STATE OF SOUTH DAKOTA
Ralph Herseth, Governor

STATE GEOLOGICAL SURVEY
Allen F. Agnew, State Geologist

SPECIAL REPORT 9

SHALLOW WATER SUPPLY FOR THE CITY OF SELBY

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UNIVERSITY OF SOUTH DAKOTA
VERMILLION, SOUTH DAKOTA
DECEMBER, 1960

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SHALLOW WATER SUPPLY FOR THE CITY OF SELBY

INTRODUCTION

On September 21, 1959, the Selby City Council requested the State Geological Survey to advise them on the possibilities of a shallow ground water supply near Selby. In response to this request, the State Geological Survey sent a field party to Selby to conduct a shallow ground water survey from August 1 to August 20, 1960.

The surficial geology within an area of about 32 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 32 holes, drilled with the State Geological Survey's jeep-mounted auger drill operated by Jerry Schweigert and Mark McDermott. A plane table survey was made by the writer and Gary Pressler of Selby; Pressler's services were supplied by the city. An inventory of domestic farm and stock wells within the Selby 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 Selby 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 Selby area is located.

E. P. Rothrock, former State Geologist, made a reconnaissance ground water survey of the outwash area south of Selby in 1956. The next year, K. Y. Lee investigated the outwash area south of Selby, and with the use of the Bays Resistivity Instrument ER-7 he determined (1957) the thickness of the outwash sand and gravel on the basis of the apparent resistivities.

SURFICIAL GEOLOGY OF THE SELBY AREA

As shown by Figure 1, the surficial geology of the Selby area consists of end moraine, ground moraine, sand dune deposits, and outwash 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. Sand dune deposits are wind-transported and wind-deposited sand. Outwash is stratified silt, sand, and gravel deposited by meltwater usually in front of end moraines.

Two outwash areas are shown on Figure 1. The smaller outwash area south of Selby is here designated as the "Selby outwash south"; the larger outwash area north of Selby is here designated as the "Selby outwash north".

