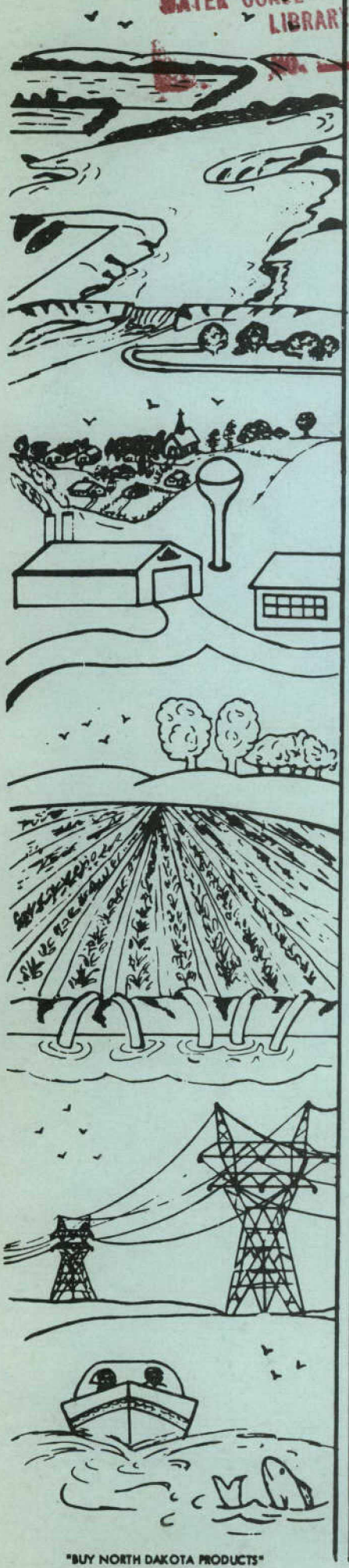

INVESTIGATION OF GROUND-WATER CONDITIONS AT LAKE METIGOSHE STATE PARK BOTTINEAU COUNTY NORTH DAKOTA

N.D.S.W.C. PROJECT NO. 1451

NORTH DAKOTA GROUND-WATER STUDIES NO. 68

By
Clifford H. Beeks Jr.
Ground - Water Geologist

Published By
North Dakota State Water Commission
1301 State Capitol
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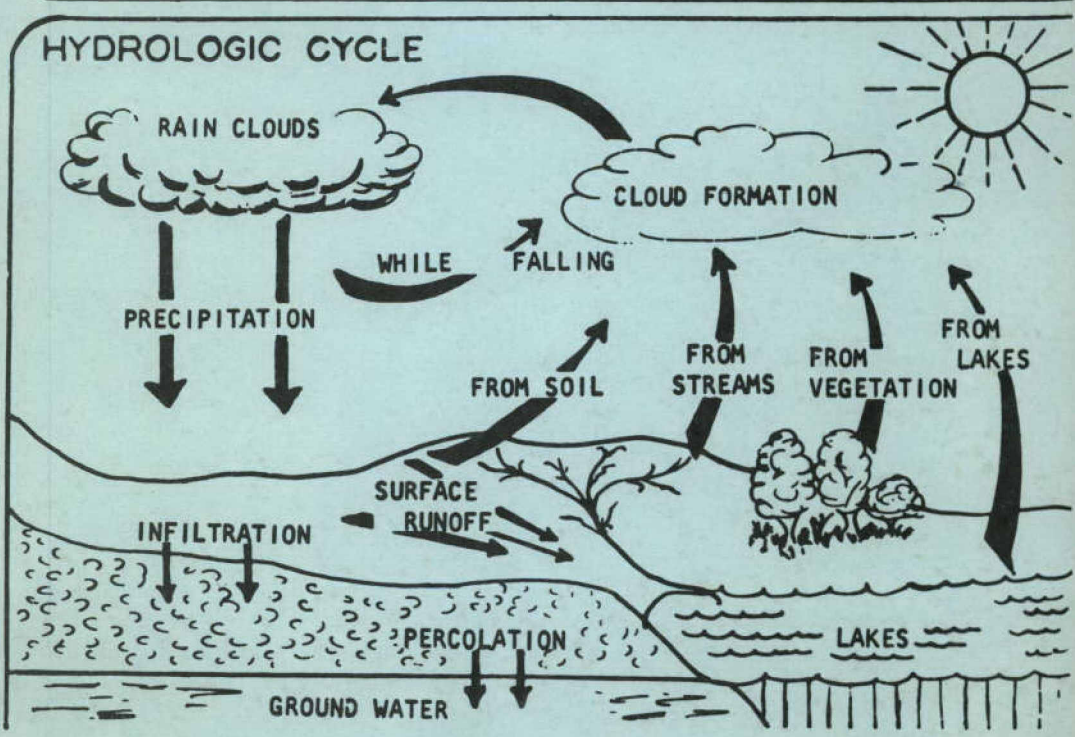
- 1967 -



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INTRODUCTION

Purpose and Scope

In October, 1966, the State Water Commission drilled a series of test holes at Lake Metigoshe State Park in cooperation with the State Park Service. The purpose of the test drilling was to locate a suitable water supply for new park facilities.

