

ARTESIAN WATER FROM GLACIAL DRIFT
NEAR LEHR, LOGAN AND MC INTOSH COUNTIES,

NORTH DAKOTA

By
D. G. Adolphson
Geological Survey
United States Department of the Interior

NORTH DAKOTA GROUND WATER STUDIES
NO.38

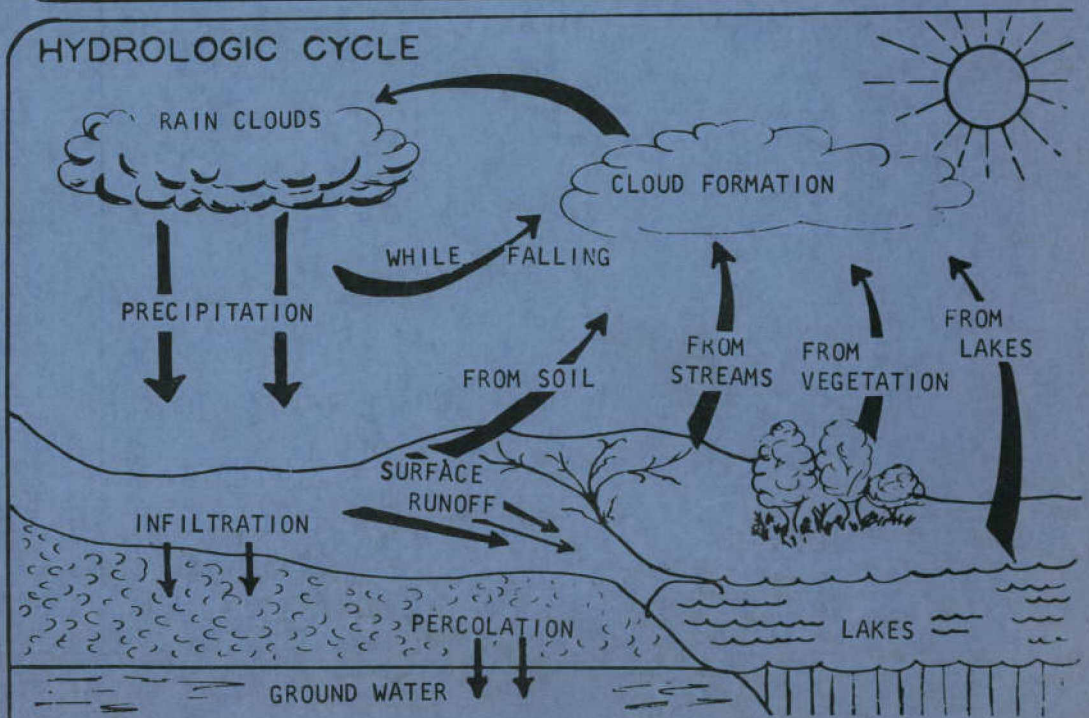
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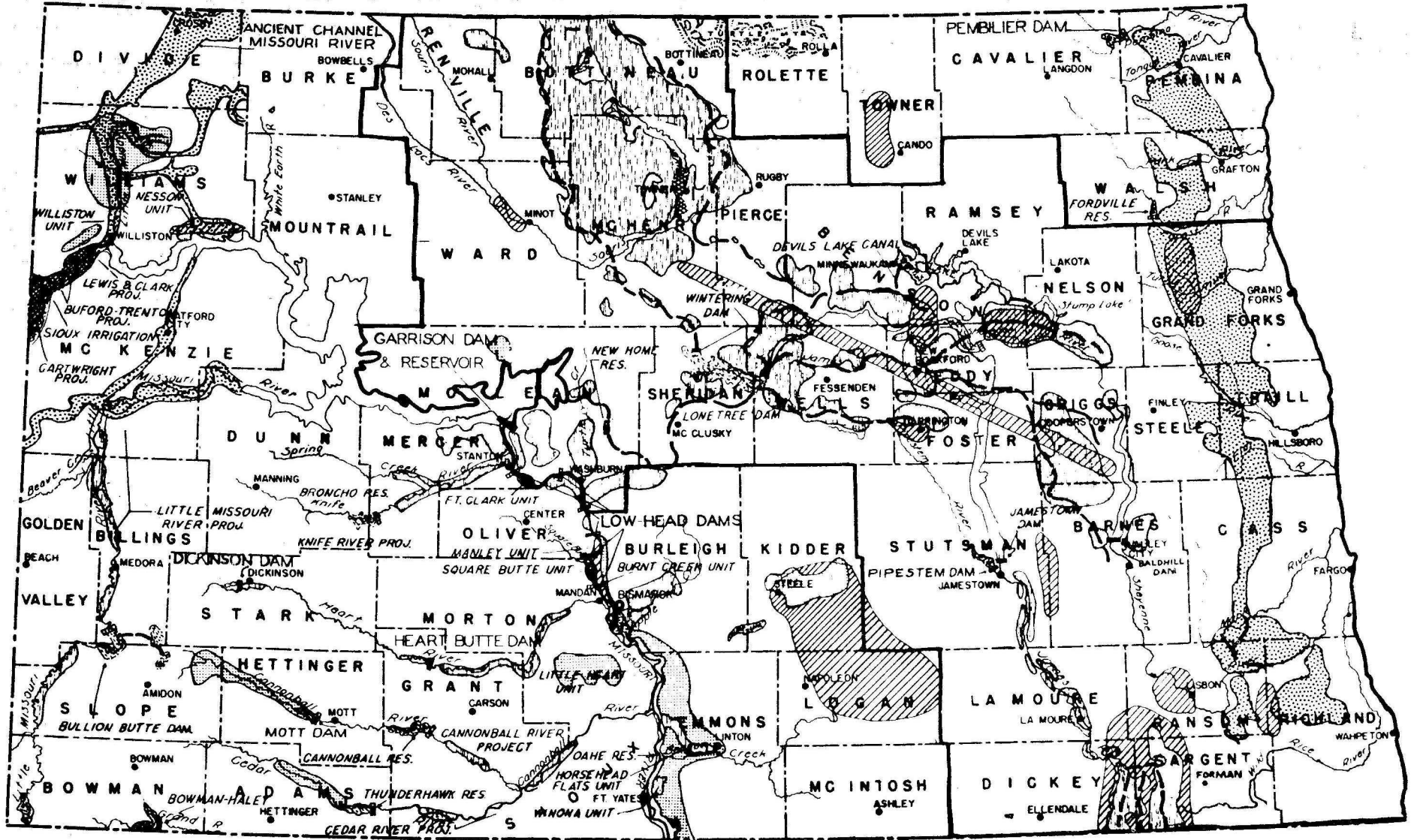
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




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-  AREAS CONSIDERED IRRIGABLE
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E R R A T A

Artesian water from glacial drift near Lehr, Logan
and McIntosh Counties, North Dakota

North Dakota Ground-Water Studies No. 38

Attached are corrections for figure 3 (following page 6) and for pages 14 through 21. They may be stapled over the original pages of your copy(ies) of the report as appropriate.