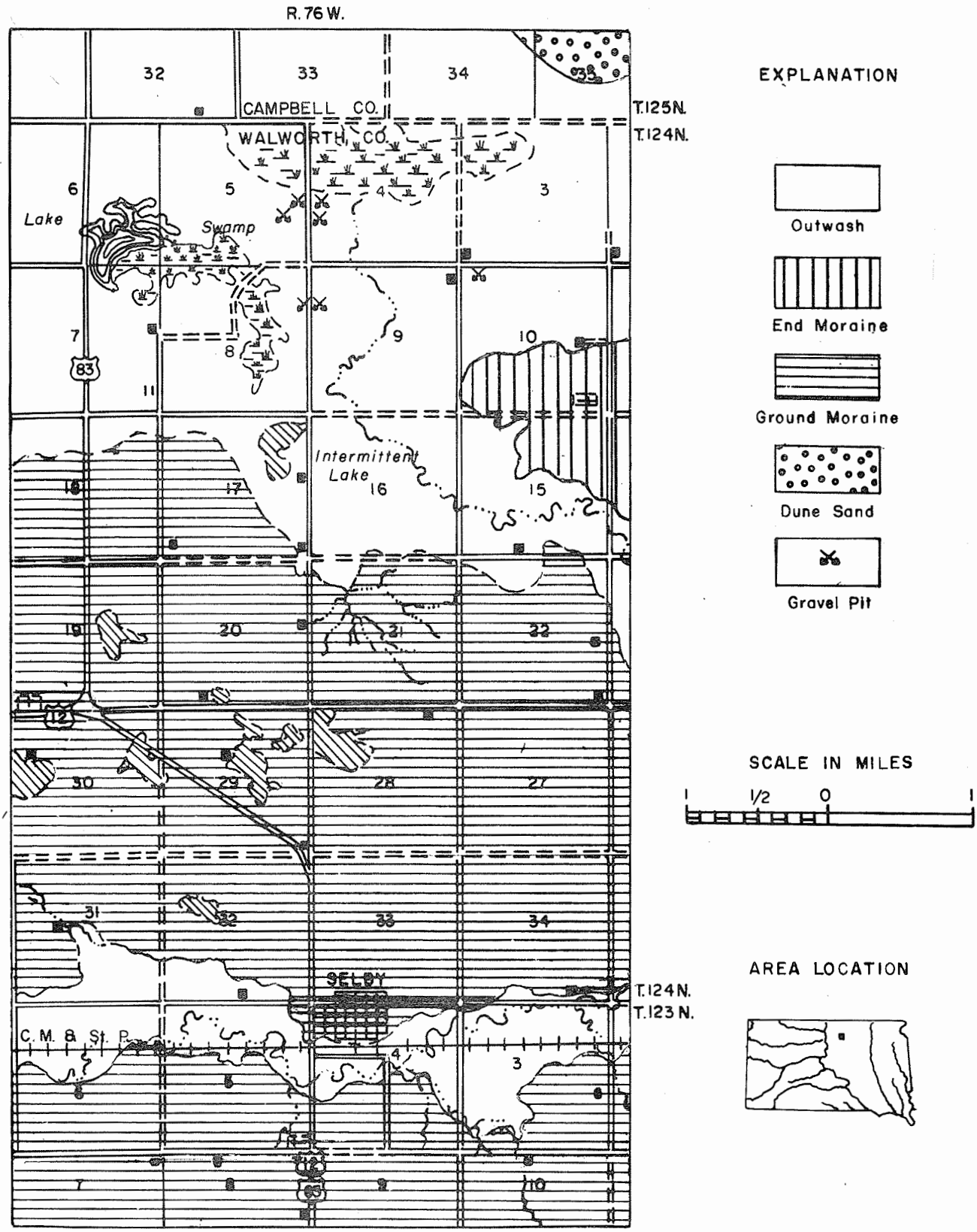

Figure I. MAP SHOWING GENERALIZED SURFACE GEOLOGY OF THE SELBY AREA

by

H. D. Wong

1960

The Selby Outwash South

The Selby outwash south is an east-west deposit of sand and gravel at the south edge of Selby (fig. 1). The mapped portion of this outwash is about 4 miles long; it varies from about ¼-mile to 1 mile in width. This outwash covers an area of approximately 2½ square miles.

The Selby outwash south was prospected by 17 drill holes. Fifty percent of the holes drilled in the eastern part of this outwash failed to penetrate a boulder zone 7 to 8 feet below the surface (sec. 3, T. 123 N., R. 76 W.). The inadequacy of the light jeep-mounted auger drill in attempting to penetrate the formation is to be regretted, since no thickness determination of the deposit could be obtained at these localities.

The thickness of sand and gravel within the Selby outwash south ranges from about 6 to 19 feet, with a maximum thickness of water-saturated material of 15 feet.

The Selby Outwash North

The southern limit of the Selby outwash north lies about 3 miles north of Selby. The outwash is more extensive than shown by Figure 1. Flint (1955) shows this outwash area extending north 25 miles to the North Dakota border, with an average width of about 4 to 5 miles. About 12 square miles of this outwash was mapped (see fig. 1).

The Selby outwash north was prospected by 10 test holes. The thickness of sand and gravel ranges from 10 to 54 feet, with an average of about 31 feet. The depth to water was obtained in one-third of the test holes drilled in this outwash; the remaining test holes caved. Depth to water ranges from 9 to 17 feet below the surface of the ground. The amount of water-saturated sand and gravel ranges from about 10 to 35 feet, with an average of 22 feet.

Figure 2 is a map showing part of the ancient pre-glacial buried valley of the Grand River, and a prominent north-south tributary, whose confluence with the ancient Grand River lies within the area of the shallow outwash of Figure 1.