The survey consisted of test drilling, observation well installation, and chemical analyses of water samples for quality determination.

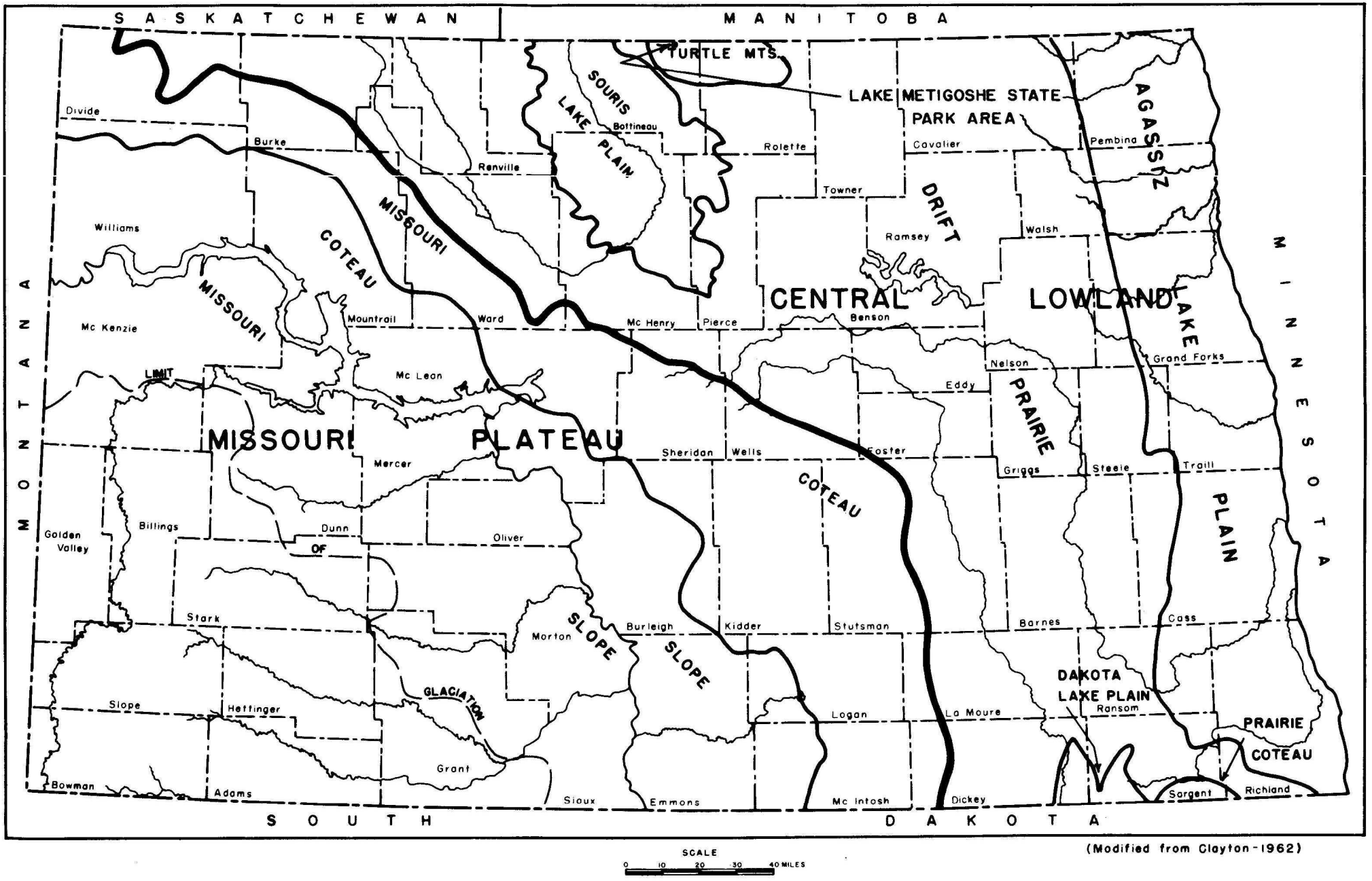
The study was under the direct supervision of the author. Test drilling was done by Lewis Knutson and Hugh Jacobson using the state-owned hydraulic rotary drilling rig. Chemical analyses of water samples were performed by Donald Delzer, State Water Commission Chemist, at the State Laboratories in Bismarck.