U. S. Geological Survey
Groundwater Branch
Grand Forks, North Dakota

ARTESIAN WATER FROM GLACIAL DRIFT NEAR LEHR
LOGAN AND McINTOSH COUNTIES, NORTH DAKOTA

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North Dakota State Water Conservation Commission
1301 State Capitol, Bismarck, North Dakota

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ARTESIAN WATER FROM GLACIAL DRIFT NEAR LEHR
LOGAN AND McINTOSH COUNTIES, NORTH DAKOTA

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Introduction

As a part of the cooperative ground-water investigations program, the North Dakota State Water Conservation Commission, the North Dakota Geological Survey, and the United States Geological Survey make studies of the ground-water resources available for municipal use in various parts of North Dakota. Investigations are made of small areas surrounding towns which have requested aid from the North Dakota State Water Conservation Commission or the State Geologist. When adequate funds become available, more complete investigations will be made of larger areas, such as counties. Reports on these larger areas will include the results of the small municipal water-supply studies.

The field work for this investigation was done in 1956 and data from the test drilling and the analysis of a quality-of-water sample were released to the North Dakota State Water Conservation Commission at that time. The plan at that time was to publish the data with results from an areal ground-water investigation of a larger region. However, as a more comprehensive regional study has not been initiated, this report was prepared in 1960. The field work consisted of test drilling with a rig owned by the State Water Conservation Commission. A total of 17 test holes were drilled to depths ranging from 100 to 450 feet and averaging 175 feet. Samples of the formations were taken from each 5-foot interval. A sample of ground water was obtained from one test hole, and a chemical analysis was made by the North Dakota State Laboratories Department.

Location and Extent of Area

Lehr, which has a population of 381 (1960 census), is at the northern edge of McIntosh and the southern edge of Logan Counties in south-central North Dakota. It is served by the Minneapolis, St. Paul Sault Ste. Marie Railroad and State Highways 30 and 13. Approximately 16 square miles, parts of T. 133 N., Rs. 69 and 70 W., and T. 132 N., Rs. 69 and 70 W., are included in the area described in this report.

The area (fig. 1) is in the glaciated part of the Missouri Plateau physiographic province of Simpson (1929, p. 10-11), which consists of a broad belt of morainic ridges and hills (sometimes referred to as the Altamont Moraine) formed by one of the advances of the Wisconsin ice sheet in the Pleistocene Epoch. This belt of moraines, which is characterized by numerous undrained depressions, trends southeastward across North Dakota. The undrained depressions in the Lehr area are occupied by swamps, but after heavy precipitation these may become intermittent lakes or ponds. The average annual precipitation in the Lehr area is about $16\frac{1}{2}$ inches.