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 sands and gravels in the Selby 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

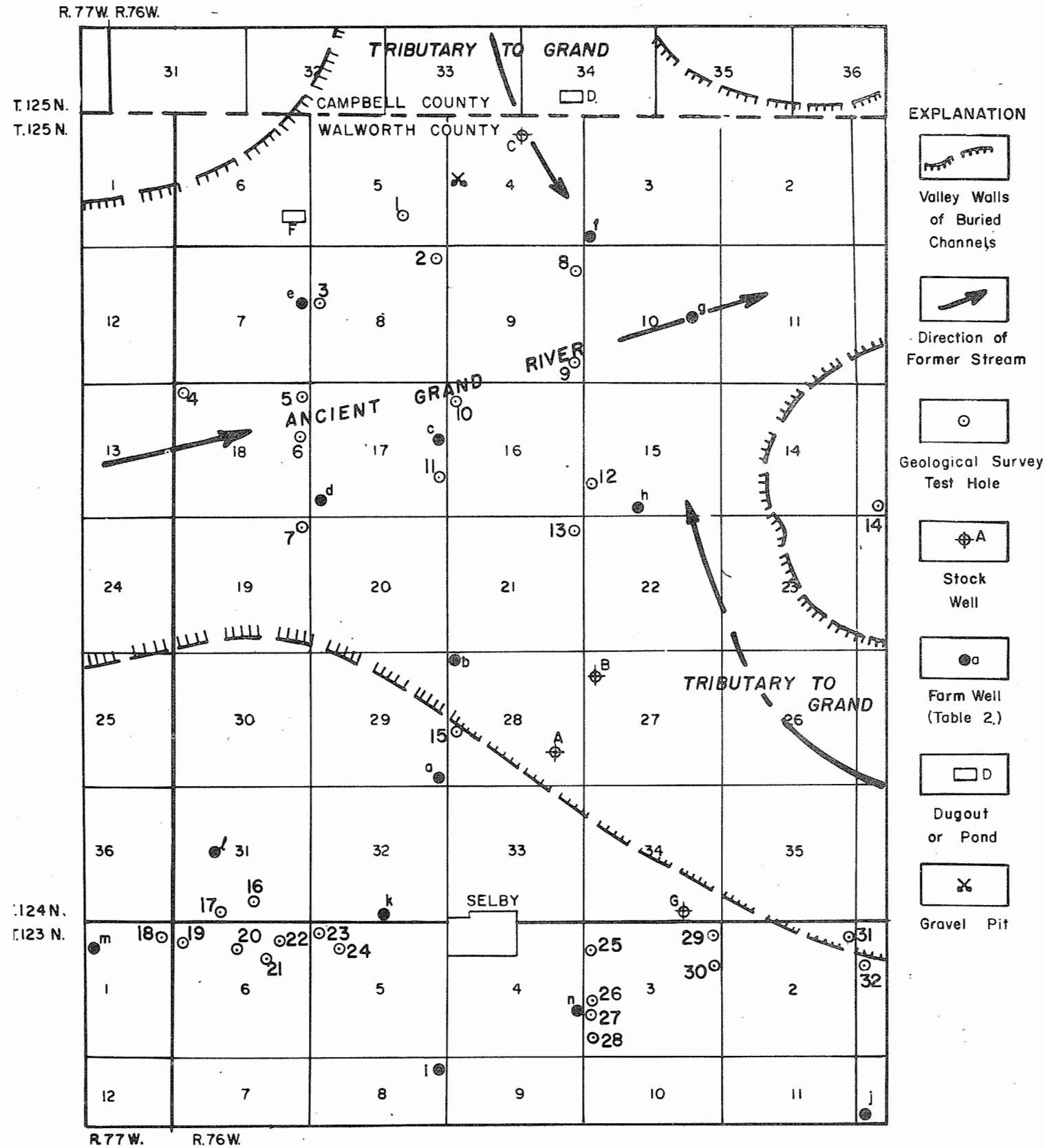

Figure 2. MAP SHOWING INFERRED PRE-GLACIAL BURIED CHANNELS IN THE SELBY AREA (after Flint, 1955), AND DATA

Scale in Miles

1 1/2 0 1

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, because it contains assorted sizes.

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 yearly 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 3 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 Selby

At present the city of Selby obtains its water supply from four wells located on the northern side of the Selby outwash south. These wells are reported to be 30-40 feet deep.

