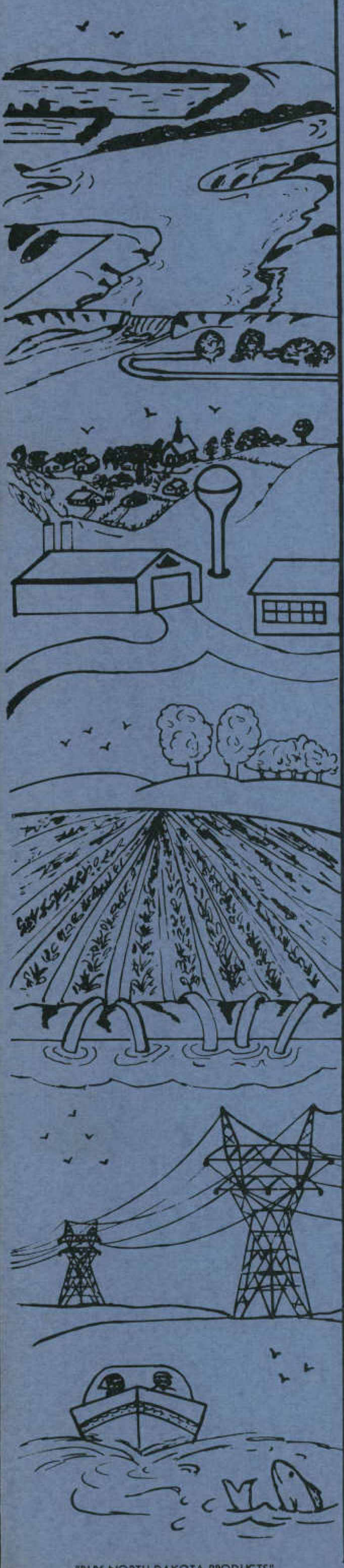

GROUND WATER NEAR HOOPLE WALSH AND PEMBINA COUNTIES NORTH DAKOTA

By
H. M. Jensen and Edward Bradley
Geological Survey
United States Department of the Interior

NORTH DAKOTA GROUND WATER STUDIES

NO. 49

Prepared by the United States Geological Survey in cooperation with the North Dakota State Water Conservation Commission

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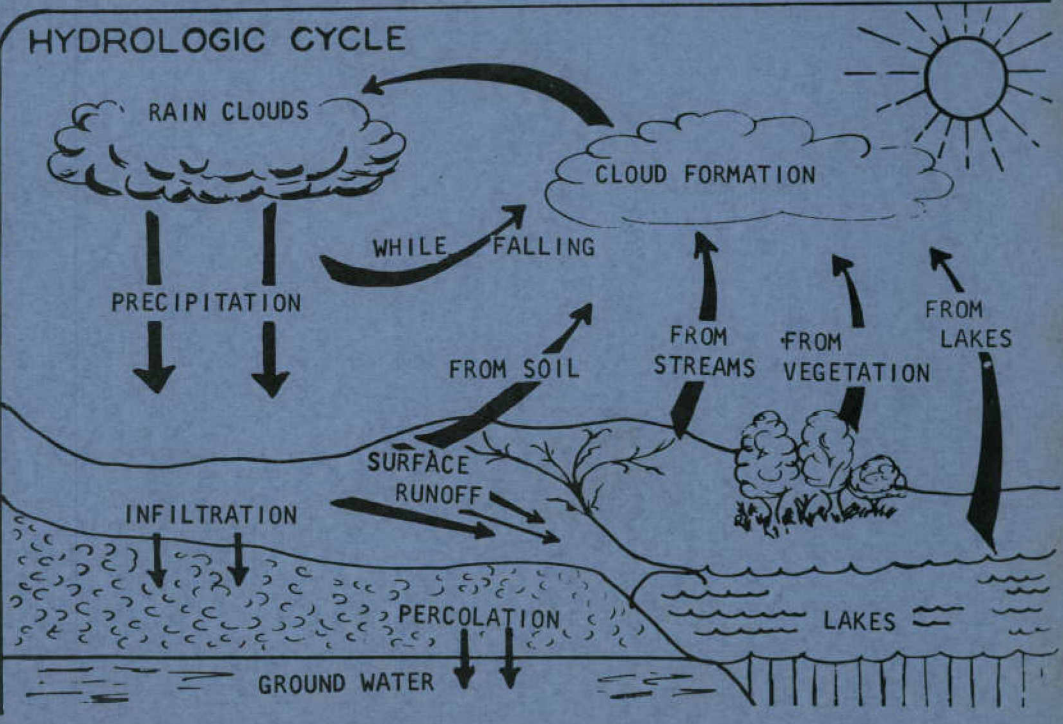