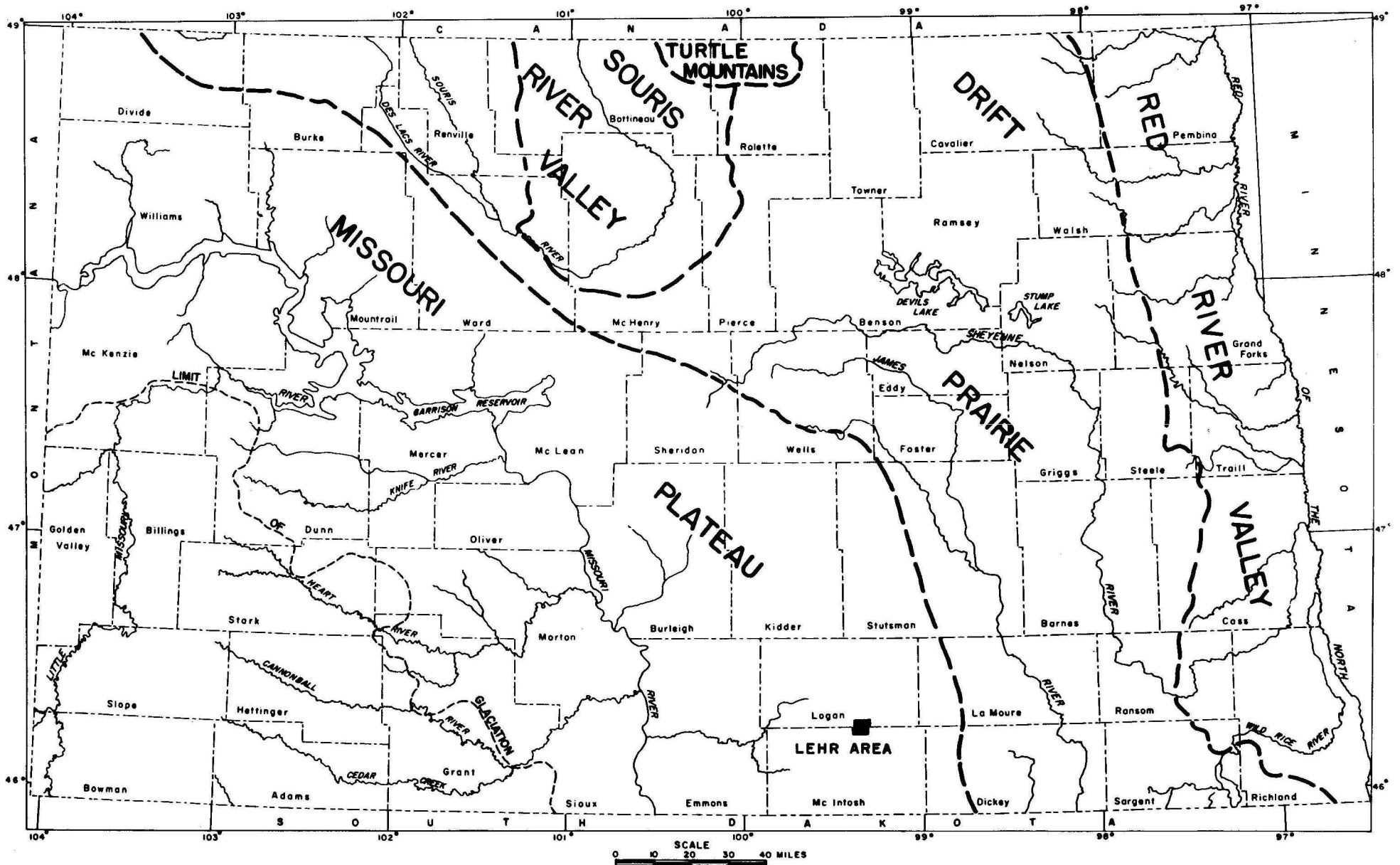
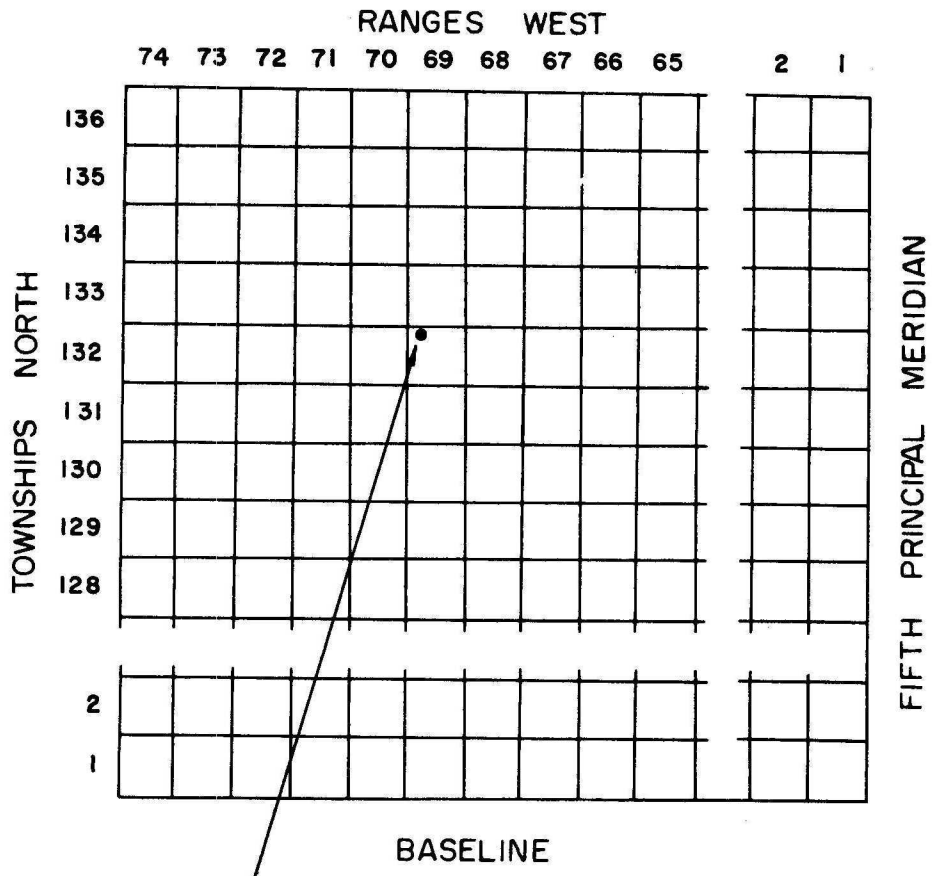


FIGURE 1-- PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA AND LOCATION OF THE LEHR AREA
(MODIFIED FROM SIMPSON, 1929)

Well-Numbering System

The well-numbering system used in this report, illustrated in figure 2, is based upon the location of the well in the federal system of rectangular surveys of the public lands. The first numeral denotes the township north of the base line, the second numeral denotes the range west of the fifth principal meridian, and the third numeral 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 numerals are added if more than one well is shown in a 10-acre tract. Thus, well 132-69-5bad is in the $SE\frac{1}{4}NE\frac{1}{4}NW\frac{1}{4}$ sec. 5, T. 132 N., R. 69 W.



132-69-5 bad

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

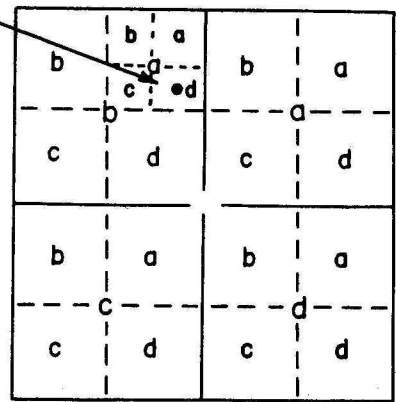


Figure 2 -- Sketch illustrating well-numbering system

Geology and Ground Water

The surface of the Lehr area is covered by unconsolidated deposits of glacial drift consisting primarily of till. Ordinarily till is composed of a heterogeneous mixture of rock material ranging in size from clay to boulders. Because openings or pore spaces between the larger particles of the till are generally filled with fine particles, the unit has low permeability and does not yield water to wells readily. However, isolated deposits or lenses of stratified sand and gravel occur at places within the till, and where these are saturated, they provide a relatively productive source of ground water.