Southeast of the city, the deposit of the Selby outwash south is thickest toward its southern edge (Lee, 1957, fig. 2). Lee based the thickness determinations for this outwash on earth resistivity readings. Only one of the four drill holes in the west part of Sec. 3, T. 123 N., R. 76 W. was able to check the thickness, because the drilling equipment could not penetrate a boulder zone 7 to 8 feet below the surface. On the basis of Lee's interpretation of the thickness of the deposit, the four city wells were not completed in outwash sand and gravel, because the base of the outwash deposit along its northern edge is only 3 to 5 feet below the surface. These wells, 30-40 feet deep, were probably completed in sand and gravel lenses in the underlying till, or possibly in the channel of the ancient Grand River. The thickness of sand and gravel in the eastern and western parts of the Selby outwash south ranges from 6 to 19 feet, where penetrated by drill holes (fig. 2).

In an attempt to locate a nearby source of water for the city, drill holes were located near the southern edge of the buried pre-glacial

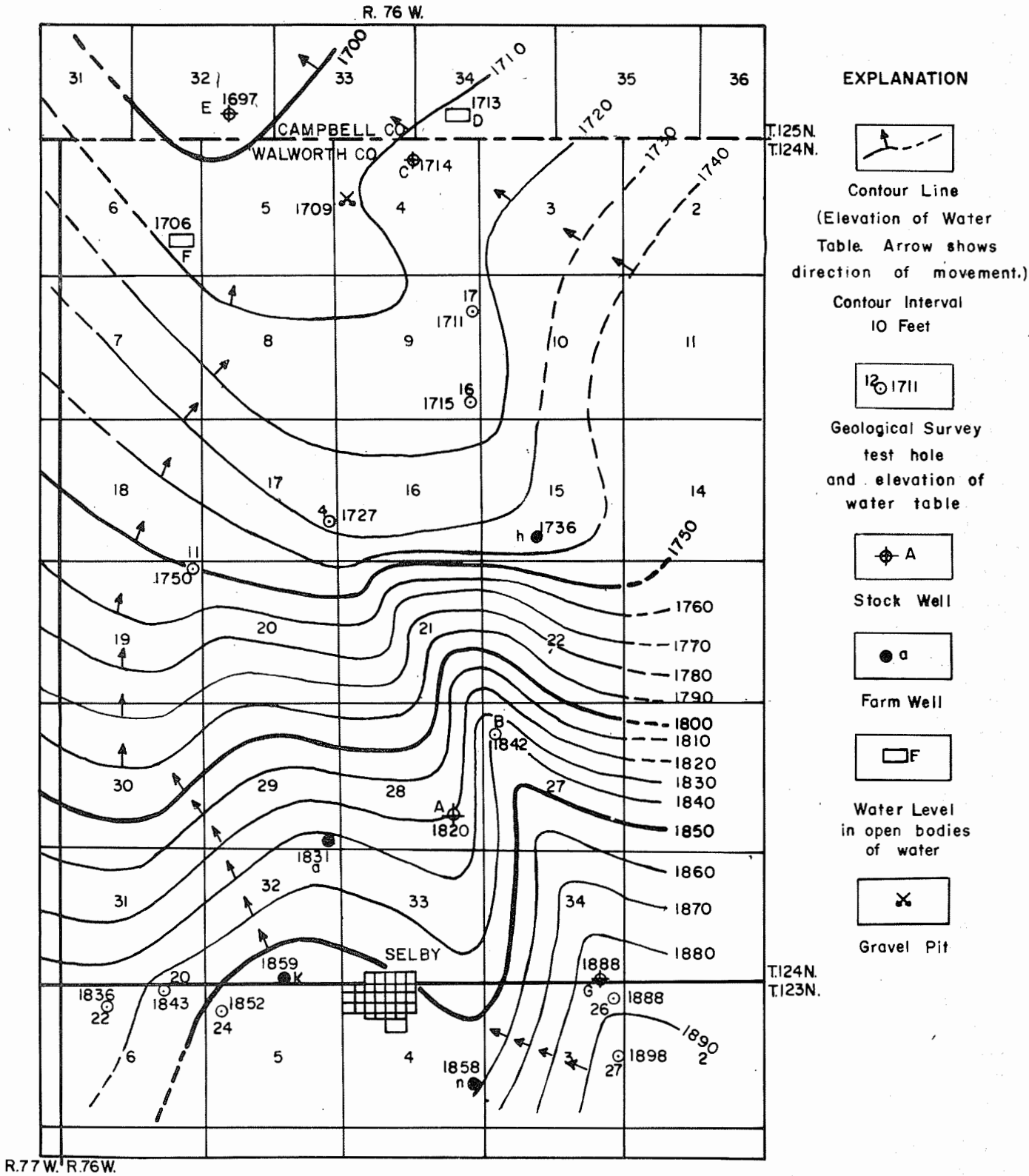

Figure 3. WATER TABLE MAP OF THE SELBY AREA

Scale in Miles

1 1/2 0 1 2

valley of the Ancient Grand River 3 miles north of Selby (fig. 2). Six attempts were made in Sec. 28, T. 123 N., R. 76 W., but drilling was hindered by boulders. One test hole (No. 15) penetrated surficial material to a depth of 14 feet before drilling was stopped by boulders; therefore, the presence of this inferred buried outwash was not confirmed because of the inadequacy of the drill rig.

The most favorable shallow water aquifer near the city of Selby is the Selby outwash north, the southern edge of which lies about 3 miles north of Selby. The Selby outwash north occupies an area of about 12 square miles on Figure 1, although the entire outwash is more extensive. The thickness of sand and gravel within this outwash ranges between 10 and 54 feet, with an average of 31 feet. The thickness of water-saturated sand and gravel in the outwash ranges from 10 to 35 feet, with an average of 22 feet.

The water table map (fig. 3) for the Selby area shows widely spaced contour lines for the upper surface of ground water in the Selby outwash north. The wide spacing of contour lines indicates high permeability--a condition of the deposit that is supported by the texture and relative cleanness of the sand and gravel in most of the drill holes. Ground water movement, in general, is toward the north.