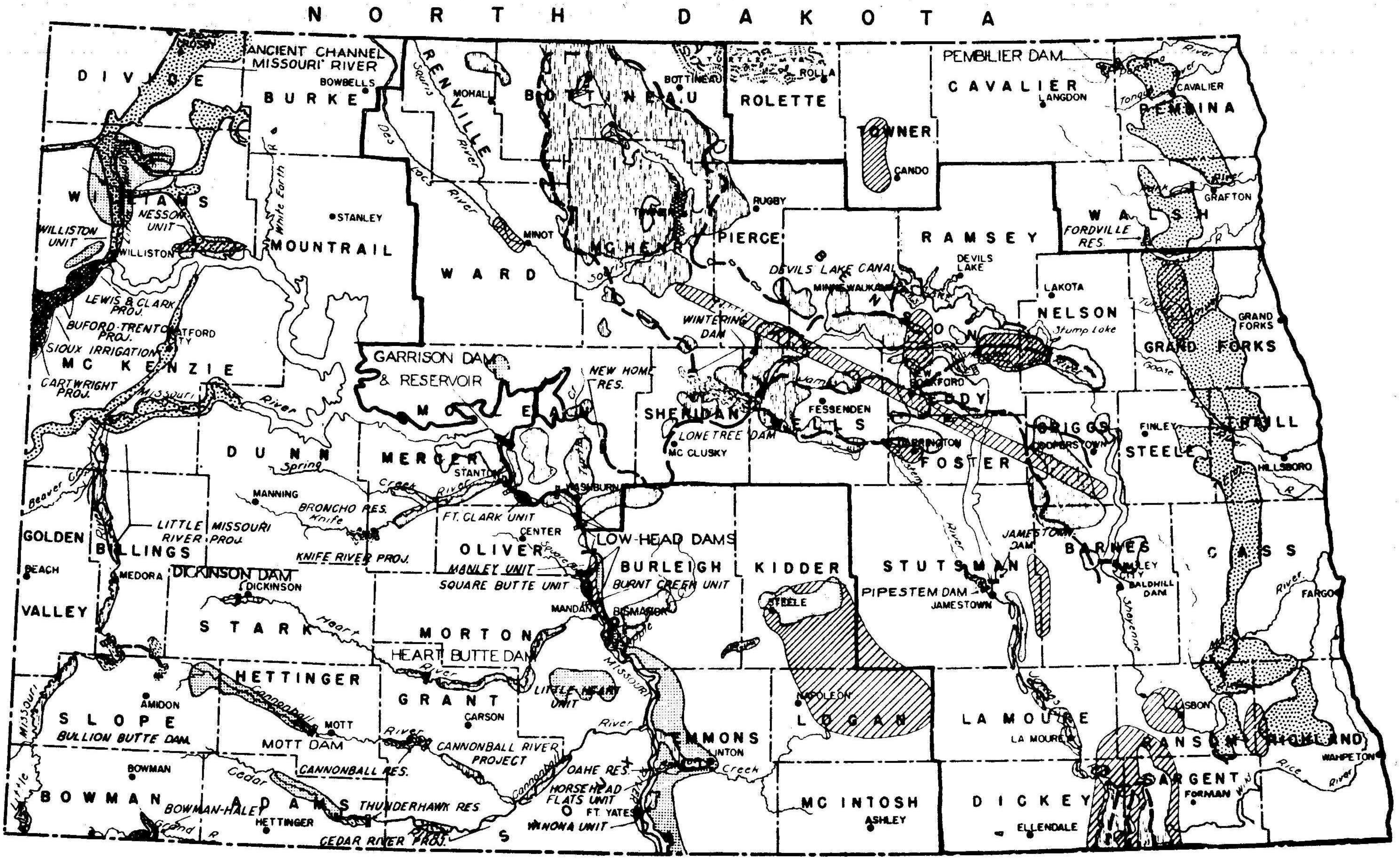

NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

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GROUND WATER NEAR HOOPLE, WALSH AND PEMBINA COUNTIES, NORTH DAKOTA

By
H. M. Jensen and Edward Bradley

Introduction

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

The present investigation, which began in 1959, was made at the request of the city council of Hoople. It included test drilling, inventory of selected wells (table 1), evaluation of available geologic and hydrologic data, and preparation of this report.

The well-numbering system, illustrated in figure 1, is based on the Federal system of rectangular surveys of public lands. The first numeral denotes the township north of the base line which extends laterally across the middle of Arkansas, and the second numeral denotes the range west of the fifth principal meridian; 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, test hole or spring is shown in a given 10-acre tract or quarter-quarter section. Thus, a well numbered 158-55-15daa (fig. 1) would be in the northeast quarter of the northeast quarter of the southeast quarter, sec. 15, T. 158 N., R. 55 W.

Geography

The Hoople area is in the Red River Valley, which is a relatively flat-lying glacial-lake plain that slopes gently toward the Red River. (See fig. 2.) The report area includes 104 square miles surrounding and largely west of Hoople, which had a population of 334 in 1960. Beaches and other shoreline deposits, which mark successive stages of glacial Lake Agassiz, cross the Hoople area in a north-south direction. The most prominent of these features are those west of the McCauleyville Beach, about 6 miles west of Hoople. From the McCauleyville Beach eastward, the shoreline features are minor undulating swells that seldom are more than a few feet above the lake plain. The climate in the Hoople area is sub-humid. The average annual precipitation is about 20 inches.

