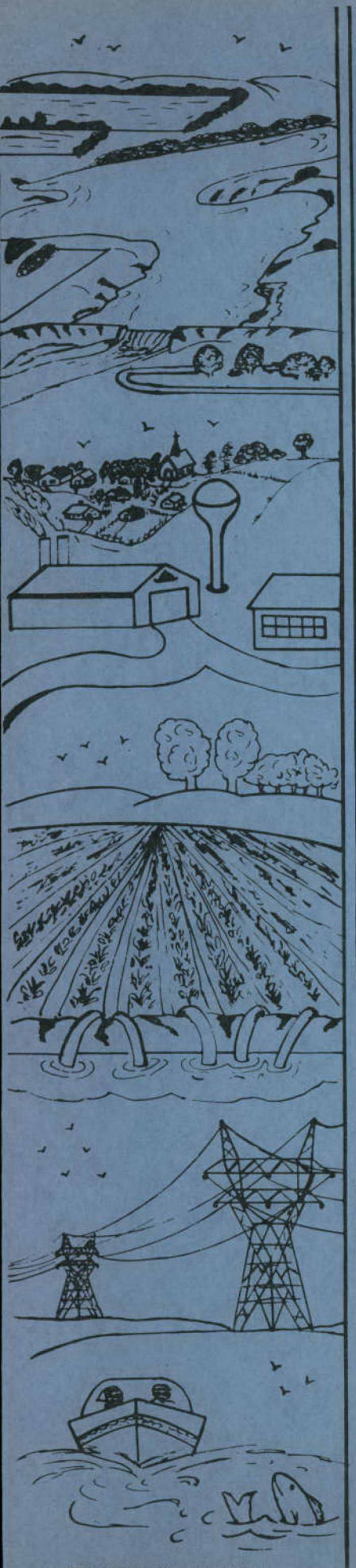

"BUY NORTH DAKOTA PRODUCTS"

GROUND WATER IN THE HATTON AREA

TRAILL AND STEELE COUNTIES, NORTH DAKOTA

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

NORTH DAKOTA GROUND WATER STUDIES
NO.39

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

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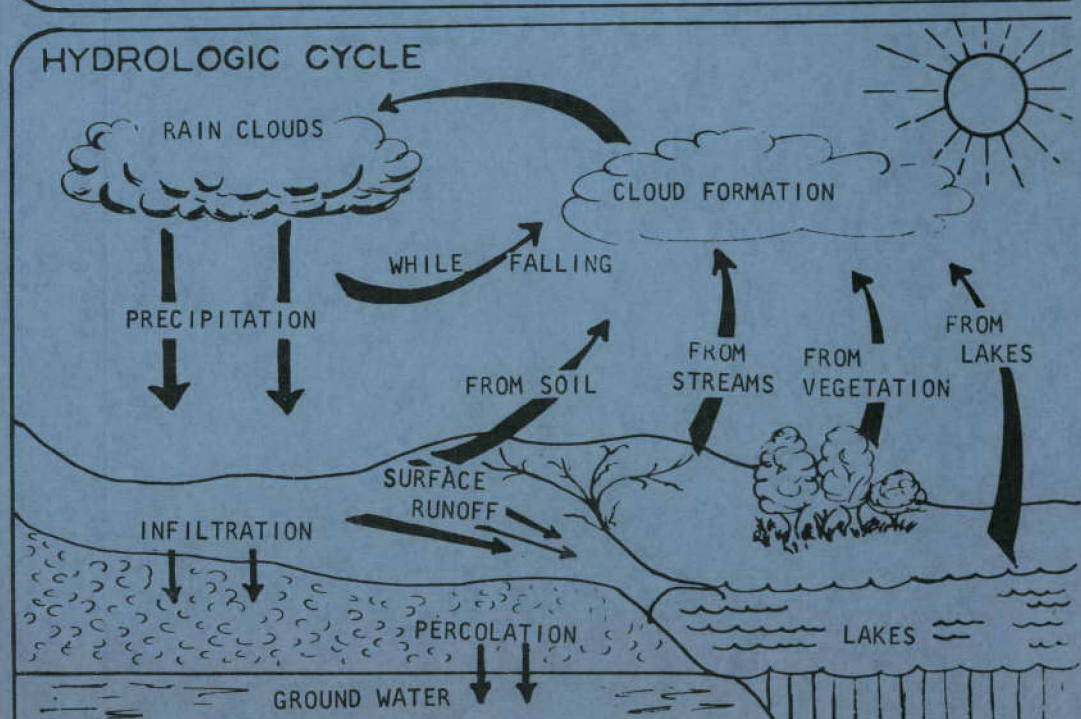