Sand and gravel deposits underlie till or fine-grained glacial material in a shallow valley or depression 1 mile west of Lehr. The sand and gravel deposits, which are saturated with ground water under artesian pressure, are surrounded by relatively impervious till. They were probably laid down by glacial melt water and they may extend continuously along the length of the valley as well as across it; if so, they constitute a relatively extensive aquifer. The sand and gravel deposits penetrated by test holes 1107, 1108, 1109, and 1110 are probably interconnected and delineate at least part of this aquifer. (See figs. 3 and 4, sec. D-D'.) The aquifer has 18 feet of medium to coarse saturated sand and 9 feet of fine to coarse saturated gravel in test hole 1108 (table 2), from which water flowed at the land surface. Probably the aquifer contains sufficient ground water for a municipal supply adequate to meet Lehr's present (1961) needs. Additional test drilling and one or more aquifer tests would be necessary to determine the hydrologic characteristics and to find the boundaries of the deposits.

An analysis of the chemical quality of ground water from test hole 1108 (132-70-lada) is given in table 1. The sampled water is very hard and has an iron content that is substantially higher than generally accepted standards. From studies of the State, however, in neighboring areas, it is apparent that the quality of ground water from glacial drift ranges considerably in character.

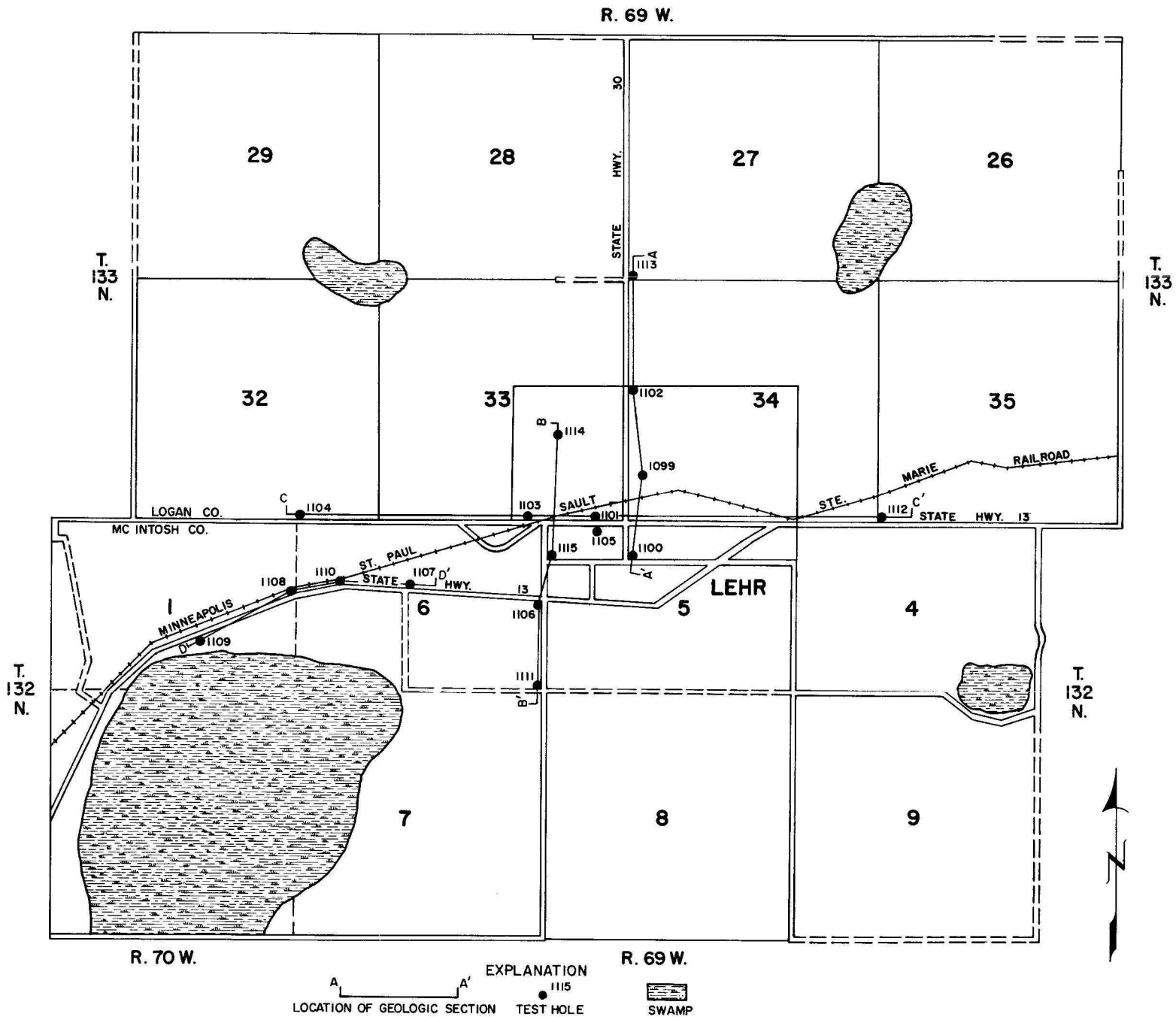


FIGURE 3 --MAP SHOWING LOCATION OF TEST HOLES IN THE LEHR AREA.