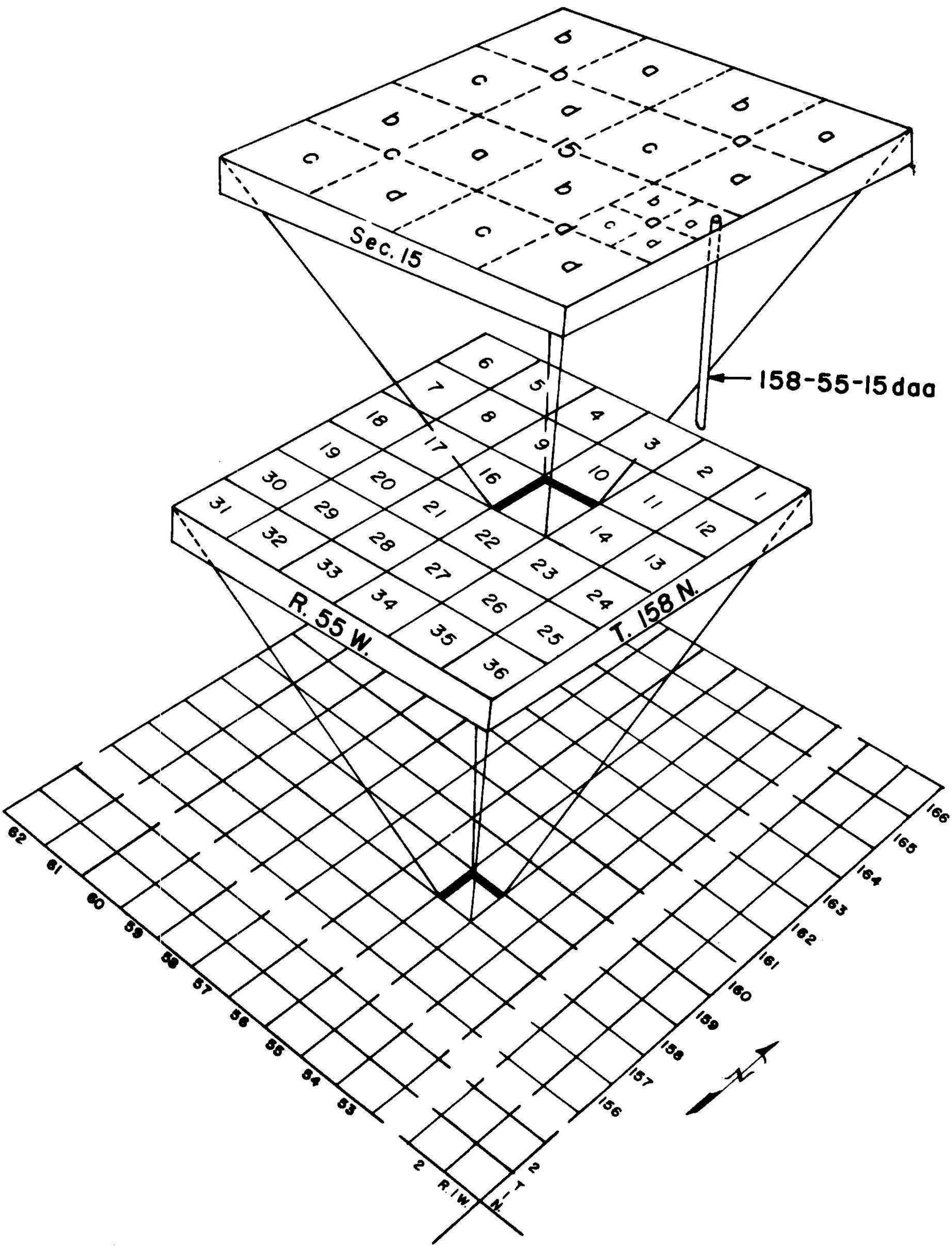

FIGURE 1 --SYSTEM OF NUMBERING SPRINGS, WELLS, AND TEST HOLES.

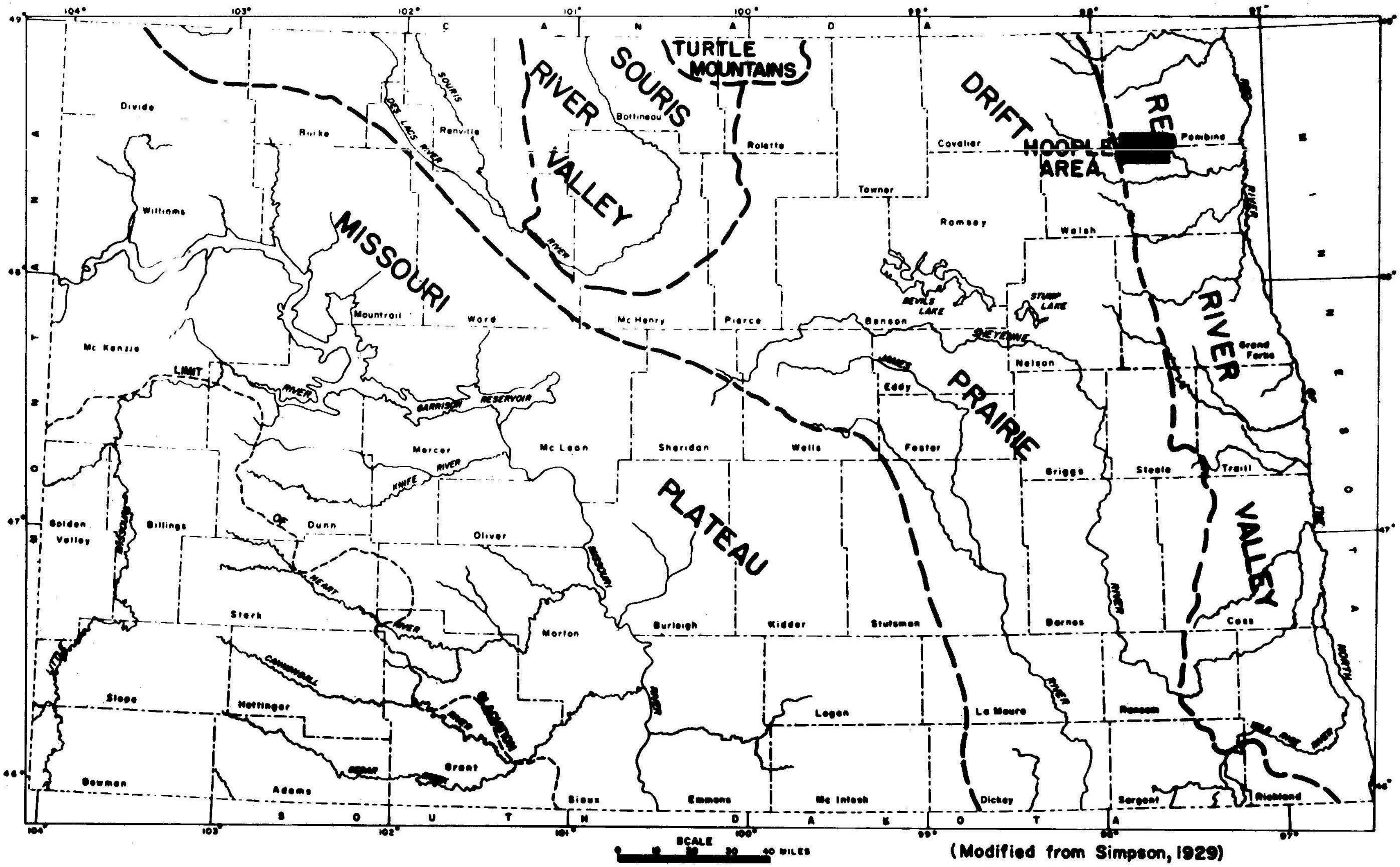

FIGURE 2--MAP SHOWING PHYSIOGRAPHIC PROVINCES OF NORTH DAKOTA AND LOCATION OF THE HOOPLE AREA

Surface drainage, which is intermittent, is through the Middle Branch and North Branch of the Park River and through Cart Creek. (See fig. 3.) The channel of the Middle Branch of the Park River west of the McCauleyville Beach is deeply incised in glacial drift and can carry a large amount of runoff from spring snowmelt and heavy rains; however, all the stream channels east of the McCauleyville Beach are narrow and shallow. Heavy runoff often overflows these channels and floods the surrounding lake plain. During most of the year, however, the channels are dry or contain only small ponds and marshes.

Geology and Ground-Water Conditions

In the Hoople area ground water occurs in Recent alluvium, Pleistocene glacial drift, and bedrock. The glacial drift is divided into deposits of glacial Lake Agassiz and till and associated sand and gravel. The Lake Agassiz deposits may be subdivided into beach deposits and silt and clay. The youngest bedrock in the area is composed of shale and sand of Cretaceous age. Study of available geologic, hydrologic, and quality-of-water information prior to test drilling showed that water of suitable quality for municipal use would most likely be found in aquifers in the beach or shore deposits; therefore, many of the test holes were located on or near the beach ridges. (See fig. 3.)

