STATE OF SOUTH DAKOTA
Ralph Herseth, Governor

STATE GEOLOGICAL SURVEY
Allen F. Agnew, State Geologist

SPECIAL REPORT 8

SHALLOW WATER SUPPLY FOR THE CITY OF CLARK

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SHALLOW WATER SUPPLY FOR THE CITY OF CLARK

INTRODUCTION

On December 2, 1959, the Clark City Council requested the State Geological Survey to advise them on the possibilities of a shallow ground water supply near Clark. In response to this request, the State Geological Survey sent a field party to Clark to conduct a shallow ground water survey from June 15 to July 8, 1960.

The surficial geology within an area of about 36 square miles (fig. 1) was mapped on air photos by the writer, using topographic expression and hand auger borings. Thicknesses of sand and gravel were determined by 16 holes, drilled with the State Geological Survey's jeep-mounted auger drill operated by Jerry Schweigert and Mark McDermott. Plane table traverses were run by LaMont Sorenson and Cleo Christensen of the Geological Survey, with the assistance of Robert Wagner of Clark. Wagner's services were supplied by the city. An inventory of domestic farm and stock wells within the Clark area was made (Appendix B).

The writer profited from the many helpful suggestions of M. J. Tipton, supervisor of the field project. The writer wishes also to thank the residents of the Clark area for their cooperation during the progress of the field work.

PREVIOUS WORK

R. F. Flint (1955) made a reconnaissance study of the glacial deposits of South Dakota east of the Missouri River, in which the Clark area is located.

SURFICIAL GEOLOGY OF THE CLARK AREA

As shown by Figure 1, the surficial geology of the Clark area consists of end moraine, ground moraine, outwash and terrace deposits. End moraine is a ridgelike glacial accumulation of unstratified clay, silt, sand, and gravel that was built along the margin of an ice sheet. Ground moraine is glacial deposits of unstratified clay, silt, sand, and gravel of low relief and is devoid of transverse linear elements. Outwash is stratified silt, sand, and gravel deposited by meltwater, usually in front of end moraines.

The outwash within the Clark area varies in width from 1½ to 4 miles. The northern and southern limits of this outwash lie beyond the northern and southern boundaries of the mapped area. The thickness of sand and gravel within the area of the 16 test holes ranges from 4 to 37 feet, with an average thickness of 22 feet. From the test holes, it has been determined that the thickness of water-saturated sand and gravel ranges from 3 to 28 feet, with an average of 15 feet. The eastern part of the outwash is topographically higher, and does not have a typically flat outwash surface. This problem was not investigated further at this time, because of its more academic nature.

Older levels of outwash materials are represented by bench-like terraces of sand and gravel (Qt) along the western and eastern edges of the outwash area.