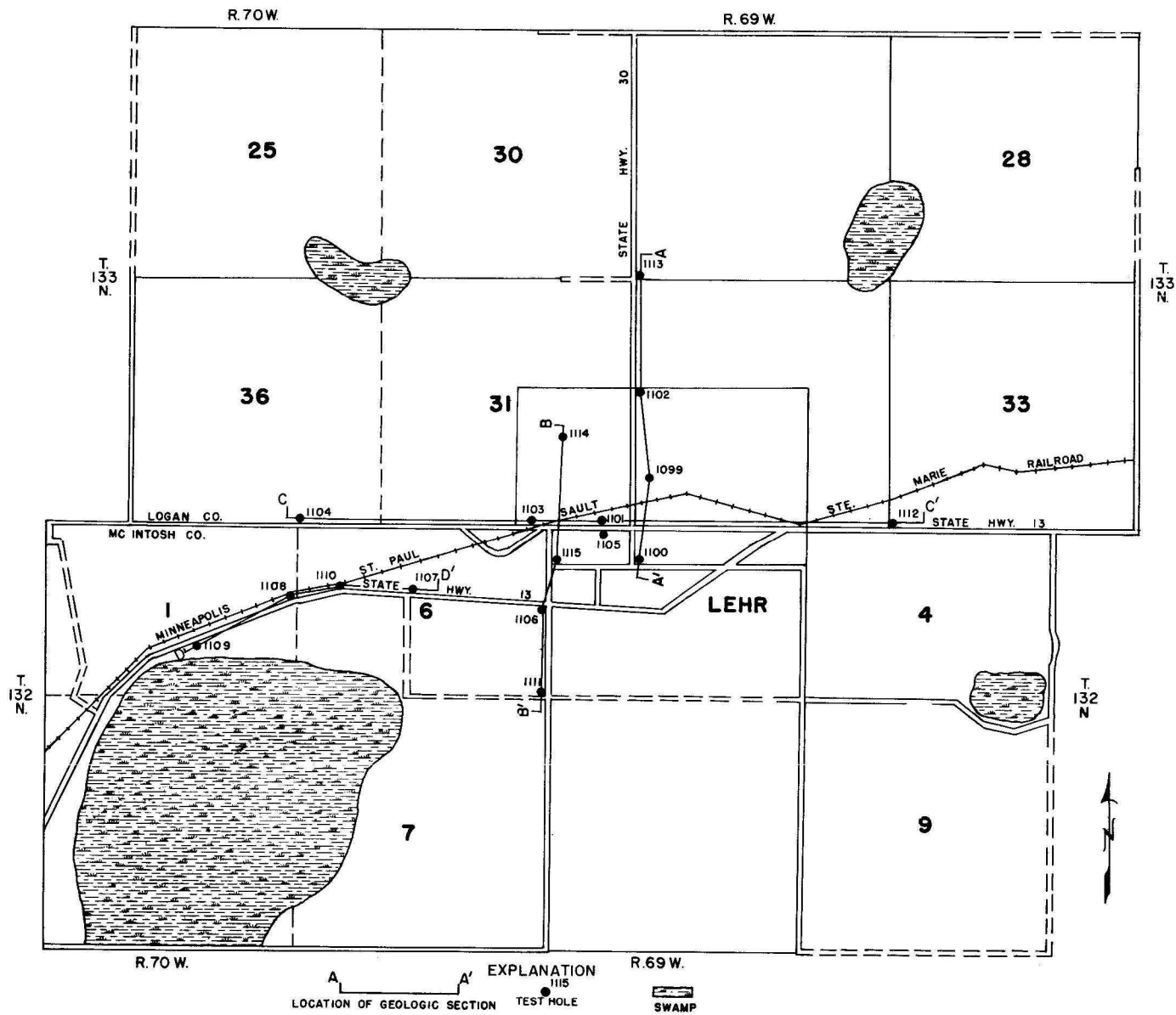


FIGURE 3 --MAP SHOWING LOCATION OF TEST HOLES IN THE LEHR AREA

The Pierre Shale of Late Cretaceous age underlies the glacial drift in the entire area. In the test holes penetrating bedrock, the depth to the Pierre ranges from 55 to 442 feet and averages 153 feet. The Pierre is not a source of water to wells or springs in the area.

Conclusion

Water-yielding deposits in the Lehr area occur as isolated sand and gravel lenses within the till. Ordinarily these lenses are not connected and, therefore, are not sources of large ground-water supplies. In a valley west of Lehr, fine-grained glacial deposits are underlain by what may be a relatively large saturated sand and gravel lens within the till; the aquifer in this lens may yield enough ground water to meet Lehr's present (1961) demands. For a more complete appraisal of the quantity and quality of ground water in the area, additional hydrologic and geologic data are needed.

