK DIAGRAMS SHOWING THE STRATIGRAPHIC RELATION OF SUBSURFACE SEDIMENTS AT MOUND CITY, CAMPBELL CO.

OF THE RESERVOIR ARE CONSIDERED AS THE CHIEF FACTORS IN CONTROLLING THE WATER SUPPLY.

THE TOPOGRAPHY OF BOTH THE DRIFT SURFACE AND BOTTOM OF THE RESERVOIR: THE LAND FORMS OF BOTH THE DRIFT AND OUTWASH BOTTOM SURFACES GENERALLY INFLUENCE THE FLOWAGE OF GROUND WATER, AND THE SHAPE OF WATER TABLE COMMONLY CONFORMS THE REGIONAL SURFACE TOPOGRAPHY. THE PRESENT SURFACE SLOPE IS ABOUT 25 DEGREES PER MILE. ALTHOUGH THE MANTLE ROCKS CONSIST OF UNCONSOLIDATED WISCONSIN DRIFT, A CONSIDERABLE AMOUNT OF ANNUAL PRECIPITATION MIGHT BE CARRIED AWAY AS RUN OFF, AND EVENTUALLY IS LOST TO CREEKS. DRILLING SHOWS THAT THE OUTWASH BOTTOM CONFIGURATION IS COMPARATIVELY MORE RUGGED. AS SHOWN BY TEST HOLE NUMBER ONE THE THICKNESS OF SAND IS 95 FEET, WHILE AT TEST HOLE NUMBER TWO THE THICKNESS OF SAND IS 125 FEET. THESE TWO TEST HOLES ARE ONLY ABOUT SEVEN HUNDRED FEET APART. WITHIN THIS SHORT DISTANCE, THE SHAPE OF THE BOTTOM OF THE RESERVOIR INDICATED BY THE CHANGE IN THICKNESS OF SAND, DROPS THIRTY FEET. THIS STEEP SUBSURFACE SHAPE APPARENTLY FACILITATES RAPID FLOWAGE IN THE SHALLOW WATER BODY, AND THE RUGGED SUBSURFACE CONFIGURATION DIRECTLY INFLUENCES THE SHAPE OF WATER TABLE, WHICH COULD NOT BE PROPERLY PRESENT AT THE SITE OF MOUND CITY.

THE CHARACTER OF THE WISCONSIN DRIFT: THIS REGION THE MANTLE ROCKS CONSIST OF UNCONSOLIDATED WISCONSIN DRIFT. GENERALLY SPEAKING "BOULDER CLAY" OF THE IOWAN DRIFT IS MADE OF A HETEROGENEOUS, UNASSORTED MIXTURE OF PARTICLES OF GREAT VARIETY IN SIZE, AND IS NOT A GOOD MATERIAL FOR WATER STORAGE. THE OUTWASH SAND AND GRAVEL IS COMMONLY CONSIDERED AS A GOOD WATER RESERVOIR. AT MOUND CITY THE LATE CARY OUTWASH CONSISTS OF SAND, AND IS INTERCALATED WITH A BLUISH GRAY CLAY LAYER ALONG THE WESTERN MARGIN OF THE OUTWASH. THE SANDS, AS MENTIONED BEFORE, ARE VERY WELL SORTED AND CONTAIN THE HIGHEST DEGREE OF UNIFORMITY OF PARTICLE SIZE; THEREFORE, THESE SEDIMENTS HAVE A HIGH PERCENTAGE OF POROSITY, AND COULD STORE MORE WATER THAN UNSORTED TILL. IN ADDITION TO THE POROSITY, THE AMOUNT OF SHALLOW WATER WHICH CAN MOVE THROUGH THE SANDS TOWARD A PUMPING WELL IS DIRECTLY INFLUENCED BY THE PERMEABILITY OF THE MATERIAL. THE PERMEABILITY CONTROLS THE RELATIVE EASE OF FLOW OF FLUID, AND IS CONTROLLED BY THE SIZE, SHAPE AND ARRANGEMENT OF THE OPENINGS WITHIN THE SEDIMENT. COARSE GRAVEL GENERALLY HAS LARGER OPENINGS THAN THE FINE- TO MEDIUM-GRAINED SANDS, THUS, THE COARSE GRAVEL AFFORDS EASY PASSAGE FOR FLUID.