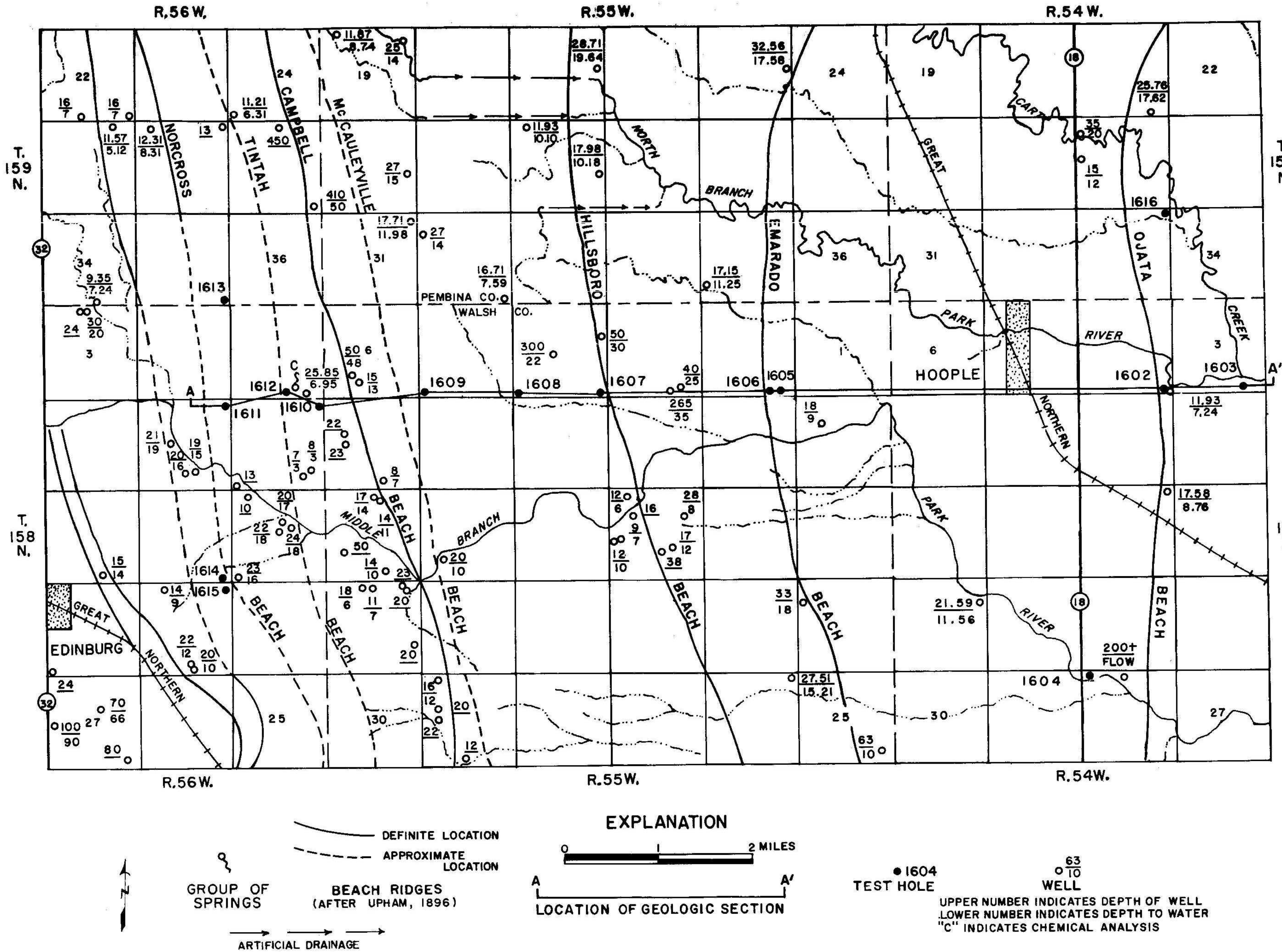

FIGURE 3--MAP OF THE HOOPLE AREA SHOWING LOCATION OF WELLS, TEST HOLES, SPRINGS, BEACHES, AND GEOLOGIC SECTION.

Recent alluvium

Recent alluvial deposits occupy the principal drainage channels in the area. The deposits range in thickness from 0 to about 5 feet and contain thin beds of silt, clay, and small amounts of fine sand. Because the deposits are small in areal extent and relatively impermeable, they yield little water to wells.

Pleistocene glacial drift

Deposits of glacial Lake Agassiz.--Beach or shore deposits overlie deposits of lacustrine silt and clay and till and associated sand and gravel. The deposits consist of variable concentrations of sand and gravel and (or) silt or clay. Test hole 1611 (158-56-11aaa) penetrated 30 feet of sand and gravel; lesser thicknesses were penetrated in other test holes west of the Campbell Beach (fig. 3 and table 2). Test drilling showed that east of the Campbell Beach the deposits are composed primarily of silt and clay.

The more permeable sand and (or) gravel sections of the beach or shore deposits generally yield sufficient water to wells for domestic and farm use. Springs located about 8 miles west of Hoople in sec. 1, T. 158 N., R. 56 W. discharge from permeable deposits of the Tintah Beach and perhaps other beach ridges west of the Tintah Beach. The discharge of several springs forms a run or small stream that flows eastward beyond the Campbell Beach. In 1959 at one location the discharge was 120 gpm (gallons per minute) on April 22, 27 gpm on August 19, and 86 gpm on November 3. These measurements show the seasonal variation in the discharge and thus the probable fluctuation of the quantity of water available to wells from the beach deposits.

Probably a single well in the beach or shore deposits would not yield enough water for municipal needs; further investigation, however, might locate an area where a series of wells with a collection system could furnish enough water for a small town. The area of springs located in sec. 1, T. 158 N., R. 56 W. warrants further study as a possible source of supply for Hoople.

The silt and clay deposits of Lake Agassiz are generally laminated; some layers contain thin stringers of sand. Test hole 1602 (158-54-4ddd2) penetrated 131 feet of the deposits (fig. 4). Thicker deposits probably occur eastward toward the axis of the Red River Valley. The material as a whole is relatively impermeable and does not ordinarily yield enough water for withdrawal by wells.