Location and General Features

Lake Metigoshe State Park includes all of Section 36 and 87 acres in Section 35 in Township 164 North, Range 75 West. The entire area is located in the Turtle Mountains District of the Central Lowland Physiographic Province of North Dakota as shown in figure 1. Surface elevations range from 2,138 feet above mean sea level at Lake Metigoshe near the southwest edge of the park to about 2,210 feet on a hilltop in the southeast corner of the park.

Drainage in Lake Metigoshe State Park is nonintegrated. The area has a scenic knob and kettle topography and is heavily forested.

U. S. Weather Bureau climatological data recorded at Bottineau, 12 miles south of the park, shows the mean annual temperature to be 39.5^{0}F based on a 74 year record through 1965. Average annual precipitation based on the same record is 15.91 inches (U. S. Department of Commerce, 1966).



(Modified from Clayton-1962)

FIGURE 1--MAP OF NORTH DAKOTA SHOWING PHYSIOGRAPHIC PROVINCES AND LOCATION OF THE LAKE METIGOSHE STATE PARK AREA

Well-Numbering System

The well-numbering system used in this report and illustrated in figure 2, is based on the location of the well in the Federal system of rectangular surveys of public lands. The first number denotes the township north and the second number denotes the range west, both referred to the Fifth Principal Meridian and base line. The third number denotes the section in which the well is located. The letters a,b,c, and d designate respectively the northeast, northwest, southwest, and southeast quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections (10-acre tracts). Consecutive terminal numbers are added if more than one well is located in a 10-acre tract. Thus, well 164-75-35ddc would be located in the $SW\frac{1}{4}$,$SE\frac{1}{4}$,$SE\frac{1}{4}$, Section 35, Township 164 North, Range 75 West.

GEOLOGY AND OCCURRENCE OF GROUND WATER

Geologic History

Prior to continental glaciation, a topographic bedrock high occupied the area that is the present day Turtle Mountains. During the Pleistocene Epoch or "Ice Age" continental glaciers covered this area with glacial drift forming what is now known as the Turtle Mountains Moraine (Simpson, 1929; p.8)

Glacial Drift

In the Lake Metigoshe area the drift is generally more than 200 feet thick. The major part of glacial drift consists of till, which is an unstratified mixture of clay, silt, sand, pebbles, cobbles, and boulders deposited directly by the glacier with little or no transportation by water. A minor constituent of drift is lake sediment, which consists of stratified silt and clay. Above the water table the till and lake sediment are usually yellowish gray in color with red oxidation stains. Below the water table the color is almost always some shade of gray. These sediments are predominantly very fine-grained, have a very low permeability and are therefore known as aquicludes.