AS TO THE TEXTURAL DATA SHOWN ON TABLES 1 AND 2, THE LATE CARY OUTWASH HAS A VERY LOW DEGREE OF PERMEABILITY. THEREFORE, EVEN IF THESE HIGHLY POROUS SANDS WERE COMPLETELY SATURATED WITH WATER, THE DOMESTIC WELLS WILL HAVE A SLOW RECHARGE, AND COULD

BE EASILY PUMPED DRY. HOWEVER AT MOUND CITY WATER COULD NOT BE PROPERLY STORED DUE TO THE STEEP OUTWASH BOTTOM.

DOMESTIC WELLS, DUG NEAR BY TEST HOLE NUMBER ONE, COMMONLY ENCOUNTERED THE BLUISH GRAY CLAY AT AROUND 25 FEET. THIS CLAY ACTS AS AN IMPERMEABLE LAYER IN THE RESERVOIR. SINCE THE WATER TABLE IN THE RESERVOIR IS BELOW THE BOTTOM OF THE SAND IN THE VICINITY OF TEST HOLE NO. 1, SMALL SEEPAGES OF WATER PASS THROUGH THIS SAND WHICH ARE SUFFICIENT TO SUPPLY SMALL WELLS FOR DOMESTIC USE. SUCH SEEPAGE WILL NOT SUPPLY SUFFICIENT WATER FOR A CITY WELL HOWEVER.

THE MEAN VALUES OF ANNUAL PRECIPITATION: DURING THE LAST THREE YEARS THE MEAN VALUES OF ANNUAL PRECIPITATION ISSUED BY THE STATION OF U. S. WEATHER BUREAU AT MOBRIDGE IS 11.74 INCHES. IF ONE INCH OF RAINFALL ON ONE SQUARE MILE OF LAND SURFACE IS EQUIVALENT TO 2,323,000 CUBIC FEET OF WATER OR MORE THAN 50 ACRE-FEET; THEN THE 11.74 INCHES OF PRECIPITATION WOULD BE MORE THAN 587 ACRE-FEET ON ONE SQUARE MILE. AT THE SITE OF MOUND CITY, APPROXIMATE 41 ACRE-FEET OF WATER WOULD BE STORAGED ANNUALLY. IF THE STORAGE CAPACITY IS IN A SUITABLE CONDITION, THIS AMOUNT OF WATER SHOULD BE SUFFICIENT TO FURNISH A WATER SUPPLY FOR THE WHOLE CITY.

SUMMARY

THE WATER SUPPLY AT MOUND CITY IS DIRECTLY INFLUENCED BY THE TOPOGRAPHY OF BOTH THE DRIFT SURFACE AND THE BOTTOM OF THE RESERVOIR; THE MEAN VALUE OF ANNUAL PRECIPITATION, AND THE CHARACTER OF ROCKS ARE THE SUBORDINATE FACTORS. ALTHOUGH THE LATE CARY OUTWASH HAS A HIGH PERCENTAGE OF POROSITY AND GOOD PERMEABILITY, THE ANNUAL PRECIPITATION COULD NOT BE PROPERLY STORED NEAR THE CITY BECAUSE OF THE STEEP SLOPE AND IRREGULAR SHAPE OF THE BOTTOM OF THE OUTWASH.

ON THE BASIS OF TEXTURAL STUDY ON THE TWO TEST HOLES, THE LATE CARY OUTWASH SANDS WERE FORMED THROUGH A SERIES OF DIFFERENT CONDITIONS IN WHICH THE LITTORAL BEACH SANDS ARE CLEARLY INDICATED IN THE UPPER PART, WHILE THE GLACIAL AND FLUVIAL ENVIRONMENTS ARE WELL MARKED IN THE LOWER PART.