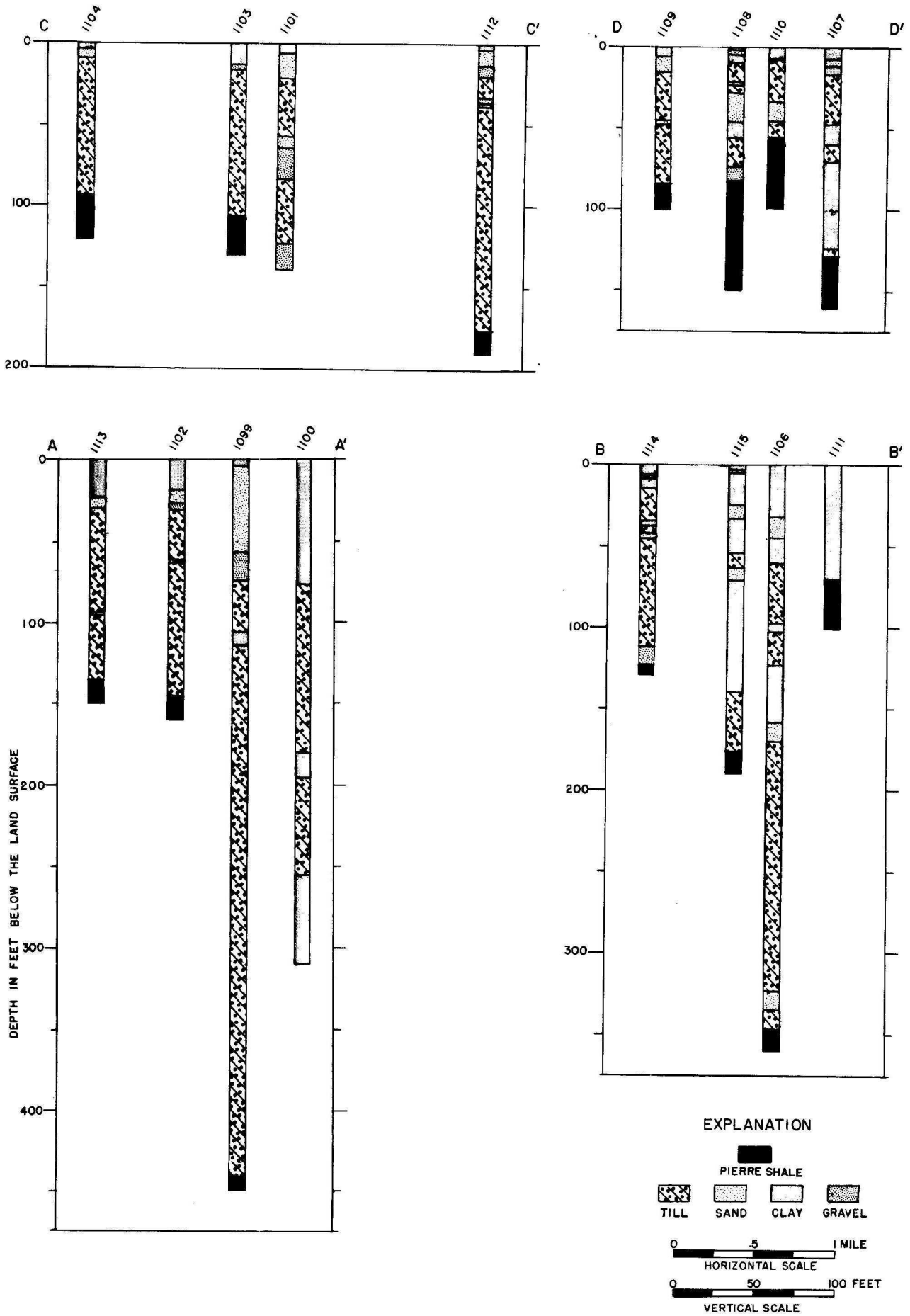


FIGURE 4-- GRAPHIC LOGS OF SELECTED TEST HOLES IN THE LEHR AREA

TABLE 1.--Chemical Analysis of Ground Water

Results in parts per million except as indicated

Well location	Well	Date of collection	Depth to water	Aquifer	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
132-70-1ada	Test hole 1108	4-6-56	Flow	Glacial drift	0.9	106	34	130

a/Includes bicarbonate (HCO_3) as carbonate (CO_3)

From Artesian Test Well Near Lehr, North Dakota

Analysis by North Dakota State Laboratories Department

Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved solids	Sum of deter- mined constituents	Hardness as CaCO ₃	Percent sodium
14	346	0	281	26	0	0.2	0.7	866	763 ^g	404	40

TABLE 2.--Logs of Test Holes

132-69-5bad
Test hole 1100

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, sandy, yellow.....	2	3
	Clay, sandy; fine to medium gravel; and shale pebbles.....	11	14
	Clay, smooth, gray.....	5	19
	Clay, smooth, yellow.....	41	60
	Clay, smooth, gray.....	16	76
	Till, clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	104	180
	Clay, sandy, yellow.....	15	195
	Till, clayey, gray; fine to medium gravel; and shale pebbles.....	60	255
	Clay, smooth, blue-gray.....	10	265
Pierre(?) Shale:	Clay, sandy, blue-gray.....	45	310

132-69-5bba
Test hole 1105

Glacial drift:			
	Topsoil, black.....	2	2
	Clay, smooth, brown.....	3	5
	Clay, yellow; fine to medium gravel; and shale pebbles.....	18	23
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	11	81
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	14	95
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	10	105
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	27	132
Pierre Shale:	Shale, gray.....	18	150

TABLE 2.--Logs of Test Holes -- Continued

132-69-5bbc
Test hole 1115

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, gray.....	1	2
	Clay, yellow; fine to medium gravel; and shale pebbles.....	1	3
	Gravel, fine to medium; clay, yellow..	1	4
	Clay, smooth, yellow.....	10	14
	Clay, smooth, brown.....	10	24
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	9	33
	Clay, yellow; fine to medium gravel; and shale pebbles.....	21	54
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	8	62
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	9	71
	Clay, sand, gray.....	69	140
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	36	176
Pierre(?) Shale:	Clay, sandy, gray.....	14	190

TABLE 2.--Logs of Test Holes -- Continued

132-69-6bca

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Clay, yellow; fine to coarse gravel; and shale pebbles.....	7	7
	Till; clayey, gray; fine to coarse gravel; and shale pebbles.....	26	33
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	12	45
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	10	55
Pierre(?) Shale:	Clay, sandy, gray.....	45	100

132-69-6bdd
Test hole 1107

Glacial drift:			
	Topsoil, black.....	2	2
	Clay, gray.....	1	3
	Clay, yellow, fine to medium gravel.....	4	7
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	4	11
	Clay, yellow; fine to medium gravel; and shale pebbles.....	5	16
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	30	46
	Clay, sandy, gray.....	13	59
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	10	69
	Clay, gray, sandy.....	54	123
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	6	129
Pierre(?) Shale:	Clay, sandy, gray.....	31	160

TABLE 2.--Logs of Test Holes -- Continued

132-69-6daa
Test hole 1106

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, yellow.....	3	4
	Clay, yellow; fine to medium gravel; and shale pebbles.....	27	31
	Sand, fine to coarse; medium gravel; and shale pebbles.....	13	44
	Clay, smooth, yellow.....	9	53
	Clay, smooth, gray.....	6	59
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	38	97
	Clay, sandy, gray.....	5	102
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	20	122
	Clay, sandy, gray.....	35	157
	Sand, fine to coarse; fine gravel; and shale pebbles.....	11	168
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	153	321
	Sand, medium to coarse; fine gravel; and shale pebbles.....	12	333
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	13	346
Pierre(?) Shale:	Shale, gray.....	14	360

132-69-6ddd
Test hole 1111

Glacial drift:			
	Topsoil, black.....	2	2
	Clay, smooth, gray.....	2	4
	Clay, smooth, yellow.....	14	18
	Clay, sandy, blue-gray.....	52	70
Pierre(?) Shale:	Clay, sandy, gray.....	30	100

TABLE 2.--Logs of Test Holes -- Continued

132-70-lada
Test hole 1108

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Clay, sandy, gray.....	2	2
	Sand, fine to coarse; medium to coarse gravel; and shale pebbles.....	3	5
	Clay, yellow; fine to medium gravel; and shale pebbles.....	5	10
	Till, clayey, gray; fine to medium gravel; and shale pebbles.....	11	21
	Sand, medium to coarse; fine gravel; and shale pebbles.....	3	24
	Till, clayey, gray; fine to medium gravel; and shale pebbles.....	4	28
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	18	46
	Clay, sandy, gray.....	10	56
	Till, gravel, fine to medium; clay, gray, and shale pebbles.....	18	74
	Gravel, fine to medium; and shale pebbles.....	9	83
Pierre(?) Shale:			
	Clay, sandy, gray.....	67	150