Recharge for the Selby area 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 GROUND WATER

Table 1 gives the analyses of water taken from wells in the Selby area. All ground water has some dissolved 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 utilized; 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.

In Table 1, samples B and C (City Wells 1 and 2) are from the Selby outwash south and samples D, E, and F are from the Selby outwash north. In general, samples D and E are of better quality than the present city wells and sample F is about the same quality. Any future city wells located in the vicinity of either sample D or E should produce a good quality water for most purposes.

Sample F is very high in nitrate content. This high nitrate concentration could be harmful to both animals and humans and should be checked immediately by the owners.

Table 1. --Chemical Analyses of Water Samples in the Selby Area*

Sample	Parts Per Million												
	Calcium	Sodium	Magnesium	Chloride	Sulphate	Iron	Manganese	Nitrogen	Fluoride	pH Acidity	Hardness calcium-carbonate	Total Solids
A	--	--	250**	250**	250**	0.3**	0.1**	10**	1.0**	--	--	500 to 1000**
B	127	142	17	10	317	0.0	1.2	0.1	0.4	--	391	852
C	168	161	41	10	552	Tr.	Tr.	0.6	0.4	--	586	1260
D	60	27	19	3	62	0.18	0.3	2.0	0.1	7.8	231	348
E	150	58	47	32	164	0.02	0.0	13.0	0.1	7.8	570	836
F	148	150	101	54	549	0.05	0.0	33.0	0.35	7.5	788	1503

A. U. S. Dept. of Public Health Drinking Water Standards (1960)
B. City Well No. 1
C. City Well No. 2
D. Moak Farm, NE¼ sec. 7, T. 124 N., R. 76 W.
E. Nusz Farm, SW¼ sec. 3, T. 124 N., R. 76 W.
F. Franks Farm, NE¼ sec. 17, T. 124 N., R. 76 W.

* Samples B and C analyzed by State Chemical Laboratory, Vermillion, (1960); Samples D, E, and F analyzed by State Board of Health, Pierre, (1961)

** not to exceed

CONCLUSIONS AND RECOMMENDATIONS

There are three areas from which the city of Selby may derive an adequate supply of shallow water. The present survey, however, can make no definite recommendations about two of these areas (the Selby outwash south and the inferred buried pre-glacial valley of the Ancient Grand River), because the drill failed to penetrate the deposits in these areas. The third area (Selby outwash north) will probably provide an adequate supply of water to the city.