AS TO THE LATER DEVELOPMENT OF WATER SUPPLY AT MOUND CITY, IT WOULD BE ADVISABLE TO HAVE TEST HOLES DRILLED OUTSIDE THE SOUTHERN LIMIT OF THE CITY OR WITHIN TWO HUNDRED FEET SOUTH OF THE TEST HOLE NUMBER ONE. ADEQUATE SCREENS SHOULD BE USED IN ANY CITY WELLS DRILLED IN THIS AREA IN ORDER TO ELIMINATE THE FINE SAND SUSPENDED IN THE WATER. THE SIZE OF THESE SCREENS SHOULD BE MADE ACCORDING TO THE TEXTURAL DATA, SHOWN ON TABLES 1 AND 2.

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APPENDIX

Well Logs in Outwash Sediments

Test Hole No. 1*

Location: Section 17
Township 126 North
Range 76 West, Campbell Co.

Elevation: 1718.008 ft.

Land Owner: Mound City

Total Depth: 100 feet

Thickness (feet)	Description
0-3	Soil, loamy and blackish gray
3-5	Sand, chiefly of medium-grained with rounded to subangular quartz grains. Pierre shale granules, and pink potash feldspar are fairly common
5-10	Sand, fine- to medium-grained, consisting chiefly of subangular quartz grains
10-25	No sample. However this interval was observed by the writer to be fine-grained sand intercalated with pebble clay at the depth of 24 feet. The clay layer is about 4.5 feet in thickness, and thins out toward east.
25-30	Sand, fine-grained with rounded to subangular quartz grains. Chert, iron-oxides and carbonates, and Pierre shale fragments are rather abundant
30-35	Sand, same as the sample 25-30
35-40	Sand, fine-grained, consisting chiefly of subangular quartz grains. Rounded Pierre shale fragments are fairly common
40-45	Sand, fine-grained, chiefly with rounded quartz grains. Pierre shale fragments are predominant. Accessory minerals are sporadically present.

* Site of the Resistivity Station #3.

THICKNESS (FEET)	DESCRIPTION
45-50	SAND, FINE-GRAINED, CONSISTING CHIEFLY OF SUBANGULAR QUARTZ GRAINS. PIERRE SHALE FRAGMENTS ARE RATHER ABUNDANT; ACCESSORY MINERALS: PINK POTASH FELDSPAR, HORNBLENDE, BIOTITE, AND IRON-OXIDES AND CARBONATES ARE SPORADIC
50-55	SAND, SAME AS THE SAMPLE 45-50
55-60	SAND, FINE- TO MEDIUM-GRAINED, CONSISTING OF ROUNDED TO SUBANGULAR QUARTZ GRAINS, AND PIERRE SHALE FRAGMENTS. PYRITE, PINK POTASH FELDSPAR AND HORNBLENDE ARE SCATTERED
60-65	SAND, FINE-GRAINED, CONSISTING CHIEFLY OF SUBANGULAR QUARTZ GRAINS, AND PIERRE SHALE FRAGMENTS. PINK POTASH FELDSPAR, IRON-OXIDES AND CARBONATES, BIOTITE, PYRITE, OLIVINE, HORNBLENDE AND SOME SCHIST AND SLATE ARE SUBORDINATE IN APPEARANCE
65-70	SAND, MEDIUM-GRAINED, CONSISTING OF ROUNDED QUARTZ GRAINS AND PIERRE SHALE FRAGMENTS. PINK POTASH FELDSPAR, PYRITE, HORNBLENDE, IRON-OXIDES AND CARBONATES ARE SPORADICALLY PRESENT
70-75	SAND, COARSE- TO MEDIUM-GRAINED, CONSISTING NEARLY OF 55 PERCENT OF ROUNDED TO SUBANGULAR QUARTZ GRAINS, AND 40 PER CENT OF PIERRE SHALE FRAGMENTS. PINK POTASH FELDSPAR, BIOTITE, PYRITE, HORNBLENDE AND FRAGMENTS OF SCHIST AND SLATE ARE RATHER COMMON
75-80	SAND, SAME AS THE SAMPLE 70-75 EXCEPT THE PRESENCE OF SCATTERED CANNEL COAL FRAGMENTS
80-85	SAND, MEDIUM- TO COARSE-GRAINED, CONSISTING OF 50 PERCENT OF ROUNDED TO SUBANGULAR QUARTZ GRAINS, AND 45 PERCENT OF PIERRE SHALE FRAGMENTS. PINK POTASH FELDSPAR, PYRITE, IRON-OXIDES AND CARBONATES, AND COAL ARE FAIRLY COMMON
85-90	SAND, CHIEFLY COARSE-GRAINED. GRANULES OF PIERRE SHALE FRAGMENTS AND SUBANGULAR QUARTZ