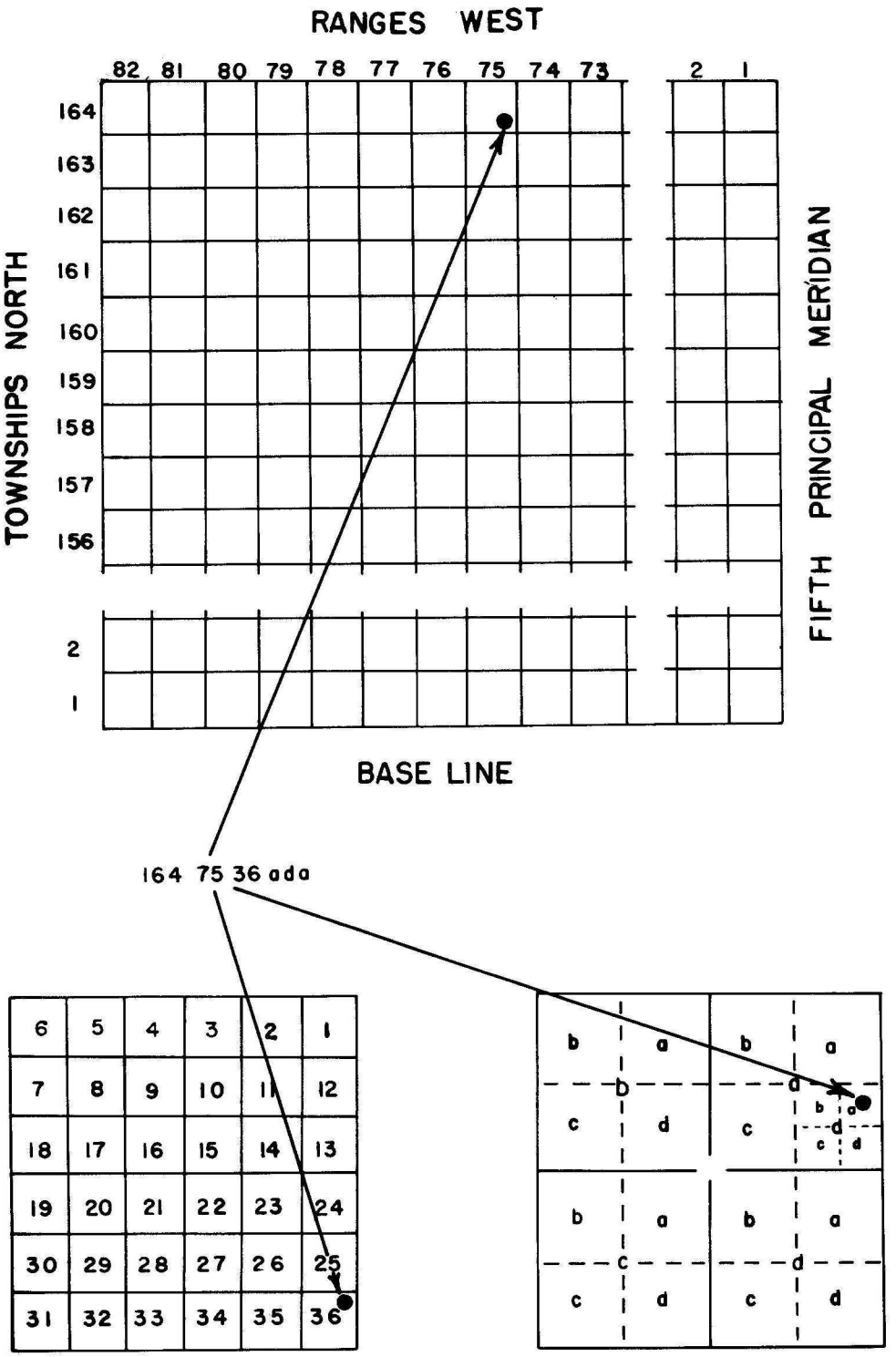


Figure 2 -- Sketch illustrating well-numbering system

Throughout the till and occassionally associated with the lake sediments are found stratified sand and gravel deposits. Below the water table these are called aquifers because they are water-bearing and yield water to wells.

In the eastern part of the park (Fig. 3) three test holes were drilled, but no aquifers of more than 10 feet in thickness were found.

In the western part four test holes were drilled through a sand and gravel aquifer ranging from 26 to 56 feet thick (See Table 4). At each of these four test hole sites observation wells were installed and water samples obtained. The upper part of the aquifer is mainly fine to coarse sand and grades into medium to coarse gravel with cobbles and sometimes boulders at the base.

Bedrock

It is proposed that the bedrock of this region is an outlier, of the Fort Union Formation of Simpson (1929; p.80). Test holes LM-4 and LM-7 were drilled to bedrock (Table 4). The bedrock in these test holes, undifferentiated in this report, was found to vary from a silty clay to a clayey silt. Color is highly variable, ranging from dusky yellow to olive gray and medium bluish gray.

WATER QUALITY

Ground water is derived primarily from rain and snowmelt. The amount and character of minerals dissolved by the water depends on the physical and chemical composition of the material it contacts, the duration of contact, temperature, pressure, and gases and minerals already in solution.

The quality of water for public supply and domestic use is commonly evaluated in relation to standards of the United States Public Health Service for drinking water. Table 1 lists, in part, standards adopted by the United States Public Health Service.