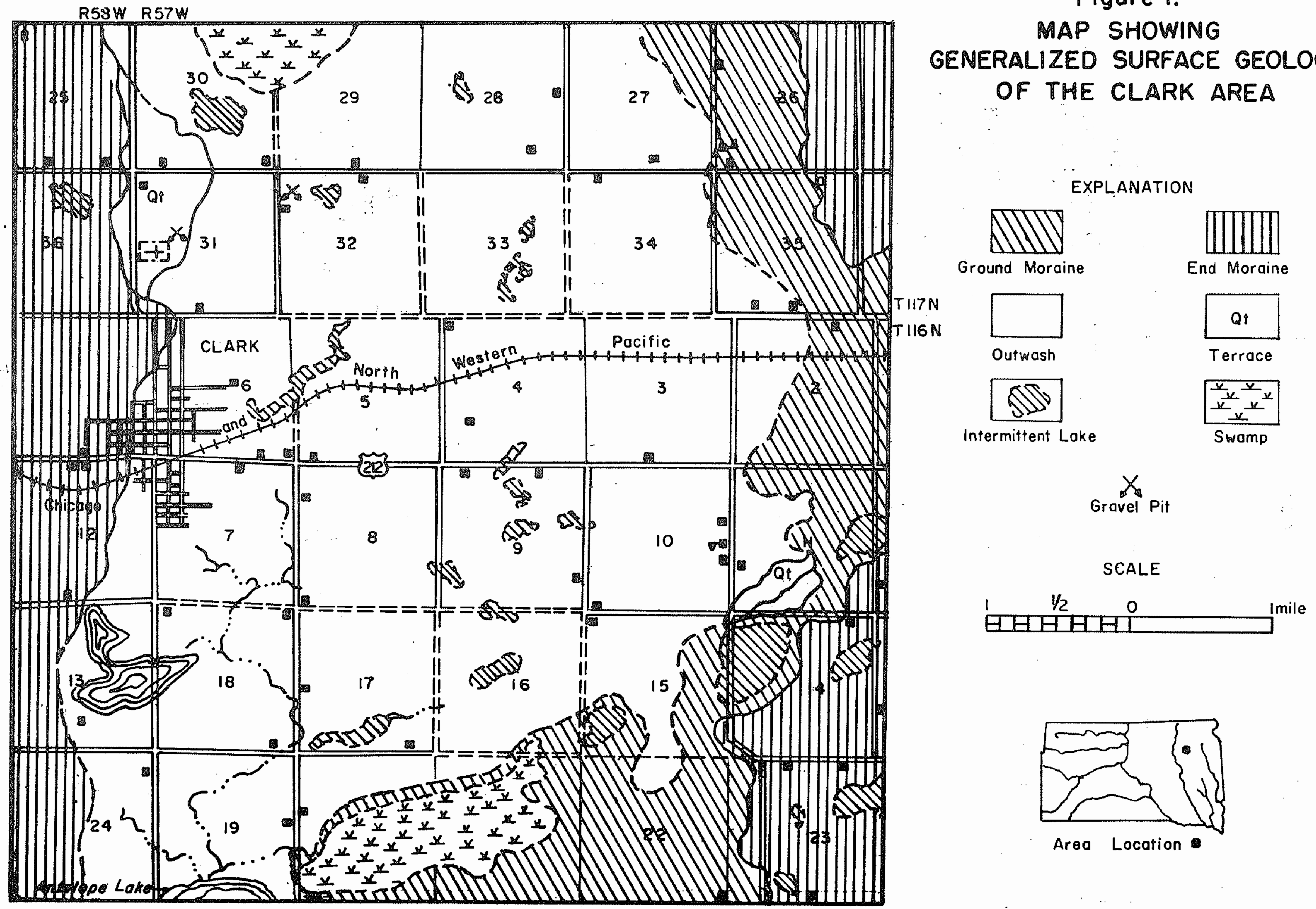

Figure I.
MAP SHOWING
GENERALIZED SURFACE GEOLOGY
OF THE CLARK AREA

GEOLOGY OF GROUND WATER

Ground water may be defined as the water in openings or voids of a rock formation or sediment below the water table; the water table thus marks the upper surface of the main body of ground water. The amount of water held in storage by a reservoir rock, or aquifer, depends on the porosity of the rock. The porosity of a rock is the ratio of the volume of the openings in the rock to the total volume of that rock expressed in percent. Porosity of sedimentary deposits such as the outwash sand and gravel in the Clark area depends on: (1) the shape and arrangement of individual particles, (2) the degree of sorting of the particles, (3) the degree of cementation and compaction of the particles, and (4) the amount of mineral matter precipitated by percolating ground waters.

Unconsolidated deposits of uniform grain size have high porosity regardless of the size of the individual grains. Thus, clays and silts have high porosity, and sands and gravels of uniform grain size have equally high porosity. A deposit of different grain sizes, however, has lower porosity, because the smaller grains occupy the openings between larger grains. This variance of grain size not only reduces the porosity but also the permeability, or the ability of a deposit to transmit a fluid. It is to be expected, therefore, that till offers poor prospects for an adequate city water supply.

Ground water is not confined to "veins" as is thought by some, but is present nearly everywhere. The existence of a supply of ground water is controlled by the behavior of the water table, or upper surface of the zone of saturation. The water table is not a stationary level surface, but an irregular surface which, in a general way, reflects the topography of the land. Daily, monthly, seasonal, and annual fluctuations of the water table are accepted facts. From a study of the water table, information about the depth to water, the direction and rate of flow, and the periodic variations of the depth to water may be obtained Observations of water table fluctuations over a period of years give indications of supply and recharge conditions in an aquifer.

Figure 2 is a map showing lines of equal elevation above sea level on top of the water table. From such a map the general character of the water-bearing deposit can be inferred with a fair degree of accuracy. Close spacing of contour lines indicates low permeability that is due to fine-grained materials, whereas widely spaced contour lines indicate high permeability that is due to coarse-grained materials.

At any moment the level of the water table represents a condition of dynamic equilibrium between the rate of recharge and the rate of discharge of ground water. Recharge is the replenishment of ground water, which is brought about mainly by precipitation in the form of rain and snow. Discharge of ground water refers to the depletion of water by both natural and artificial means such as evaporation and pumping of wells.