Selby Outwash South

The thickness of sand and gravel in the NW¼SW¼ sec. 3, T. 123 N., R. 76 W. is approximately 15 feet, as determined by apparent resistivities (Lee, 1957). It must be noted that the inability to obtain drill hole information in this area resulted in failure to check the thickness and depth of the deposit as given by the apparent resistivities. If the approximate thickness of 15 feet of sand and gravel in this area is correct, it would not be sufficient to supply an adequate quantity of water.

Buried Pre-glacial Valley of the Ancient Grand River

Figure 2 shows the approximate southern limit of the inferred buried channel of the Ancient Grand River. The probable existence of this buried channel is inferred from the topography, and its actual presence can be established by drill hole information. Six drill holes were attempted in Sec. 28, T. 124 N., R. 76 W., but the deepest penetration was only 14 feet, (test hole No. 15, see fig. 2 and Appendix A). The failure of the drill to penetrate the materials in the subsurface therefore provides no basis for definite recommendations.

Selby Outwash North

It is the conclusion of this survey that the most favorable source for the city's water supply is the aquifer in the Selby outwash north. 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 Selby outwash north aquifer in the following areas: (1) the SW¼NW¼ sec. 8, T. 124 N., R. 76 W., (2) the NW¼SE¼ sec. 5, T. 124 N., R. 76 W., and (3) the NE¼NE¼ sec. 9, T. 124 N., R. 76 W.

The above locations are recommended for testing because of the coarseness of sand and gravel in the test holes, because of the good quality water (samples D and E, table 1), because of the greater thickness of water-saturated sand and gravel, because of the high permeability indicated by the water table map (fig. 3), and because of the inferred existence of confluence of buried channels in the area (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 well.

REFERENCES CITED

Flint, R. F., 1955, Pleistocene Geology of Eastern South Dakota: U. S. Geol. Survey Prof. Paper 262, 173 pages.

Lee, K. Y., 1957, The Water Supply Near Selby, Walworth County, South Dakota: S. Dak. State Geol. Survey, Vermillion, S. Dak., 7 pages.

APPENDIX A

LOGS OF STATE GEOLOGICAL SURVEY TEST HOLES

IN THE SELBY AREA

Test Hole No. 1
Surface Elevation: 1715 feet
Depth to water: 9 feet

0- 4	soil, sandy, fine, brown; gravel, coarse
4- 9	gravel, coarse; sand, coarse, moist
9-29	sand, coarse; gravel, fine, wet
29-34	sand, coarse; clay, blue
34-44	clay, blue

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Test Hole No. 2
Surface Elevation: ?
Depth to water: none given

0- 4	silt, light brown; gravel, fine
4-14	gravel, coarse; sand, medium to coarse; fine gravel
14-19	gravel, medium to very coarse; sand, fine
19-29	sand, medium
29-34	sand, medium; brown clay
34-39	sand, fine, wet
39-44	no samples

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Test Hole No. 3
Surface Elevation: 1725
Depth to water: none given

0- 4	gravel, coarse; silt
4- 9	sand, fine to coarse; gravel
9-14	sand, fine to coarse; gravel, medium
14-19	sand, coarse; gravel, coarse
19-54	sand, coarse; gravel, medium; water
54-59	clay, blue

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Test Hole No. 4
Surface Elevation: 1729 feet
Depth to water: none given

0- 4	silt, tan to buff
4- 9	silt; sand; gravel, fine
9-14	gravel and sand

(continued on next page)

Test Hole No. 4--Continued

14-19	sand, very little moisture, fine to coarse
19-24	sand, fine to coarse, moist
24-29	sand, coarse, wet
29-34	clay, blue 32-34 feet

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Test Hole No. 5
Surface Elevation: 1733 feet
Depth to water: none given

0- 4	silt, tan to buff
4- 9	silt, tan to buff
9-14	sand, coarse; gravel, coarse
14-24	sand, fine to coarse; gravel
24-29	sand, fine to coarse; gravel, damp
29-49	sand, fine to coarse; gravel, water
49-59	clay, blue

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Test Hole No. 6
Surface Elevation: ?
Depth to water: none given