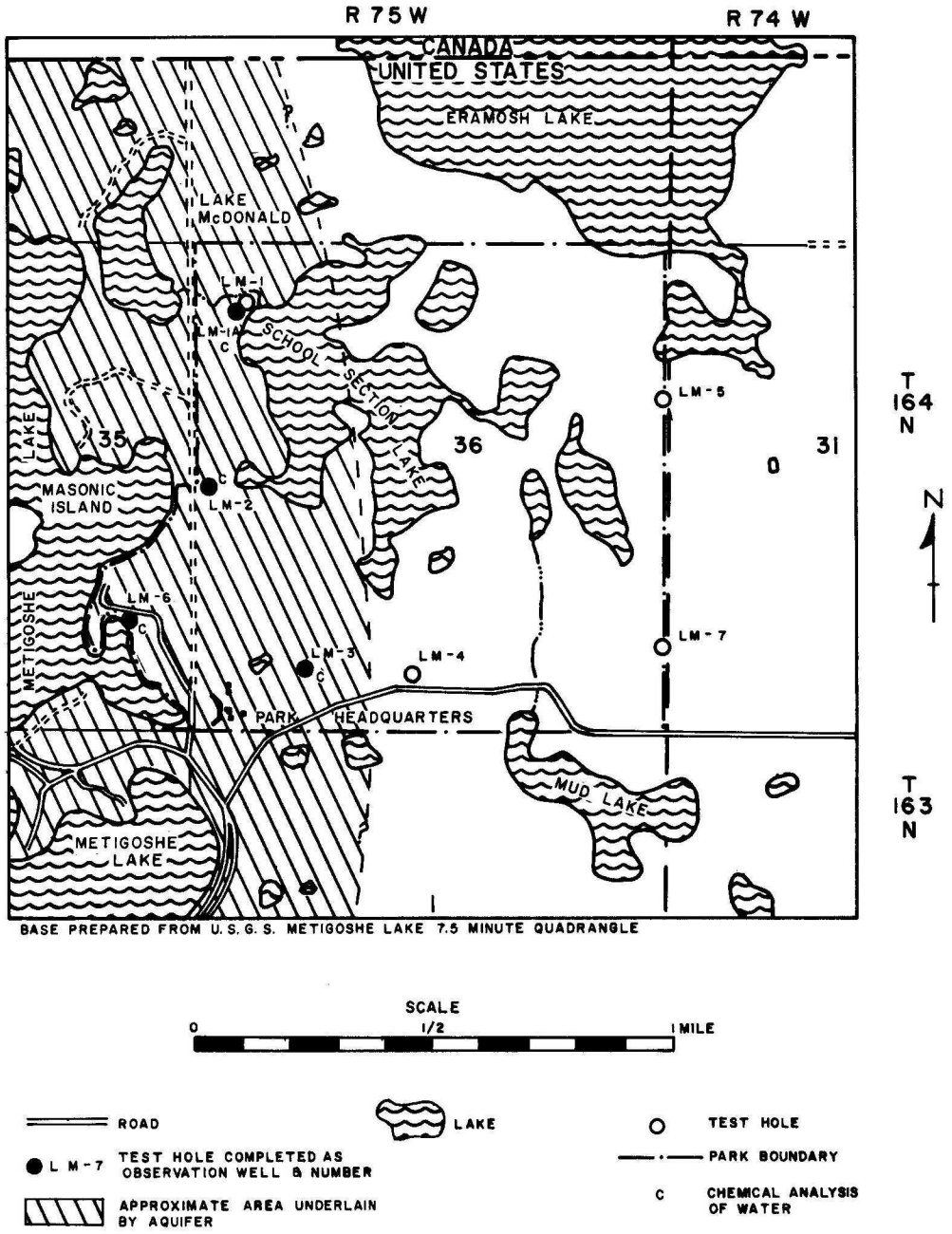


FIGURE 3--MAP OF THE LAKE METIGOSHE STATE PARK AREA SHOWING THE LOCATION OF THE TEST HOLES AND OF THE MAIN AQUIFER

Table 1
Drinking water standards of the United States Public Health Service

Iron (Fe)	.3 ppm (parts per million)
Magnesium (Mg)	125 ppm
Sulfate (SO_4)	250 ppm
Chloride (Cl)	250 ppm
Fluoride (F)	1.5 ppm
Nitrate (NO_3)	45 ppm
Total dissolved solids	500 ppm

Table 2 lists the complete analyses of the water samples taken from each of the four observation wells (Fig. 3) in the sand and gravel aquifer underlying the western part of the park.

The quality of water is generally within the U. S. Public Health Service standards with the exception of sulfates and total dissolved solids. Excessive sulfate has a laxative effect on persons unaccustomed to the water; however, a North Dakota State Department of Health survey indicates no laxative effect is noticed until the sulfate concentration reaches 600 ppm. While total dissolved solids exceed U. S. Public Health Service standards, it is rated as only average (500-1400 ppm) by the North Dakota State Department of Health. The human body may become accustomed to water containing up to 2000 ppm.

The iron content in three of the observation wells is high enough to cause staining of laundry and plumbing fixtures, and give the water a slight taste. The hardness of the water is very high and will cause increased soap consumption and scaling, but has no pathological effects. If the water is to be utilized for washroom facilities, treatment for iron removal and softening would be desirable.