AVAILABILITY OF SHALLOW GROUND WATER NEAR CLARK

The most favorable shallow water aquifer near the city of Clark is the outwash deposit of sand and gravel (fig. 1). Clark city wells No. 2

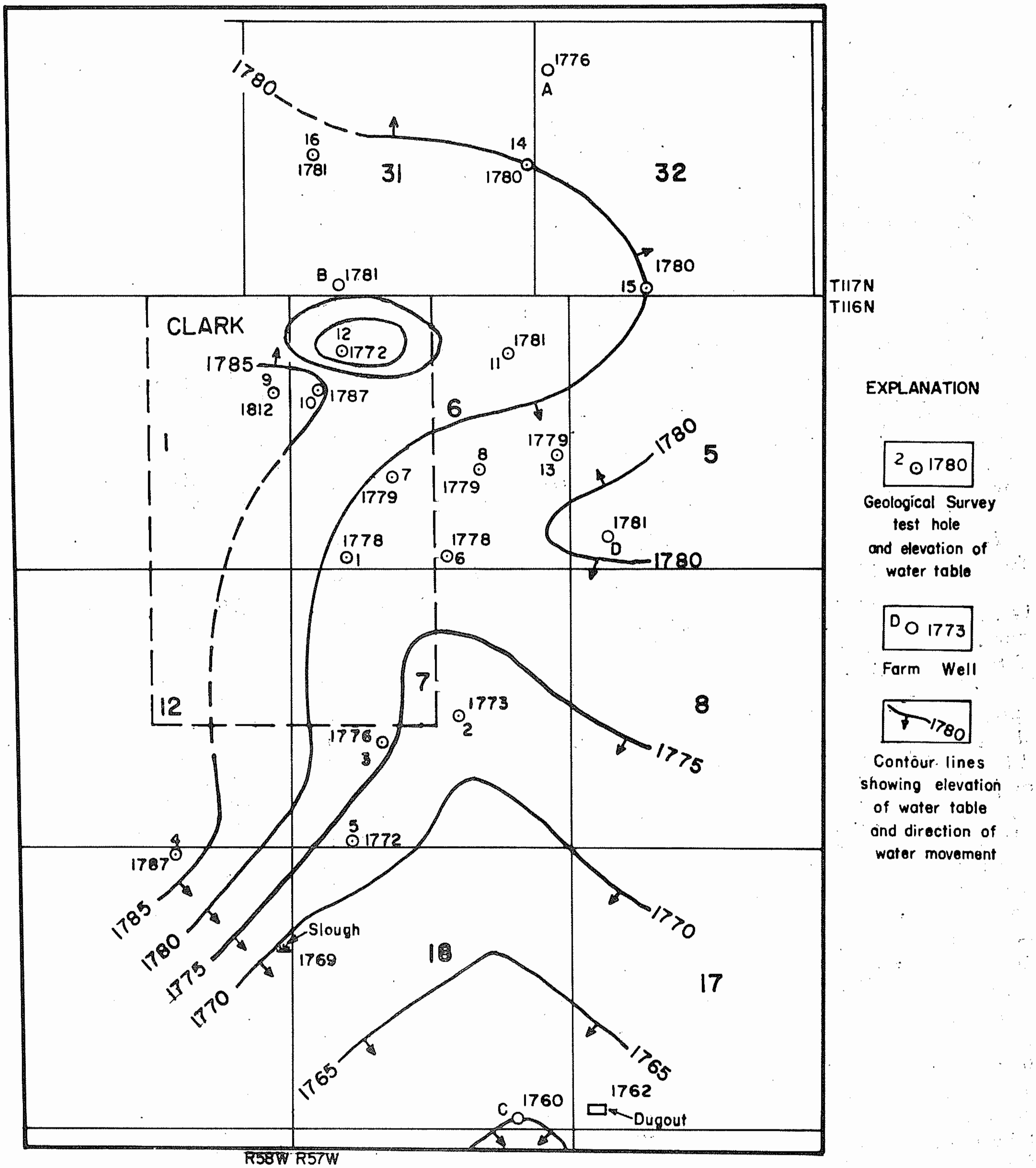

Figure 2 WATER TABLE AND DATA MAP OF THE CLARK AREA

SCALE

1 ½ 0 1 mile

and No. 3 are situated within the outwash. Although Clark city well No. 1 is also geographically located in the outwash, it produces water from a deeper zone, probably the Dakota artesian sandstone. Table 1 summarizes the information available on these three wells.