TABLE 2.--Logs of Test Holes -- Continued

132-70-lada
 Test hole 1108

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Clay, sandy, gray.....	2	2
	Sand, fine to coarse; medium to coarse gravel; and shale pebbles.....	3	5
	Clay, yellow; fine to medium gravel; and shale pebbles.....	5	10
	Till, clayey, gray; fine to medium gravel; and shale pebbles.....	11	21
	Sand, medium to coarse; fine gravel; and shale pebbles.....	3	24
	Till, clayey, gray; fine to medium gravel; and shale pebbles.....	4	28
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	18	46
	Clay, sandy, gray.....	10	56
	Till, gravel, fine to medium; clay, gray, and shale pebbles.....	18	74
	Gravel, fine to medium; and shale pebbles.....	9	83
Pierre(?) Shale:			
	Clay, sandy, gray.....	67	150

TABLE 2.--Logs of Test Holes -- Continued

132-70-1dbd
Test hole 1109

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, gray; fine to medium gravel; and shale pebbles.....	2	3
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	6
	Sand, fine to coarse; gravel, fine to medium; and shale pebbles.....	9	15
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	30	45
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	3	48
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	37	85
Pierre(?) Shale:	Clay, sandy, gray.....	15	100

133-69-27ccc
Test hole 1113

Glacial drift:			
	Topsoil, black.....	2	2
	Clay, sandy, brown.....	4	6
	Clay, yellow; fine to medium gravel; and shale pebbles.....	17	23
	Sand, fine to medium; medium to coarse gravel; cobblestones; and shale pebbles.....	7	30
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	63	93
	Gravel, fine to medium; and shale pebbles.....	2	95
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	39	134
Pierre(?) Shale:	Clay, sandy, gray.....	16	150

TABLE 2.--Logs of Test Holes -- Continued

132-70-1dbd
Test hole 1109

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, gray; fine to medium gravel; and shale pebbles.....	2	3
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	6
	Sand, fine to coarse; gravel, fine to medium; and shale pebbles.....	9	15
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	30	45
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	3	48
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	37	85
Pierre(?) Shale:	Clay, sandy, gray.....	15	100

133-69-29ccc
Test hole 1113

Glacial drift:			
	Topsoil, black.....	2	2
	Clay, sandy, brown.....	4	6
	Clay, yellow; fine to medium gravel; and shale pebbles.....	17	23
	Sand, fine to medium; medium to coarse gravel; cobblestones; and shale pebbles.....	7	30
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	63	93
	Gravel, fine to medium; and shale pebbles.....	2	95
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	39	134
Pierre(?) Shale:	Clay, sandy, gray.....	16	150

TABLE 2.--Logs of Test Holes -- Continued

133-69-32cd
 Test hole 1104

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, dark-gray.....	1	2
	Clay, gray; fine to medium gravel.....	2	4
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	6	10
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	9	19
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	51	70
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	24	94
Pierre Shale:	Shale, gray.....	26	120

TABLE 2.--Logs of Test Holes -- Continued

133-69-31dbd
Test hole 1114

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	2	2
	Clay, gray.....	1	3
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	6
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	2	8
	Clay, yellow; fine to medium gravel; and shale pebbles.....	6	14
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	20	34
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	37
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	4	41
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	3	44
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	66	110
	Gravel, fine to medium; and shale pebbles.....	13	123
Pierre(?) Shale:	Clay, sandy, gray.....	7	130

TABLE 2.--Logs of Test Holes -- Continued

133-69-33abd
Test hole 1114

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	2	2
	Clay, gray.....	1	3
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	6
	Sand, medium to coarse; fine to medium gravel; and shale pebbles.....	2	8
	Clay, yellow; fine to medium gravel; and shale pebbles.....	6	14
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	20	34
	Clay, yellow; fine to medium gravel; and shale pebbles.....	3	37
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	4	41
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	3	44
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	66	110
	Gravel, fine to medium; and shale pebbles.....	13	123
Pierre(?) Shale:	Clay, sandy, gray.....	7	130

TABLE 2.--Logs of Test Holes -- Continued

133-69-31dcd
Test hole 1103

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, dark-gray; fine to medium gravel.	2	3
	Clay, yellow; fine to medium gravel....	4	7
	Clay, smooth, yellow.....	6	13
	Gravel, fine to medium; shale pebbles..	4	17
	Clay, yellow; fine to medium gravel; and shale pebbles.....	7	24
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	43	67
	Till; gravel, fine to medium; clay, gray; and shale pebbles.....	18	85
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	21	106
Pierre Shale:			
	Shale, gray.....	24	130

TABLE 2.--Logs of Test Holes -- Continued

133-69-33dcd
Test hole 1103

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, dark-gray; fine to medium gravel.	2	3
	Clay, yellow; fine to medium gravel....	4	7
	Clay, smooth, yellow.....	6	13
	Gravel, fine to medium; shale pebbles..	4	17
	Clay, yellow; fine to medium gravel; and shale pebbles.....	7	24
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	43	67
	Till; gravel, fine to medium; clay, gray; and shale pebbles.....	18	85
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	21	106
Pierre Shale:			
	Shale, gray.....	24	130

TABLE 2.--Logs of Test Holes -- Continued

133-69-31ddc
Test hole 1101

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	4	4
	Clay, yellow; fine to medium gravel; and shale pebbles.....	2	6
	Sand, fine to coarse; fine gravel; and shale pebbles.....	9	15
	Sand, fine to medium; fine gravel, and shale pebbles.....	7	22
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	35	57
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	8	65
	Gravel, fine; fine to coarse sand; and shale pebbles.....	19	84
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	38	122
	Gravel, fine to medium, and shale pebbles.....	18	140

TABLE 2.--Logs of Test Holes -- Continued

133-69-33ddc
Test hole 1101

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	4	4
	Clay, yellow; fine to medium gravel; and shale pebbles.....	2	6
	Sand, fine to coarse; fine gravel; and shale pebbles.....	9	15
	Sand, fine to medium; fine gravel, and shale pebbles.....	7	22
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	35	57
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	8	65
	Gravel, fine; fine to coarse sand; and shale pebbles.....	19	84
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	38	122
	Gravel, fine to medium, and shale pebbles.....	18	140