OF GROUND WATER

(Cl)	(F)	(NO_3)	(B)	Total dissolved solids	Total hardness as $CaCO_3$	Total hardness noncarbonate	% Sodium	SAR	Specific conductance (Micromhos, 25°C)	pH
2.6	0.2	0.0	0.02	1030	808	285	6	0.4	1430	7.7
3.3	0.2	0.0	0.55	940	665	324	8	0.5	1260	7.6
3.9	0.2	0.2	0.36	1040	723	363	9	0.6	1390	7.5
3.6	0.2	0.1	0.35	871	613	272	9	0.5	1190	7.6

Table 2 -- CHEMICAL ANAYLSES

Location	Depth of well (feet)	Aquifer	Date of collection	(SiO_2)	(Fe)	(Ca)	(Mg)	(Na)	(K)	(HCO_3)	(CO_3)	(SO_4)
164-75-35-ddc	157½	Qd*	10-18-66	27	1.1	170	93	24	9.8	638	0	327
164-75-36-bb	105	Qd	10-13-66	27	0.56	170	59	28	6.7	417	0	379
164-75-36-cbb	126	Qd	10-17-66	26	0.16	193	59	34	8.2	440	0	435
164-75-36-cdb	147	Qd	10-17-66	27	1.6	162	51	29	6.9	417	0	337

*Glacial Drift

TABLE 3
RECORD OF TEST HOLES

Depth to water: Measured water levels in feet to nearest hundreth

Depth of well: Measured to nearest $\frac{1}{2}$ foot
Use of water: T, test hole; O, Observation Well

Location No.	Test Hole Number	Depth (feet)	Diameter (inches)	Type	Date Completed	Depth to Water Below Land Surface (feet)	Date of measure-ment	Use of Water	Aquifer	Remarks
164-75-35 ddc	LM-6	157½	4 3/4	drill	10-18-66	63.05	10-19-66	O	sand & gravel	complete chemical analysis
-36 ada	LM-5	168	4 3/4	drill	10-18-66	---	---	T	sand & gravel	no observation well, limited aquifers
-36bb	LM-1	231	4 3/4	drill	10-12-66	---	---	T	sand & gravel	no observation well, limited aquifers
-36bb	LM-1A	105	4 3/4	drill	10-13-66	64.60	10-17-66	O	sand & gravel	complete chemical analysis
-36cbb	LM-2	126	4 3/4	drill	10-17-66	61.43	10-17-66	O	sand & gravel	complete chemical analysis
-36cda	LM-4	262½	4 3/4	drill	10-18-66	---	---	T	sand & gravel	no observation well, limited aquifers
-36cdb	LM-3	147	4 3/4	drill	10-17-66	82.20	10-18-66	O	sand & gravel	complete chemical analysis
-36dda	LM-7	315	4 3/4	drill	10-19-66	---	---	T	sand & gravel	no observation well limited aquifers

RECOMMENDATION

This investigation revealed an aquifer underlying the western part of Lake Metigoshe State Park. Although water levels are low (See Table 3), the thickness and projected aerial extent of the aquifer indicate adequate quantities of water are available for limited development.

Chemical analyses indicate the water in the aquifer is of acceptable quality by North Dakota State Department of Health standards, but iron removal and softening would greatly enhance the potability of the water.

Figure 3 shows the approximate area within the park that is underlain by the aquifer. Maximum yields to wells could be anticipated where the aquifer attains its greatest thickness (See Table 4).

Table 4
Logs of Test Holes
164-75-35ddc

Test Hole LM-6

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Clay, silty, dusky brown, cohesive, non-calcareous (topsoil) - - - - - - - - - - -	1	1
	Clay, silty, yellowish gray to dusky yellow, cohesive, plastic, calcareous - - - - - -	20	21
	Sand, medium to coarse, gravelly, subangular to subrounded, moderately sorted - - - - -	7	28
	Clay, silty, oliver gray, cohesive, plastic slightly calcareous - - - - - - - - - - -	38	66
	Clay, silty with sand grains, pebbles, and erratics, olive gray, cohesive, plastic, calcareous (till) - - - - - - - - - - - -	10	76
	Sand, fine to medium, subangular to sub-rounded, well sorted - - - - - - - - - -	6	82
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted - - - - -	13	95

164-75-35ddc
(cont.)
Test Hole LM-6

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Clay, silty with sand grains, pebbles, and erratics, cohesive, plastic, calcareous, olive gray, (till) - - - - -	5	100
	Sand, medium to coarse, gravelly, subangular to subrounded, moderately sorted, predominantly limestone and shale - - -	37	137
	Clay, silty with sand grains and pebbles, olive gray, cohesive, plastic, calcareous, (till) - - - - - - - - - - - - - - - - - - -	6	143
	Sand, medium to coarse, gravelly with a few cobbles, subangular to subrounded, poorly sorted, predominantly limestone, shale and quartz; takes water -	5	148
	Clay, silty to gravelly with erratics, olive gray; cohesive, plastic, calcareous; (till) - - - - - - - - - - - - - - - - - -	10	158