Table 1.--Data on the Clark City Wells

Well Number	Total Depth (feet)	Well Diameter (inches)	Pumping Capacity (gpm)
1	511	8	250
2	32	30	220
3	31	24	35

The outwash is 1½-4 miles wide; its northern and southern limits lie beyond the boundaries of the area mapped. In and near the city, the outwash was penetrated by 16 test holes, the logs of which are given at the end of this report (Appendix A). On the basis of the test holes, the thickness of sand and gravel within the outwash ranges from 4 to 37 feet, with an average thickness of 22 feet. The thickness of water-saturated sand and gravel in the outwash ranges from 3 to 28 feet, with an average thickness of 15 feet. Measurements in the test holes show that the water table lies 3 to 20 feet below the ground surface, with depths of 6 to 8 feet being common.

In general, medium-grained sand and gravel is present northeast, east, and southeast of the city, and fine-grained sand occurs south of the city. The close spacing of contour lines (fig. 2) south of the city in the NE corner of sec. 13, T. 116 N., R. 58 W., the NW corner of sec. 18, T. 116 N., R. 57 W., and the SW corner of sec. 7, T. 116 N., R. 57 W., indicates an area of low permeability that is due to these fine-grained materials; this conclusion is supported by the log of test hole No. 5 (Appendix A).

The anomalous low near test hole No. 12 (fig. 2) is apparently due to a zone of clay in the interval between 14 and 19 feet deep (see log, Appendix A).

Ground water movement in the outwash is toward the south. Recharge is from precipitation in the form of rain and snow. Discharge is by evaporation and transpiration, by pumping from wells, and by lateral underflow of water in the aquifer.

QUALITY OF WATER

Table 2 gives the analyses of water samples taken from wells in the Clark area. All ground water has some dissolved mineral salts, but the nature and quantity of the chemical salts in solution may vary from area to area, and from formation to formation. Some dissolved elements, such as iron or sulphur, give to water a disagreeable taste or render the water unfit for certain industrial uses. Among the most abundant soluble salts in ground water are compounds of Calcium (Ca), sodium (Na), and magnesium (Mg). In some localities, calcium and magnesium may not be present in amounts large enough to affect the taste of water, but can give it a quality called hardness which affects its domestic and industrial uses. Ground water ordinarily has been filtered through the rocks and sediments for various periods of time, before it is used; it is, therefore, relatively free from harmful bacteria, mud, and other suspended materials, except where modified by local conditions. The degree of hardness in water is usually expressed in parts of dissolved mineral salts per million parts of water, and water containing more than 120 parts per million is considered hard.

Table 2.--Chemical Analyses of Water Samples in the Clark Area*

Sample	Parts Per Million										Hard-ness $CaCO_3$	Total Solids
	Ca	Na	Mg	Cl	SO_4	Fe	Mn	N	F	pH		
A	--	--	150**	250**	250**	0.3**	0.1**	10**	1.0**	--	--	500 to 1000 **
B	44	687	11	201	979	Tr.	0.0	0.9	0.4	--	157	2252
C	134	48	34	45	342	0.0	0.0	0.2	0.0	--	475	872
D	149	15	40	0	141	1.0	0.0	69.5	0.0	--	537	962
E	139	400	69	80	1076	1.1	Tr.	2.2	0.2	--	632	2136
F	124	15	95	4	343	0.8	1.0	1.4	0.0	--	701	798
G	163	97	81	107	487	0.0	0.0	32.5	0.0	--	740	1444

A. U. S. Dept. of Public Health Drinking Water Standards (1960)
B. City Well (500 feet deep)
C. City Park Well (30 feet deep)
D. Guffey Farm, SW¼ sec. 5, T. 116 N., R. 57 W.
E. Geise Farm, NW¼ sec. 18, T. 116 N., R. 57 W.
F. Benson Farm, SW¼ sec. 31, T. 117 N., R. 57 W.
G. Larson Farm, NW¼ sec. 32, T. 117 N., R. 57 W.

* Analyses by State Chemical Laboratory, Vermillion, S. Dak., 1960
** not to exceed

Of the waters analyzed in Table 1, the sample having the best chemical quality is the City Park well (sample C). Water from this well is hard and has a slightly higher sulfate content than is recommended.

All of the other samples must be considered poor quality water, the poorest being samples B, E and G.