THICKNESS (FEET)	DESCRIPTION
	GRAINS ARE THE CHIEF CONSTITUENTS. PINK POTASH FELDSPAR, PYRITE, AND GRANITE ARE RATHER COMMON
90-95	SAND, SAME AS THE SAMPLE 85-90 EXCEPT THE PRESENCE OF RATHER ABUNDANT POTASH FELDSPAR AND GRANITE FRAGMENTS
95-100	CLAY AND PIERRE SHALE, BLUISH MEDIUM GRAY CLAY, WITH SOME ANGULAR, FINE-LAMINATED PIERRE SHALE WHICH IS APPARENTLY UNCONFORMABLY OVERLAIN BY THE CLAY

TEST HOLE No. 2*

LOCATION: SECTION 17
TOWNSHIP 126 NORTH
RANGE 76 WEST, CAMPBELL CO.

ELEVATION: UNKNOWN

LAND OWNER: MOUND CITY

TOTAL DEPTH: 165 FEET

THICKNESS (FEET)	DESCRIPTION
0-2.5	SOIL, LOAMY AND GRAY
2.5-5	SAND, FINE- TO MEDIUM-GRAINED, CONSISTING CHIEFLY OF ROUNDED TO SUBANGULAR QUARTZ GRAINS. PINK POTASH FELDSPAR, IRON-OXIDES AND CARBONATES, BIOTITE ARE FAIRLY COMMON, AND SPORADICALLY WITH SOME ROCK GRANITE AND PIERRE SHALE FRAGMENTS
5-10	SAND, COARSE- TO MEDIUM-GRAINED, MADE OF ROUNDED TO SUBANGULAR QUARTZ GRAINS, AND ROUNDED PIERRE SHALE FRAGMENTS. THE ACCESSORY MINERALS ARE FAIRLY COMMON
10-15	SAND, FINE- TO MEDIUM-GRAINED; ROUNDED TO SUBANGULAR QUARTZ GRAINS AND PIERRE SHALE FRAGMENTS ARE THE CHIEF CONSTITUENTS. PINK POTASH FELDSPAR, HORNBLENDE, AUGITE, OLIVINE, IRON-OXIDES AND CARBONATES, AND PYRITE ARE IN ASSOCIATION WITH GRANITE AND CHERT
15-20	SAND, COARSE- TO MEDIUM-GRAINED, CONSISTING CHIEFLY OF ROUNDED QUARTZ GRAINS. PIERRE SHALE, GRANITE, DIORITIC ROCKS, AND SLATE ARE FAIRLY COMMON; PINK POTASH FELDSPAR, IRON-OXIDES AND CARBONATES, CHERT, HORNBLENDE AND PYRITE ARE SCATTERED THROUGH THE MASS OF QUARTZ GRAINS
20-25	SAND, MEDIUM- TO COARSE-GRAINED WITH ROUNDED TO SUBANGULAR QUARTZ GRAINS AND PIERRE SHALE FRAGMENTS. GRANITE, DIORITIC AND BASALTIC ROCKS, AND SLATE IN ASSOCIATION WITH CANNEL COAL, PINK POTASH FELDSPAR, HORNBLENDE, IRON-OXIDES AND CARBONATES, OLIVINE AND CHERT ARE

* SITE OF THE RESISTIVITY STATION #7.