Electric Log to 62 feet
Observation Well

164-75-36ada
Test Hole LM-5

Glacial Drift:			
	Clay, silty, dusky brown, cohesive, noncalcareous (topsoil) - - - - - - - - - - -	1	1
	Clay, silty, yellowish gray to dusky yellow; cohesive, plastic, calcareous - - -	12	13
	Gravel, fine to coarse, sandy, subangular to subrounded, poorly sorted; predominantly quartz and limestone with some shale - - -	3	16
	Clay, silty, olive gray; cohesive, plastic, slightly calcareous - - - - - - -	25	41
	Sand, fine to medium, subangular to subrounded, well sorted; predominantly quartz -	8	49
	Clay, silty with a few sand grains and pebbles, olive gray, cohesive, plastic slightly calcareous (till) - - - - - - - - -	95	144

164-75-36ada
(cont.)
Test Hole LM-5

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Sand, medium to coarse, gravelly, subangular to subrounded, poorly sorted; predominantly limestone, shale and quartz - - - - - - - - - - - - - - - -	8	152
	Clay, silty with sand grains, gravel, and erratics, dusky yellow, cohesive plastic, slightly calcareous (till) - - - - - - - -	16	168

Electric Log

164-75-36bb
Test Hole LM-1

Glacial Drift:			
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted - - - - -	12	12
	Clay, silty, dusky yellow, cohesive, plastic, calcareous - - - - - - - - - - - - -	6	18
	Clay, silty, olive gray, cohesive, plastic, calcareous - - - - - - - - - - - - - - - - -	25	43
	Clay, silty with a few sand grains and pebbles, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - - - -	21	64
	Sand, medium to coarse, fine to medium gravel, subangular to subrounded; predominantly shale, limestone, and quartz, and a little lignite - - - - - - - - - - - - - - - - - - -	49	113
	Clay, silty with sand grains and pebbles, olive gray, cohesive, plastic, slighty calcareous (till) - - - - - - - - - - - - - -	21	134
	Sand, medium to coarse, gravelly, subangular to subrounded, poorly sorted; predominantly shale, limestone, and quartz - - - - - - - -	8	142
	Clay, silty with sand grains and pebbles, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - - - - - - - -	44	186

164-75-36bb
(cont.)
Test Hole LM-1

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Sand, medium to coarse, gravelly subangular to subrounded, poorly sorted; predominantly limestone, shale, and quartz; takes water - -	12	198
	Clay, silty with sand grains, pebbles and erratics, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - - - -	33	231

Electric Log

164-75-36bb$_2$
Test Hole LM-1A

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted - - - - - -	3	3
	Clay, silty, dusky yellow, cohesive, plastic, calcareous - - - - - - - - - - - - - - - - -	9	12
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted - - - - -	4	16
	Clay, silty, olive gray, cohesive, plastic, calcareous - - - - - - - - - - - - - - - - -	32	48
	Clay, silty with a few sand grains and pebbles, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - - - -	18	66
	Sand, fine to coarse, subangular to subrounded, moderately well sorted - - - -	8	74
	Sand, medium to coarse, gravelly, subangular to subrounded, poorly sorted; predominantly limestone, shale, and quartz - - - - - - - - -	31	105

No electric log
Observation Well

164-75-36cbb
Test Hole LM-2

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Clay, silty, dusky brown, cohesive, plastic, non-calcareous (topsoil) - - - -	4	4
	Clay, silty, yellowish gray, cohesive, plastic, non-calcareous - - - - - - - - -	4	8
	Clay, silty with sand grains and pebbles, dusky yellow, cohesive, plastic, slightly calcareous (till) - - - - - - - - - - -	12	20
	Clay, silty with sand grains, pebbles and erratics, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - -	38	58
	Sand, fine to coarse, subangular to subrounded, moderately well sorted, predominantly quartz with some limestone and shale - - - - - - - - - - - - - - - - - -	7	65
	Sand, fine to coarse, slightly gravelly, subangular to subrounded, moderately poor sorting; predominantly shale and quartz and some limestone; takes water - - - - - - -	37	102
	Gravel, fine to coarse, sandy with erratics, subangular to subrounded, poorly sorted; predominantly limestone with some shale and quartz, takes water - - - - - - - - - -	12	114
	Clay, silty with sand grains, pebbles and erratics, olive gray, cohesive, plastic calcareous to slightly calcareous (till) -	12	126

Electric Log
Observation Well

164-75-36cda
Test Hole LM-4

Glacial Drift:			
	Clay, silty, dusky brown, cohesive, plastic, non-calcareous (topsoil) - - - - - - - - -	1	1
	Clay, silty and gravelly, dusky yellow, cohesive, plastic, slightly calcareous (till) - - - -	8	9