Till and associated sand and gravel deposits.--Till and associated sand and gravel deposits were penetrated in most of the test holes (table 2). Two test holes, 1608 and 1610, (158-55-4ccc and 158-56-12aaa) penetrated 158 feet of the deposits. The till is an unstratified, heterogeneous mixture of clay, sand, gravel, and boulders. Because it is composed of unsorted material and because the spaces between the larger particles are filled with finer materials, till does not ordinarily yield water readily to wells.

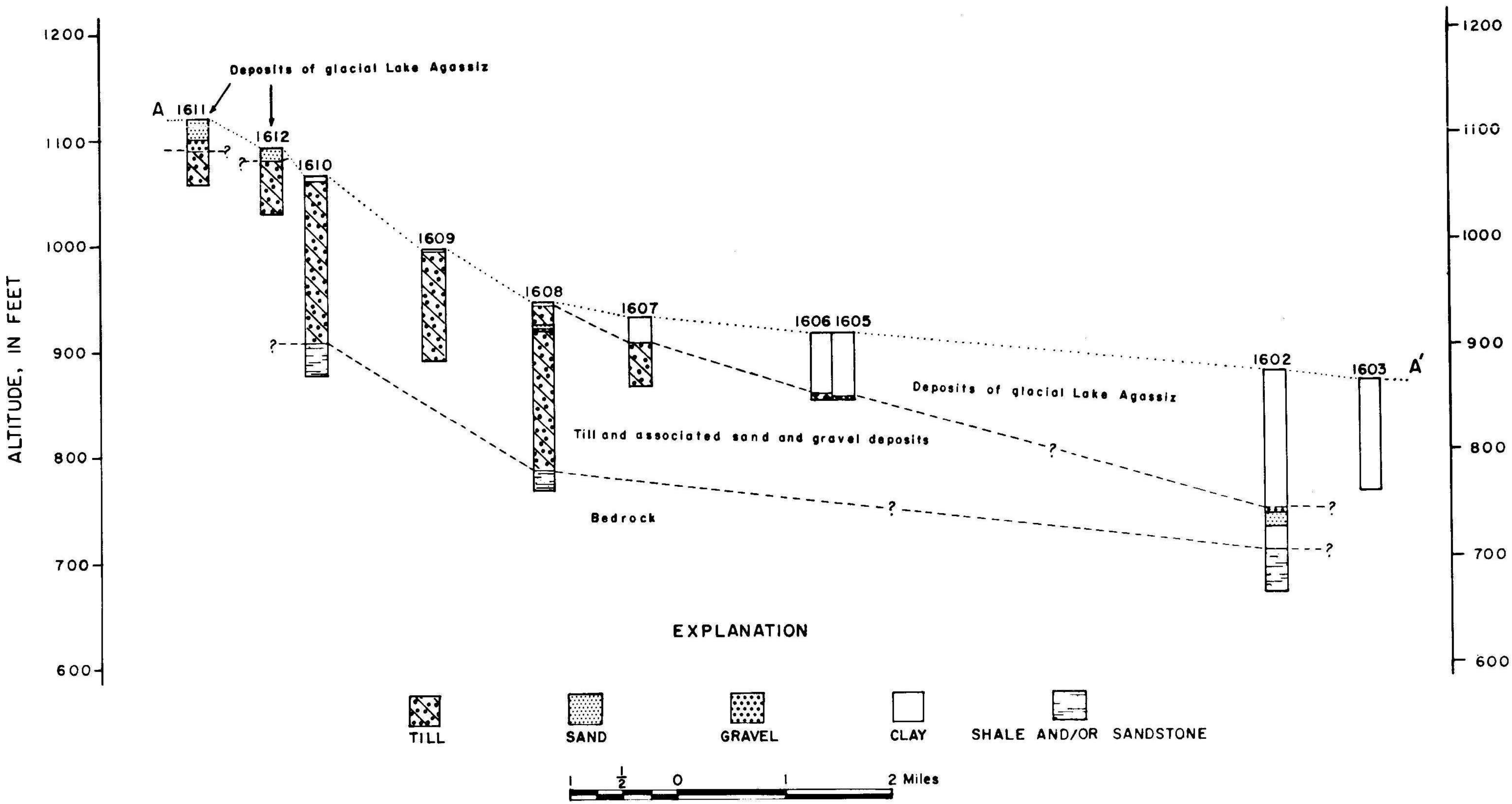

FIGURE 4--GEOLOGIC SECTION IN THE HOOPLE AREA

Stratified sand and gravel deposits associated with the till were formed as alluvial deposits by local melt water of glacial streams. The deposits are not exposed and can be found only by test drilling. Test holes 1608 and 1602 penetrated stratified sand and gravel deposits 10 and 17 feet thick respectively. Many of the stratified deposits contain ground water and are small isolated aquifers; but, because they are completely surrounded by till, they are replenished relatively slowly. The deposits yield only small quantities of water -- generally enough for domestic and farm use.

Bedrock formations

Rocks of Cretaceous and Paleozoic age underlie the glacial drift in the Hoople area. The Dakota(?) Sandstone of Early Cretaceous age contains one or more aquifers and lies between 200 and 500 feet below the land surface in the report area. The formation yields small quantities of water to wells, and, although it has a high dissolved-solids content (ordinarily more than 3,000 parts per million), it is used for general domestic and farm uses at some places. Paleozoic rocks, which contain water with a high dissolved-solids content, are tapped by a well at Grafton, about 15 miles southeast of Hoople (Simpson, 1929, p. 246). These rocks probably underlie the Dakota(?) Sandstone in the Hoople area, but they are not known to be penetrated by wells.

Quality of Water

An analysis of water collected from a spring located in the SW$\frac{1}{4}$ of the SE$\frac{1}{4}$ of sec. 1, T. 158 N., R. 56 W. is reported as follows by the State Laboratories Department, Bismarck, N. Dak.:

	Concentration (ppm)
Iron (Fe)	.22
Calcium (Ca)	56
Magnesium (Mg)	30
Sodium (Na)	20
Potassium (K)	3.5
Bicarbonate (HCO_3)	254
Carbonate (CO_3)	14
Sulfate (SO_4)	74
Boron (B)	0.2
Chloride (Cl)	11
Fluoride (F)	0.3
Nitrate (NO_3)	1.6
Dissolved Solids	
Residue at 100°C	403
Residue after ignition	334

Drilled and dug wells at numerous farmsteads in the area obtain water of reported similar quality from the aquifers in the beach or shore deposits.