Sample D could be considered a good quality water except for the extremely high nitrate content. Sample G is also very high in nitrate. This high nitrate concentration could be harmful to both animals and humans and should be checked immediately by the owners.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the city obtain the services of a commercial well driller licensed by the State of South Dakota to test further the productive capacity of the aquifer in the following areas: (1) the NE1/4 sec. 6, T. 116 N., R. 57 W., (2) the SE1/4 sec. 31, T. 117 N., R. 57 W., and (3) the SW1/4SE1/4 sec. 6, T. 116 N., R. 57 W.

The above locations are recommended for testing because of the coarseness of sand and gravel in the test holes, because of the greater thickness of water-saturated sand and gravel, and because of high permeability displayed on the water table map (fig. 2).

The city should obtain a water permit from the State Water Resources Commission before any final well installation is made. The State Department of Health should be consulted for bacteriological and chemical analysis of the water, and for the requirements of well construction. Finally, it is suggested that the city employ an engineering firm licensed by the State of South Dakota to plan the construction and development of the wells.

REFERENCES CITED

Flint, R. F., 1955, Pleistocene Geology of Eastern South Dakota: U. S. Geol. Survey, Prof. Paper 262.

Hopkins, O. C., and Gullens, Oscar, 1960, New U. S. Public Health Service Standards: Jour. Amer. Water Works Assoc., v. 52, no. 9, p. 1161-8, Sept.

APPENDIX A

LOGS OF GEOLOGICAL SURVEY TEST HOLES IN CLARK AREA

(For map locations, see Figure 2)

G. S. Test Hole No. 1
Surface Elevation: 1784 feet
Depth to water: 6 feet

0- 4	clay, black and brown; some coarse sand
4- 9	clay, brown; medium to coarse sand, damp
9-14	sand, fine, gray, wet
14-19	sand, medium, wet
19-34	sand, medium to coarse, very wet
34-39	clay, blue

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G. S. Test Hole No. 2
Surface Elevation: 1779 feet
Depth to water: 6 feet

0- 4	soil, black; gravel and fine sand
4- 9	sand, fine; light-brown clay
9-14	clay, water
14-19	clay, blue

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G. S. Test Hole No. 3
Surface Elevation: 1791 feet
Depth to water: 15 feet

0- 4	soil, black; gravel and fine sand
4- 9	sand, fine to medium, yellow
9-14	sand, fine to medium, yellow
14-19	sand, fine to medium, dark gray
19-29	sand, fine, gray, very wet
29-39	clay, blue

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G. S. Test Hole No. 4
Surface Elevation: 1793 feet
Depth to water: 6 feet

0- 4	sand, coarse, brown; gravel; light-brown clay
4-14	clay, light brown, very wet
14-19	clay, blue

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G. S. Test Hole No. 5
Surface Elevation: 1780 feet
Depth to water: 8 feet

0- 4	soil, black; medium to coarse brown sand; gravel
4- 9	sandy clay, brown, wet
9-14	sand, very fine, brown, wet
14-19	sand, fine, brown; gray mud
19-24	sand, very fine, gray
24-29	clay, blue

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G. S. Test Hole No. 6
Surface Elevation: 1784 feet
Depth to water: 6 feet

0- 4	soil, black; gravel
4- 9	sand, medium to coarse, gray
9-19	sand, coarse
19-24	sand, medium
24-29	sand, medium; blue clay

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G. S. Test Hole No. 7
Surface Elevation: 1787 feet
Depth to water: 8 feet

0- 4	soil; gravel and sand
4- 9	gravel
9-24	sand, coarse
24-34	clay, blue

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G. S. Test Hole No. 8
Surface Elevation: 1782 feet
Depth to water: 3 feet

0- 4	soil, black; clay and gravel
4-19	sand, coarse; water
19-24	clay, blue

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G. S. Test Hole No. 9
Surface Elevation: 1826 feet
Depth to water: ---

0- 4	gravel
4- 9	gravel and sand
9-19	sand, coarse; gravel
19-24	clay, brown and blue

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G. S. Test Hole No. 10
Surface Elevation: 1799 feet
Depth to water: 12 feet

0- 4	clay, light brown
4- 9	sand, medium to coarse; gravel
9-14	sand, medium to coarse
14-19	gravel
19-24	sand, fine to medium
24-29	sand, fine, wet
29-34	sand, fine; blue clay

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G. S. Test Hole No. 11
Surface Elevation: 1789 feet
Depth to water: 8 feet