164-75-36cda
(cont.)
Test Hole LM-4

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Clay, silty, dusky yellow, cohesive, plastic, slightly calcareous - - - - - - -	10	19
	Clay, silty, olive gray, cohesive, plastic, slighty calcareous - - - - - - - - - - - -	13	32
	Clay, silty with a few sand grains and pebbles, olive gray, cohesive, plastic slightly calcareous (till) - - - - - - - -	106	138
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted; predominantly limestone, shale, and quartz,- - - - - - -	8	146
	Clay, silty with a few sand grains and pebbles, dusky yellow, cohesive, plastic, slightly calcareous (till) - - - - - - - -	17	163
	Clay, silty with a few sand grains and pebbles, olive gray, cohesive, plastic, slightly calcareous (till) - - - - - - - - - - - - - -	41	204
	Sand, medium to coarse; gravelly, subangular to subrounded, moderately poor sorting; predominantly limestone, shale, and quartz-	10	214
Bedrock, undifferentiated:			
	Silt, clayey, dusky yellow to light olive gray, cohesive, plastic, non-calcareous - - - - -	49	263

Electric Log

164-75-36cdb
Test Hole LM-3

Glacial Drift:			
	Clay, silty with a few sand grains and pebbles, dusky yellow, cohesive, plastic, calcareous (till) - - - - - - - - - - - -	9	9
	Clay, silty, yellowish gray, cohesive, plastic, slightly calcareous - - - - - - -	11	20
	Sand, fine to coarse, slightly gravelly, subangular to subrounded, moderately sorted; predominantly quartz with shale and limestone - - - - - - - - - - - - - - - - -	3	23

164-75-36cdb
Test Hole LM-3
(cont.)

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:			
	Clay and silt, dusky yellow, moderately cohesive and plastic, slightly calcareous	3	26
	Sand, fine to medium, subangular to subrounded, well sorted; predominantly quartz	7	33
	Clay, silty, dusky yellow, cohesive, plastic, slightly calcareous	5	38
	Clay, silty, olive gray, cohesive, plastic, slightly calcareous	27	65
	Clay, silty with a few sand grains, pebbles, and erratics, olive gray, cohesive, plastic, slightly calcareous (till)	12	77
	Sand, fine to medium, subangular to subrounded, well sorted; predominantly quartz	7	84
	Clay, silty with a few sand grains, pebbles, and erratics, olive gray, cohesive, plastic, slightly calcareous (till)	22	106
	Sand, fine to coarse, subangular to subrounded well sorted; predominantly quartz with shale and limestone	5	111
	Sand, fine to coarse, slightly gravelly, subangular to subrounded, poorly sorted; predominantly shale and quartz with limestone	17	128
	Gravel, sandy with erratics, subangular to subrounded; poorly sorted,	4	132
	Clay, silty with a few sand grains, pebbles and erratics, olive gray, cohesive, plastic, calcareous (till)	15	147

Electric Log
Observation Well

164-75-36dda
Test Hole LM-7

Formation	Material	Thickness (feet)	Depth (feet)
Glacial Drift:	Clay, silty, dusky brown, cohesive, plastic, non-calcareous (topsoil)	1	1
	Clay, silty, dusky yellow, cohesive, plastic, slightly calcareous	17	18
	Clay, silty, olive gray, cohesive, plastic, slightly calcareous	13	31
	Clay, silty with a few sand grains and pebbles; olive gray, cohesive, plastic, slightly calcareous (till)	13	44
	Sand, fine, silty, subangular to subrounded, well sorted; predominantly quartz	5	49
	Clay, silty with a few sand grains, pebbles, and erratics, olive gray, cohesive, plastic, slightly calcareous (till)	102	151
	Sand, medium to coarse, gravelly, subangular to subrounded, moderately sorted, predominantly shale and limestone with quartz	9	160
	Clay, silty with a few sand grains, pebbles and erratics, dusky yellow, cohesive, plastic, slightly calcareous (till)	9	169
	Sand, medium to coarse, gravelly, subangular to subrounded, moderate sorting; predominantly limestone, shale, and quartz	10	179
	Clay, silty with a few sand grains, pebbles, and erratics, olive gray, cohesive, plastic, slightly calcareous (till)	22	201
	Silt and clay with a few sand grains and pebbles, dusky yellow to olive gray, cohesive, plastic, slightly calcareous (till)	19	220
	Clay, silty with a few sand grains, pebbles and erratics, olive gray, cohesive, plastic, slightly calcareous (till)	50	270
	Sand, fine to coarse, gravelly, subangular to subrounded, moderately sorted; predominantly limestone shale, and quartz;	4	274
Bedrock, undifferentiated:	Clay, silty, olive gray to medium bluish gray, cohesive, plastic, non-calcareous	41	315

Electric Log

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