0-14	silt, tan to buff
14-16	stopped by rock at 16 feet

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Test Hole No. 7
Surface Elevation: 1759 feet
Depth to water: 9 feet

0- 4	topsoil, gray; clay, brown, pebbly
4-14	clay, brown, moist; some sand and gravel
14-19	sand, fine, water
19-29	clay, blue

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Test Hole No. 8
Surface Elevation: 1723 feet
Depth to water: 12 feet

0- 4	clay, brownish gray
4- 9	sand; mud; clay; water
9-14	gravel; sand, coarse, wet

(continued on next page)

Test Hole No. 8--Continued

14-39	gravel; sand, coarse, water
39-49	clay, blue

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Test Hole No. 9
Surface Elevation: 1733 feet
Depth to water: 17 feet

0- 4	silt and clay; sand
4- 9	sand; clay, brown
9-14	sand, medium; clay, brown
14-19	sand, medium; gravel, fine to medium
19-24	sand, medium, wet
24-29	no sample, drills as wet sand
29-34	sand, medium, wet
34-39	sand, medium, brown
39-44	clay, blue?
44-49	clay, blue

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Test Hole No. 10
Surface Elevation: 1723 feet
Depth to water: hole caved

0- 4	topsoil, black
4- 9	clay, black; clay, brown
9-24	clay, brown, water

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Test Hole No. 11
Surface Elevation: 1737 feet
Depth to water: 9 feet

0- 4	topsoil, 2 feet, brown, sandy; gravel; clay, light brown
4- 9	gravel,coarse to medium; sand, coarse, moist
9-14	gravel, coarse, moist; sand, coarse
14-24	gravel, fine, wet; sand, coarse
24-29	clay, blue

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Test Hole No. 12
Surface Elevation: 1752 feet
Depth to water: none

0- 4	clay, light brown, sand
4- 9	till, brown

(continued on next page)

Test Hole No. 12--Continued

9-14	sand, fine, with brown clay
14-19	sand, fine, brown, wet
19-24	clay, blue, sandy

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Test Hole No. 13
Surface Elevation: ?
Depth to water: none

0- 4	clay, brown, gravel and sand
4- 9	clay, grayish brown; sand, medium; gravel, medium
9-14	sand, medium; gravel, medium

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Test Hole No. 14
Surface Elevation: ?
Depth to water: none given

0- 4	gravel, coarse; sand
4- 9	sand, medium
9-24	gravel, medium to coarse

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Test Hole No. 15
Surface Elevation: ?
Depth to water: stopped by rock

0- 9	silt, dry, gray; sand, fine
9-14	silt, dry, gray; gravel, coarse

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Test Hole No. 16
Surface Elevation: 1848 feet
Depth to water: none

0- 4	topsoil; clay, black
4-14	clay, brown
14-19	clay, blue

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Test Hole No. 17
Surface Elevation: 1852 feet
Depth to water: hole caved

0- 4	silt, yellow; sand, coarse

(continued on next page)

Test Hole No. 17--Continued

4- 9	gravel, medium; sand, medium, damp
9-14	sand, medium, damp
14-24	clay, blue

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Test Hole No. 18
Surface Elevation: 1846 feet
Depth to water: 8 feet

0- 9	silt, brownish yellow
9-14	gravel, medium, dry; sand, fine; clay, brown, damp
14-19	sand, fine to medium, wet
19-24	sand, medium, wet; clay, blue

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Test Hole No. 19
Surface Elevation: 1848 feet
Depth to water: hole caved

0- 4	silt, brown
4- 9	sand, coarse; gravel, fine
9-14	gravel, medium; clay or mud matrix, water
14-19	clay, blue

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Test Hole No. 20
Surface Elevation: 1844 feet
Depth to water: 8 feet

0- 4	gravel, fine to medium, with coarse sand and clay
4-14	sand, fine to medium, damp
14-19	sand, fine, wet, with medium sand
19-29	sand, fine; mud or clay
29-34	clay, blue

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Test Hole No. 21
Surface Elevation: ?
Depth to water: 6 feet

0- 4	clay, brown
4- 9	clay, light brown, with fine sand
9-14	gravel, fine; sand, coarse, brown mud matrix
14-19	clay, blue