THICKNESS (FEET)	DESCRIPTION
	SPORADICALLY PRESENT.
25-30	SAND, VERY COARSE- TO COARSE-GRAINED, CONSISTING CHIEFLY OF SUBANGULAR QUARTZ GRAINS, PIERRE SHALE AND GRANITE FRAGMENTS. BASALTIC AND DIORITIC ROCKS AND SLATE, IN ASSOCIATION WITH SOME ACCESSORY MINERALS: PINK POTASH FELDSPAR, HORNBLENDE, GARNET, BIOTITE, IRON-OXIDES AND CARBONATES, AND ROSE QUARTZ ARE SPORADICALLY PRESENT
30-35	SAND, SAME AS THE SAMPLE 25-30 EXCEPT THE PRESENCE OF SOME CANNEL COAL
35-40	SAND, SAME AS THE SAMPLE, 25-30 EXCEPT THE PRESENCE OF SOME ACTINOLITE
40-45	SAND, MEDIUM- TO COARSE-GRAINED, CONSISTING CHIEFLY OF ROUNDED TO SUBANGULAR QUARTZ GRAINS AND PIERRE SHALE FRAGMENTS. BASALTIC AND DIORITIC ROCKS, COAL, SLATE, CHERT AND SANDSTONE IN ASSOCIATION WITH SOME ACCESSORY MINERALS: ROSE QUARTZ, IRON-OXIDES AND CARBONATES, BIOTITES AND POTASH FELDSPAR
45-50	SAND, CHIEFLY COARSE-GRAINED, SOMEWHAT MEDIUM-GRAINED WITH ROUNDED QUARTZ GRAINS AND GRANULES OF PIERRE SHALE; IN ADDITION TO THE FOREGOING ACCESSORY MINERALS EPIDOTE IS PRESENT
50-55	SAND, COARSE- TO MEDIUM-GRAINED CONSISTING CHIEFLY OF SUBANGULAR QUARTZ GRAINS. ACCESSORY MINERALS, MENTIONED IN SAMPLE 40-45 ARE FAIRLY COMMON
55-60	SAND, SAME AS THE SAMPLE 45-50
60-65	SAND, FINE- TO MEDIUM-GRAINED. ROUNDED TO SUBANGULAR QUARTZ GRAINS, PIERRE SHALE, AND SOME GRANITE ARE THE MAIN CONSTITUENTS
65-70	SAND, FINE-, MEDIUM- TO COARSE-GRAINED; WITH A CONSIDERABLE AMOUNT OF PIERRE SHALE AND GRANITE FRAGMENTS. PINK POTASH FELDSPAR, HORNBLENDE, CHERT, PYRITE AND BIOTITE ARE SPORADIC

Thickness (feet)	Description
70-75	Sand, fine- to medium-grained; in addition to the subangular quartz grains, accessory minerals and rock fragments: feldspar, pyrite, hornblende, iron-oxides and carbonates, garnet, tourmaline, biotite, Pierre shale, granite, and amphibolite are subordinate in amount
75-80	Sand, medium- to fine-grained, consisting chiefly of subangular quartz grains and Pierre shale fragments
80-85	Sand, same as the sample 75-80
85-90	Sand, medium- to coarse-grained; subangular quartz grains and rounded Pierre shale fragments are the chief constituents. Pink potash feldspar, hornblende, iron-oxides and carbonates, pyrite, chert, and cannel coal are sporadically present
90-95	Sand, fine- to medium-grained consisting chiefly of subangular quartz grains. Pierre shale granules, pink potash feldspar, iron-oxides and carbonates, and hornblende are fairly common
95-100	Sand, fine- to medium-grained, somewhat coarse-grained and made of rounded to subangular quartz grains. Pierre shale fragments in association with some accessory minerals, mentioned as before are sporadic
100-105	Sand, same as the sample 95-100 except the presence of comparatively more Pierre shale and pink potash feldspar
105-110	Sand, very coarse to coarse-grained, somewhat medium-grained; consisting chiefly of rounded to subangular quartz grains, and Pierre shale fragments. Accessory minerals as mentioned before are present
110-115	Sand as the sample 105-110
115-120	Sand, coarse to very coarse-grained; consisting

Thickness (feet)	Description
	chiefly of rounded Pierre shale, granites, and subangular quartz grains with some sporadic accessory minerals
120-125	Sand same as the sample 115-120
125-130	Clay, medium gray, silty and calcareous
130-135	No sample
135-140	Clay, same as the sample 125-130
140-145	Clay, blackish gray, silty and calcareous
145-165	Clay, same as the sample 140-145 except the presence of Pierre shale probably at the base