0- 4	soil, black; fine sand
4- 9	sand, medium; gravel
9-14	sand, coarse; gravel
14-19	sand, coarse, damp
19-24	sand, coarse, wet
24-29	clay, blue

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G. S. Test Hole No. 12
Surface Elevation: 1792 feet
Depth to water: 20 feet

0- 4	soil, black; gravel
4- 9	sand, coarse; gravel
9-14	gravel
14-19	clay, brown; medium sand
19-29	sand, brown, wet
29-39	sand, fine, gray, very wet
39-44	clay, blue

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G. S. Test Hole No. 13
Surface Elevation: 1789 feet
Depth to water: 10 feet

0- 4	soil, black; fine sand. with clay
4- 9	sand, fine, brown and gray
9-14	sand, fine to medium, very wet
14-19	sand, fine to medium
19-24	clay, blue

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G. S. Test Hole No. 14
Surface Elevation: 1788 feet
Depth to water: 8 feet

0- 4	gravel
4- 9	gravel and coarse sand
9-14	gravel and coarse damp sand
14-19	sand, coarse, wet
19-24	sand, fine, gray, very wet
24-29	clay, blue

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G. S. Test Hole No. 15
Surface Elevation: 1787 feet
Depth to water: 7 feet

0- 4	soil, black; fine to medium sand
4- 9	sand, coarse; gravel
9-14	clay, brown; coarse damp sand
14-19	sand, fine, gray, wet
19-24	sand, fine, brown, wet
24-29	sand, fine, gray; blue clay
29-34	clay, blue

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G. S. Test Hole No. 16
Surface Elevation: 1797 feet
Depth to water: 16 feet

0- 4	soil, brown; gravel
4- 9	gravel; fine sand with clay
9-14	gravel; fine sand with clay
14-24	gravel
24-34	sand, coarse; gravel
34-39	clay, blue

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APPENDIX B

DATA FROM WELLS IN CLARK AREA
July, 1960

Location	Owner or Tenant	Elev. of Surface (feet)	Depth of Well	Geological Source of Water	Depth to Water (feet) July, 1960
SW¼SW¼ sec. 30, T. 117 N., R. 57 W.	Melvin Wika		14	Outwash	11
SE¼SE¼ sec. 30, T. 117 N., R. 57 W.	William Cypher		32	Outwash	
SE¼SE¼ sec. 28, T. 117 N., R. 57 W.	Ralph Ackerman		140	Outwash	80
A (fig. 2)	Milton Larson	1793	22	Outwash	17
B (fig. 2)	Max Bennson	1791	14	Outwash	10
SE¼SE¼ sec. 2, T. 116 N., R. 58 W.	Bob Sutton		130	Till (sand & gravel)	100
NE¼NW¼ sec. 11, T. 116 N., R. 58 W.	Willie Collins		100		25
NE¼NE¼ sec. 10, T. 116 N., R. 58 W.	Alfred Hess		120	Till (sand)	80
NW¼NE¼ sec. 32, T. 117 N., R. 57 W.	Alvin Wika	1787	480	?	225
SW¼NW¼ sec. 26, T. 117 N., R. 57 W.	H. W. Hansen		415	?	215

Appendix B--Data From Wells in Clark Area --Continued

Location	Owner or Tenant	Elev. of Surface (feet)	Depth of Well	Geologic Source of Water	Depth to Water (feet) July, 1960
SW¼SE¼ sec. 27, T. 117 N., R. 57 W.	Carryll Brown		432	?	190
SE¼SW¼ sec. 35, T. 117 N., R. 57 W.	Karl Hendrickson		166	?	100
SW¼SE¼ sec. 35, T. 117 N., R. 57 W.	Earnest Johnson		500	?	?
NW¼NW¼ sec. 9, T. 116 N., R. 57 W.	Nelson Hackett		?	?	9.5
SE¼SW¼ sec. 3, T. 116 N., R. 57 W.	Walter Ick		500	?	?
C (fig. 2)	Fasture Well	1764	?	?	4
NE¼NE¼ sec. 25, T. 116 N., R. 58 W.	Pasture Well	1758	?	?	9
NE¼NE¼ sec. 24, T. 116 N., R. 58 W.	Darrell Warkenthien		450	?	200
NE¼NE¼ sec. 23, T. 116 N., R. 58 W.	Harold Johnson		100	?	40
D (fig. 2)	Vern Guffey	1791	28	Outwash	10