Aquifers in the till and associated sand and gravel deposits and in the bedrock generally yield water that has a higher dissolved-solids content than the water of beach or shore deposits; therefore, it is less suitable for domestic or public supply use.

Summary and Conclusions

Deposits of Recent alluvium found in the drainage channels in the Hoople area consist primarily of silt and clay. The deposits are relatively impermeable and are not a good source of water for wells.

Glacial drift in the area consists of deposits of Lake Agassiz and till and associated sand and gravel. Lake Agassiz deposits include (1) beach or shore deposits and (2) silt and clay deposits. The lacustrine deposits are relatively impermeable and are not generally sources of ground water. Beach or shore deposits contain small quantities of ground water at shallow depths from which numerous farm wells obtain enough water for general domestic and farm use. Springs about 8 miles west of Hoople discharge water from the deposits, but the yield fluctuates seasonally. The feasibility of installing a series of shallow wells with a collection system in this spring area should be considered as a possible municipal supply for Hoople. The quality of water from beach or shore deposits is satisfactory for most uses.

Lenticular sand and gravel deposits associated with the glacial till generally are aquifers. The deposits yield sufficient water for domestic or farm supplies, but the water has a high dissolved-solids content (generally more than 2,000 ppm). Deposits capable of supplying enough water for Hoople were not located by the test drilling.

Small supplies of water may be obtained from the Dakota(?) Sandstone of Cretaceous age. The water from this formation, however, has a high dissolved-solids content and would be of very poor quality for municipal use. Paleozoic rocks, although not penetrated by test holes, probably are present in the area and would also yield water with a high dissolved-solids content.

TABLE 1.--Records of wells,

Depth of well and depth to water: Measured depths are given in feet, tenths, and (or) hundredths; reported depths are given in feet.

Type of well: Dr, drilled; Du, dug; Sp, spring or springs.

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed
158-54					
3ddc	Test hole 1603	105	5	Dr	9-24-59
4ddd1	E. T. Odegard	11.93	38	Du	....
4ddd2	Test hole 1602	210	5	Dr	9-23-59
16aaa	Unknown	17.58	48	Du	....
19aad	H. R. Hart	21.59	48	Du	....
28baa	Otto Paulson	200 +	3	Dr	....
28bbb	Test hole 1604	52.5	5	Dr	9-24-59
158-55					
2dcd	Test hole 1606	63	5	Dr	9-24-59
2ddc	Test hole 1605	63	5	Dr	9-24-59
3dcd1	Fedje	265	2	Dr	1957
3dcd2	..do....	40	24	Dr	1955
4ad	Rose Moore	50	36	Du	....
4caa	Carleton Rinde	300	4	Dr	1939
4ccc	Test hole 1608	178½	5	Dr	9-25-59
4ddd	Test hole 1607	63	5	Dr	9-24-59
5ccc	Test hole 1609	105	5	Dr	9-25-59
6cdb1	K. B. Rollefstad	50	24	Dr	1939
6cdb2	..do....	15	48	Du	1909
7bdc1	Tillie Holms	22	24	Dr	....
7bdc2	..do....	23	24	Dr	....
7dc	Erickson Bros.	8	8	Dr	....
12bdb	Thelmer Johnson	18	48	Du	1939
15adb	G. Langrud	28	42	Du	....
15bba	H. Ostenrud	12	24	Du	....
15bdb	Alma Olson	16	24	Dr	1949
15cbb1	F. H. Berg	12	24	Du	....
15cbb2	..do....	9	30	Du	....
15db1	P. H. Borge	17	28	Dr	....
15db2	..do....	38	28	Dr	1923
17cbd	Rustgard sisters	20	24	Dr	....
18abb1	Albert Anderson	17	8	Dr	1939
18abb2	..do....	14	24	Dr	....

test holes, and springs

Use of water: D, domestic; S, stock; N, none; T, test hole.

Remarks: Adequate supply means quantity reported sufficient for use indicated.

Depth to water below land surface (feet)	Date of measurement	Use of water	Aquifer	Remarks
.....	....	T	......	See log.
7.24	9-16-59	S	Sand	Adequate supply.
.....	....	T	......	See log.
8.76	9-16-59	S	......	
11.56	9-16-59	S	..do..	Alkaline.
Flow	9-16-59	S	..do..	Adequate supply.
.....	....	T	......	See log.
.....	....	T	......	....Do....
.....	....	T	......	....Do....
35	....	S	..do...	Adequate supply.
25	....	S	Clay	Inadequate supply.
30	....	D,S	......	Adequate supply.
22	....	S	Sand	....Do....
.....	....	T	......	See log.
.....	....	T	......	....Do....
.....	....	T	......	....Do....
48	....	D,S	Clay	Adequate supply.
13	....	S	..do..	....Do....
.....	....	D	Sand	....Do....
.....	....	S	..do..	....Do....
7	....	D,S	..do..	....Do....
9	....	D,S	..do..	....Do....
8	....	N	......	....Do....
6	....	D,S	..do..	....Do....
.....	....	D,S	..do..	....Do....
10	....	D	..do..	....Do....
7	....	S	..do..	....Do....
12	....	D	..do..	....Do....
.....	....	S	Clay	....Do....
10	....	D,S	Sand	....Do....
14	....	D	Gravel	....Do....
11	....	S	Sand	....Do....