TABLE 2.--Logs of Test Holes -- Continued

133-69-32bcc
Test hole 1102

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, dark-gray.....	2	3
	Clay, gray; fine to medium gravel; and shale pebbles.....	4	7
	Clay, smooth, gray.....	12	19
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	7	26
	Gravel, fine to medium; and shale pebbles.....	4	30
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	30	60
	Sand, medium to coarse; fine to medium gravel.....	2	62
	Till; clay, gray, fine to medium gravel; and shale pebbles.....	68	130
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	15	145
Pierre Shale:	Shale, gray.....	15	160

TABLE 2.--Logs of Test Holes -- Continued

133-69-3¹/₄bcc
 Test hole 1102

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, dark-gray.....	2	3
	Clay, gray; fine to medium gravel; and shale pebbles.....	4	7
	Clay, smooth, gray.....	12	19
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	7	26
	Gravel, fine to medium; and shale pebbles.....	4	30
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	30	60
	Sand, medium to coarse; fine to medium gravel.....	2	62
	Till; clay, gray, fine to medium gravel; and shale pebbles.....	68	130
	Till; gravel, fine to medium; gray clay (large proportion of gravel); and shale pebbles.....	15	145
Pierre Shale:	Shale, gray.....	15	160

TABLE 2.--Logs of Test Holes -- Continued

133-69-32ccb
Test hole 1099

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, gray.....	3	4
	Sand, fine to coarse; gravel; and shale pebbles.....	12	16
	Sand, fine.....	5	21
	Sand, fine to coarse; fine gravel; gray clay; and shale pebbles.....	11	32
	Gravel, fine to medium; gray clay; and fine sand.....	18	50
	Till; clayey, gray, fine to medium gravel; and shale pebbles.....	10	60
	Till; clayey, gray; fine gravel (large proportion of gravel); and shale pebbles.....	5	65
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	16	81
	Clay, sandy, gray.....	7	88
	Till; gravel, fine to medium; gray clay (large proportion of gravel)...	47	135
	Till; gravel, fine to medium; gray clay; lignite fragments; and shale pebbles (large proportion of gravel)	115	250
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	30	280
	Till; clayey, smooth, gray; fine to medium gravel; lignite fragments; and shale pebbles (proportion of clay in samples increases in depth).....	110	390
	Till; clayey, blue-gray; fine to medium gravel; lignite fragments; and shale pebbles.....	52	442
Pierre Shale:	Shale, gray.....	8	450

TABLE 2.--Logs of Test Holes -- Continued

133-69-34ccb
 Test hole 1099

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, gray.....	3	4
	Sand, fine to coarse; gravel; and shale pebbles.....	12	16
	Sand, fine.....	5	21
	Sand, fine to coarse; fine gravel; gray clay; and shale pebbles.....	11	32
	Gravel, fine to medium; gray clay; and fine sand.....	18	50
	Till; clayey, gray, fine to medium gravel; and shale pebbles.....	10	60
	Till; clayey, gray; fine gravel (large proportion of gravel); and shale pebbles.....	5	65
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	16	81
	Clay, sandy, gray.....	7	88
	Till; gravel, fine to medium; gray clay (large proportion of gravel)...	47	135
	Till; gravel, fine to medium; gray clay; lignite fragments; and shale pebbles (large proportion of gravel)	115	250
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	30	280
	Till; clayey, smooth, gray; fine to medium gravel; lignite fragments; and shale pebbles (proportion of clay in samples increases in depth).....	110	390
	Till; clayey, blue-gray; fine to medium gravel; lignite fragments; and shale pebbles.....	52	442
Pierre Shale:	Shale, gray.....	8	450

TABLE 2.--Logs of Test Holes -- Continued

133-69-33ccc
 Test hole 1112

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Clay, sandy, brown; fine to medium gravel.....	1	1
	Clay, sandy, yellow; fine to medium gravel.....	2	3
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	10	13
	Gravel, fine to medium; and shale pebbles.....	6	19
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	12	31
	Sand, fine to coarse; fine gravel; and shale pebbles.....	3	34
	Gravel, fine to medium; and shale pebbles.....	3	37
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	69	106
	Till; clayey, gray; medium to coarse sand; fine to medium gravel, and shale pebbles.....	11	117
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	59	176
Pierre(?) Shale:	Clay, sandy, gray.....	14	190

TABLE 2.--Logs of Test Holes -- Continued

133-69-35ccc
Test hole 1112

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Clay, sandy, brown; fine to medium gravel.....	1	1
	Clay, sandy, yellow; fine to medium gravel.....	2	3
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	10	13
	Gravel, fine to medium; and shale pebbles.....	6	19
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	12	31
	Sand, fine to coarse; fine gravel; and shale pebbles.....	3	34
	Gravel, fine to medium; and shale pebbles.....	3	37
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	69	106
	Till; clayey, gray; medium to coarse sand; fine to medium gravel, and shale pebbles.....	11	117
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	59	176
Pierre(?) Shale:	Clay, sandy, gray.....	14	190

TABLE 2.--Logs of Test Holes -- Continued

133-70-36dcd
Test hole 1104

<u>Formation</u>	<u>Material</u>	<u>Thickness</u> (feet)	<u>Depth</u> (feet)
Glacial drift:			
	Topsoil, black.....	1	1
	Clay, smooth, dark-gray.....	1	2
	Clay, gray; fine to medium gravel.....	2	4
	Sand, fine to coarse; fine to medium gravel; and shale pebbles.....	6	10
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	9	19
	Till; clayey, gray; fine to medium gravel; lignite fragments; and shale pebbles.....	51	70
	Till; clayey, gray; fine to medium gravel; and shale pebbles.....	24	94
Pierre Shale:			
	Shale, gray.....	26	120

Reference

Simpson, H. E., 1929, Geology and ground-water resources of North Dakota, with a discussion of the chemical character of the water, by H. B. Riffenburg: U.S. Geol. Survey Water-Supply Paper 598, 312 p.