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Test Hole No. 22
Surface Elevation: 1852 feet
Depth to water: 9 feet

0-14	clay, brown; sand
14-19	sand, clay, water (mud)
19-24	sand, medium, water
24-34	clay, blue

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Test Hole No. 23
Surface Elevation: 1869 feet
Depth to water: none

0- 4	silt, light brown; sand, fine
4- 9	sand, fine; gravel, coarse
9-14	clay, dark brown; sand, fine
14-19	till

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Test Hole No. 24
Surface Elevation: 1857 feet
Depth to water: 6 feet

0- 9	clay, brown, fine sand
9-14	sand, coarse, with fine gravel, wet
14-19	clay, blue

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Test Hole No. 25
Surface Elevation: 1890 feet
Depth to water: none

0- 4	silt, brown; gravel, coarse
4- 9	gravel, coarse; clay, brown (at 4 feet), trace of sand
9-14	clay, brown
14-29	clay, blue

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Test Hole No. 26
Surface Elevation: ?
Depth to water: stopped by rock at 8 feet; moved 30 feet south; stopped by rock at 8 feet

0- 4	clay, brownish black
4- 8	silt, 2½ feet, light brown; gravel, 1½ feet, coarse

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Test Hole No. 27
Surface Elevation: ?
Depth to water: stopped by rock at 7 feet

0-7	silt, light brown; gravel, medium

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Test Hole No. 28
Surface Elevation: ?
Depth to water: stopped by rock at 4 feet

0-4	silt, brown; gravel, medium

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Test Hole No. 29
Surface Elevation: 1895 feet
Depth to water: 7.5 feet

0- 4	clay, brown, with coarse sand
4- 9	gravel, medium, with light brown laminated clay; very wet
9-14	sand, fine; mud
14-24	sand, medium to coarse, brown mud
24-29	clay, blue

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Test Hole No. 30
Surface Elevation: 1905 feet
Depth to water: 7 feet

0- 4	topsoil, black; till?
4- 9	sand, coarse; gravel, fine; brown clay matrix, damp
9-14	sand, fine; clay, dark gray, fluid
14-24	clay, blue

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Test Hole No. 31
Surface Elevation: 1922 feet
Depth to water: none

0- 4	clay, dry, brown; sand, coarse
4- 9	clay, dry, brown; sand, coarse
9-14	clay, dry, brown; sand, medium
19-24	clay, reddish brown
24-29	clay, reddish brown
29-34	clay, blue

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Test Hole No. 32
Surface Elevation: 1904 feet
Depth to water: none given

0- 9	clay, brown, with sand and gravel
9-19	clay, light brown, with sand and gravel; water stopped by rock at 19 feet

APPENDIX B

Table 2.--Data on Wells, Dugout , and Pond in Selby Area, Aug., 1960

(for locations see fig. 2)

Sample	Owner or Tenant	Elevation of Surface (feet)	Depth of Well (feet)	Geologic Source of Water	Depth to water (feet) Aug., 1960
a	Oscar Byre	1867.1	36	Till(gravel)	24
b	John Steder	?	76	?	31
c	John Scheuer	?	?	?	6
d	John Scheuer	?	50	Till(gravel)	16
e	Herb Moak	?	35	Outwash	24
f	Eddie Nusz	?	22	Outwash	22
g	Howard Rau	?	11	Outwash	7
h	Fred Rosin	1746.1	32	Outwash	31
i	Art Sieck	?	2100?	?	150
j	Christ Reus	?	50	Till(gravel)	30
k	Dorothy Smith	1872.1	100	Till(gravel)	50
l	V. Thorstenson	1860.9	100	Till(gravel)	50
m	M. Thorstenson	1847.7	18	Outwash	7
n	Wayne Flemmer	1896.9	33	Outwash	28
A	stock well	1839.3	?	?	19
B	stock well	1859.4	?	?	17
C	stock well	1718.4	?	Outwash	4
D	dugout	1712.9	?	Outwash	0
E	stock well	1710.9	?	Outwash?	14
F	pond	1706	?	?	0
G	stock well	1894.1	?	?	6
H	gravel pit	1709	?	?	0