TABLE 1.--Records of wells,

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed
158-55 (Cont.)					
18cbd	Tilbert Peterson	50	36	Dr	1924
18dc	Henry Langrud	14	36	Dr	1955
19aab1	Joseph Lindell	20	36	Du	1927
19aab2	..do....	23	36	Du	....
19baa1	Floyd Greenwood	18	120	Du	1950
19baa2	..do....	11	36	Du	1954
19dad	Norman Monsebroten	20	24	Dr	1957
24bbc	John Roholt	33	48	Du	....
25dd	Theodore Holt	63	3	Dr	....
26aaa	Unknown	27.51	48	Du	....
29bba	Emil Halgard	16	32	Du	1938
29bcd1	B. A. Larson	20	36	Du	....
29bcd2	..do....	22	36	Du	....
29cdd	Edwin Olson	12	36	Du	1958
158-56					
1dc	Edward Moe	......	..	Sp	....
1dcc	Test hole 1612	63	5	Dr	9-28-59
1ddc	Edward Moe	25.85	24	Dr	1956
3baa1	Ralph Rustan	24	24	Dr	1929
3baa2	..do....	30	24	Dr	....
11aaa	Test hole 1611	63	5	Dr	9-26-59
11bdc	Alfred Moe	21	8	Du	1952
11dcb1	John Sveen	19	12	Dr	....
11dcb2	..do....	20	12	Dr	....
12aaa	Test hole 1610	189	5	Dr	9-26-59
12ccc	Mrs. Charles Folson	13	24	Du	....
12ddb1	Charley Bernaas	7	6	Dr	....
12ddb2	..do....	8	6	Dr	1939
13acc1	G. W. Laithwaite	22	48	Du	....
13acc2	..do....	20	36	Du	1917
13acc3	..do....	24	36	Dr	1909
13bba	Kenneth Folson	10	36	Du	1953
13ccc	John E. Evenson	23	30	Dr	1957
14ddd	Test hole 1614	135	5	Dr	9-28-59

test holes, and springs -- Continued

Depth to water below land surface (feet)	Date of measurement	Use of water	Aquifer	Remarks
.....	....	S	Sand	Adequate supply.
10	....	D,S	..do..	....Do....
.....	....	D	Gravel	....Do....
.....	....	S	..do..	....Do....
6	....	PS, D,S	Sand	Adequate supply; sells water to people in the community.
7	....	D	..do..	Adequate supply.
.....	....	D,S	..do..	....Do....
18	....	D,S	..do..	Inadequate supply.
10	....	D,S	Gravel	Adequate supply.
15.21	....	S	Sand	Alkaline.
12	....	D	Gravel	Adequate supply.
.....	....	D	Sand	....Do....
.....	....	S	..do..	....Do....
.....	....	D	..do..	....Do....
.....	....	...	Sand, gravel	See chemical analysis.
.....	....	T	......	See log.
6.95	9-14-59	D,S	Gravel	Adequate supply.
.....	....	D	Sand	....Do....
20	....	S	..do..	....Do....
.....	....	T	......	See log.
19	....	D	Gravel	Adequate supply.
15	....	D	..do..	Adequate supply; springs in the area.
16	....	S	..do..	Adequate supply.
.....	....	T	......	See log.
.....	....	D	..do..	Adequate supply.
3	....	D	Sand	....Do....
3	....	S	..do..	....Do....
18	....	D	..do..	....Do....
17	....	S	..do..	Adequate supply; springs in the area.
18	....	D	..do..	Adequate supply.
.....	....	D,S	..do..	....Do....
16	....	D	..do..	....Do....
.....	....	T	......	See log.

TABLE 1.--Records of wells, test

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed
158-56 (Cont.)					
15dc	Burvett Branvold	15	12	Du	1958
22ccc	V. Brevik	24	48	Du	....
23aaa	Test hole 1615	63	5	Dr	9-29-59
23bab	Adolph Folson	14	36	Du	....
23dcc1	L. M. Byars	22	24	Dr	1954
23dcc2	..do....	20	24	Dr	....
27aca	Aaron Isakson	70	16	Dr	1912
27cbb	Frank Skylud	100	6	Dr	1939
27dd	Jacob Peterson	80	6	Dr	....
159-54					
21ddc	Unknown	25.76	24	Dr	....
28bbc	..do....	35	48	Du	....
28bcc	Allan Moulton	15	48	Du	....
33aaa	Test hole 1616	63	5	Dr	9-29-59
159-55					
19aa	E. G. Russum	25	48	Du	....
19bba	Unknown	11.87	48	Du	....
21add	Allan Reilly	28.71	48	Du	....
23add	Unknown	32.56	30	Dr	....
28bba	..do....	11.93	36	Du	....
28daa	..do....	17.98	24	Du	....
30daa	Leonard Estad	27	30	Du	....
31aaa	Unknown	17.71	48	Du	....
32bbc	L. Windingland	27	48	Du	....
32ddd	Unknown	16.71	48	Du	....
35ccb	Burton Harvey	17.15	48	Du	....
159-56					
22cdd	Johnson	16	60	Du	1956
22ddd	Myrdel	16	50	Du	....
24ccc	John Gudmundson	11.21	48	Du	....
25abb	Johnson	450	3	Dr	....
25ddd	Oliver Olson	410	3	Dr	....
26aaa	John Gudmundson	13	60	Du	....
26bba	John Myrdal	12.31	48	Du	....
27aab	..do....	11.57	60	Du	....
34dcc	Unknown	9.35	48	Du	....
35ddd	Test hole 1613	63	5	Dr	9-28-59

holes, and springs -- Continued

Depth to water below land surface (feet)	Date of measurement	Use of water	Aquifer	Remarks
14	....	D,S	Sand	Adequate supply.
.....	....	D,S	..do..	....Do....
.....	....	T	......	See log.
9	....	D,S	Gravel	Adequate supply.
12	....	D	..do..	....Do....
10	....	S	..do..	....Do....
66	....	D,S	Sand	....Do....
90	....	D,S	..do..	....Do....
.....	....	D,S	..do..	....Do....
17.62	9-15-59	N	......	
20	....	S	..do..	
12	....	S	..do..	....Do....
.....	....	T	......	See log.
14	....	D,S	..do..	
8.74	9-14-59	S	..do..	
19.64	9-15-59	D,S	..do..	
17.58	9-15-59	D,S	......	
10.10	9-15-59	N	..do..	
10.18	9-15-59	D,S	......	Alkaline.
15	....	D,S	..do..	Adequate supply.
11.98	9-14-59	S	..do..	
14	....	D,S	..do..	
7.59	9-15-59	D,S	..do..	
11.25	9-15-59	S	..do..	....Do....
7	....	D,S	..do..	....Do....
7	....	D,S	..do..	Inadequate supply.
6.31	9-14-59	S	Gravel	Open well.
.....	....	N	Sand	
50	....	S	..do..	Adequate supply.
.....	....	D,S	..do..	
8.31	9-14-59	S	Gravel	Inadequate supply.
5.12	9-14-59	D,S	..do..	Adequate supply.
7.24	9-14-59	N	..do..	
.....	....	T	......	See log.

TABLE 2.--Logs of test holes

158-54-3ddc
Test hole 1603

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, black	4	4
	Clay, silty, yellow to light-brown; oxidized	11	15
	Clay, silty, light-gray; calcareous	16	31
	Clay, smooth, dark-gray; calcareous	21	52
	Clay, smooth, gray; calcareous	53	105

158-54-4ddd2
Test hole 1602

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, silty, black	2	2
	Clay, silty, gray to light-gray	3	5
	Clay, silty, mottled, yellow-buff to gray; oxidized	6	11
	Clay, silty, olive-gray	25	36
	Clay, shaly, light-gray; brittle	95	131
Till and associated sand and gravel deposits:			
	Gravel, fine to medium; sand, fine to coarse	4	135
	Sand, fine to coarse with a gray-clay binder	13	148
	Clay, somewhat sandy and shaly, light-gray	9	157
	Clay, sandy, light-gray	12	169
Bedrock (Dakota(?) Sandstone):			
	Sand, silty, very fine, gray and white	41	210

158-54-28bbb
Test hole 1604

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, silty, black	4	4
	Clay, silty, yellow-gray; oxidized	7	11
	Clay, silty, yellow-brown	5	16
	Clay, silty, light-gray	$36\frac{1}{2}$	$52\frac{1}{2}$

TABLE 2.--Logs of test holes -- Continued

158-55-2dcd
Test hole 1606

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, silty, dark-brown	3	3
	Clay, silty, brown-buff to yellow-buff	12	15
	Clay, silty, light-gray	42	57
Till and associated sand and gravel deposits:			
	Clay, light-gray; fine gravel; shale pebbles (till)	6	63

158-55-2ddc
Test hole 1605

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, black	3	3
	Clay, silty, yellow to buff; oxidized	13	16
	Clay, silty, light-gray	45	61
Till and associated sand and gravel deposits:			
	Clay, gray; gravel, fine to medium (till)	2	63

TABLE 2.--Logs of test holes -- Continued

158-55-4ccc
Test hole 1608

Formation	Material	Thickness (feet)	Depth (feet)
Till and associated sand and gravel deposits:			
	Topsoil, silty, black	3	3
	Clay, yellow, oxidized; gravel, fine to medium; sand, coarse; shale pebbles (till)	13	16
	Clay, light-gray; sand, coarse; gravel, fine to medium; shale pebbles and lignite fragments (till)	5	21
	Sand, fine to coarse; shale pebbles	5	26
	Gravel, fine; shale pebbles	5	31
	Clay, sandy and silty, light-gray to olive-drab (till)	11	42
	Silt and clay, gravelly, light-gray; shale pebbles (till)	15	57
	Clay, silty, light-gray (till?)	18	75
	Silt and clay, gray; gravel, fine to medium; shale pebbles; lignite fragments (till)	83	158
Bedrock:			
	Shale, dark-gray to dark-bluish-gray	20½	178½

158-55-4ddd
Test hole 1607

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, black	3	3
	Clay, silty, yellow to buff; oxidized	12	15
	Clay, silty, gray	11	26
Till and associated sand and gravel deposits:			
	Clay, silty, light-gray; gravel, fine to medium; shale pebbles (till)	37	63

TABLE 2.--Logs of test holes -- Continued

158-55-5ccc
Test hole 1609

Formation	Material	Thickness (feet)	Depth (feet)
Till and associated sand and gravel deposits:			
	Topsoil, black------------------------	3	3
	Clay, silty, mottled, oxidized; some fine gravel (till)------------------	3	6
	Clay, silty, light-gray; some fine gravel (till)-----------------------	25	31
	Clay, gray; gravel, fine to medium; shale pebbles (till)----------------	74	105

158-56-1dcc
Test hole 1612

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Sand, silty, brown-------------------	5	5
	Sand, fine to coarse; some fine gravel; shale pebbles; lignite fragments----	7	12
Till and associated sand and gravel deposits:			
	Clay, sandy, light-gray; fine to medium gravel; shale pebbles; lignite fragments (till)----------------------	51	63

158-56-11aaa
Test hole 1611

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, sandy, black----------------	2	2
	Sand, fine to medium; shale pebbles---	19	21
	Gravel, fine to coarse----------------	9	30
Till and associated sand and gravel deposits:			
	Clay, gray; gravel, fine to medium; shale pebbles (till)----------------	33	63

TABLE 2.--Logs of test holes -- Continued

158-56-12aaa
Test hole 1610

Formation	Material	Thickness (feet)	Depth (feet)
Till and associated sand and gravel deposits:			
	Topsoil, black------------------------	1	1
	Clay, oxidized, mottled, yellow to buff; fine gravel (till)-------------	11	12
	Clay, gray; gravel, fine to medium, shale pebbles and cobblestones (till)	146	158
Bedrock:			
	Shale, dark-gray to black--------------	31	189

158-56-14ddd
Test hole 1614

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, sandy, brown------------------	2	2
	Sand, fine to medium-------------------	4	6
	Gravel, fine to medium, rounded and elongated---------------------------	7	13
Till and associated sand and gravel deposits:			
	Silt and clay, olive-gray; gravel, fine to medium (till)---------------	21	34
	Silt and clay, light-gray; gravel, fine; shale pebbles (till)----------------	8	42
	Silt and clay, gray; gravel, fine to medium; shale pebbles (till)---------	93	135

158-56-23aaa
Test hole 1615

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, sandy and silty, dark-brown--	3	3
	Sand, fine to coarse; many limestone grains----------------------------	7	10
Till and associated sand and gravel deposits:			
	Silt and clay, oxidized, mottled, yellow-buff; gravel, fine to medium; shale pebbles (till)---------------	4	14
	Silt and clay, light-gray; gravel, fine to medium; shale pebbles (till)	49	63

TABLE 2.--Logs of test holes -- Continued

159-54-33aaa
Test hole 1616

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz:			
	Topsoil, black	2	2
	Clay, silty, yellow to buff	19	21
	Clay, silty, light-gray	21	42
	Clay, smooth, dark-gray	21	63

159-56-35ddd
Test hole 1613

Formation	Material	Thickness (feet)	Depth (feet)
Till and associated sand and gravel deposits:			
	Topsoil, black	4	4
	Sand, fine to medium; shale pebbles	7	11
	Clay, gray; gravel, fine to medium; shale pebbles (till)	52	63

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