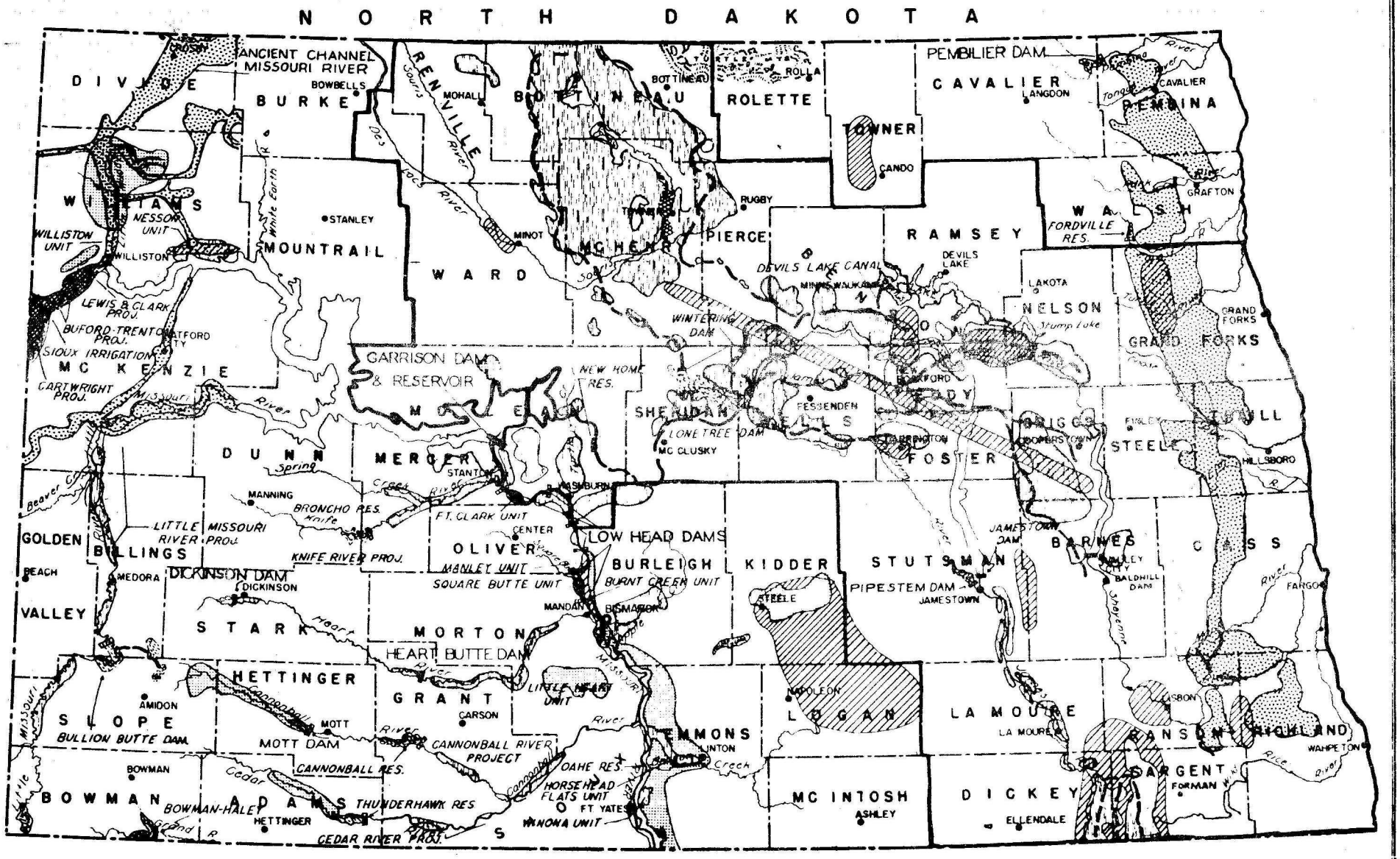

NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

PROPOSED CANALS

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

- 1962 -

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GROUND WATER IN THE HATTON AREA

TRAILL AND STEELE COUNTIES, NORTH DAKOTA

By
D. G. Adolphson

Introduction

This report presents the results of a ground-water study conducted near Hatton in Traill and Steele Counties, N. Dak., which was done as a part of the cooperative ground-water investigation program of the U.S. Geological Survey and the State of North Dakota. In 1956 the city of Hatton sought aid because its public water supply was not sufficient for sewage disposal, operation of potato-washing plants, and for sale to residents outside the city. An investigation to locate new ground-water sources was begun by the U.S. Geological Survey, North Dakota State Water Conservation Commission, and North Dakota Geological Survey. In addition the city had its wells reconditioned; this resulted in a substantial increase in yield.

The fieldwork for the investigation began in July 1956 and consisted of a study of the surface geology, collection of water samples, and drilling of test holes. Some results obtained during this investigation will be included in a later and more comprehensive report on ground-water resources of Traill County.

Well-Numbering System

The well-numbering system used in this report, illustrated in figure 1, 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 and the second numeral denotes the range west, both referred to the fifth principal meridian and base line; 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) as shown on figure 1. Thus, well 148-54-9cdd is in the $SE\frac{1}{4}SE\frac{1}{4}SW\frac{1}{4}$ sec. 9, T. 148 N., R. 54 W. Consecutive terminal numerals are added if more than one well is shown in a 10-acre tract.

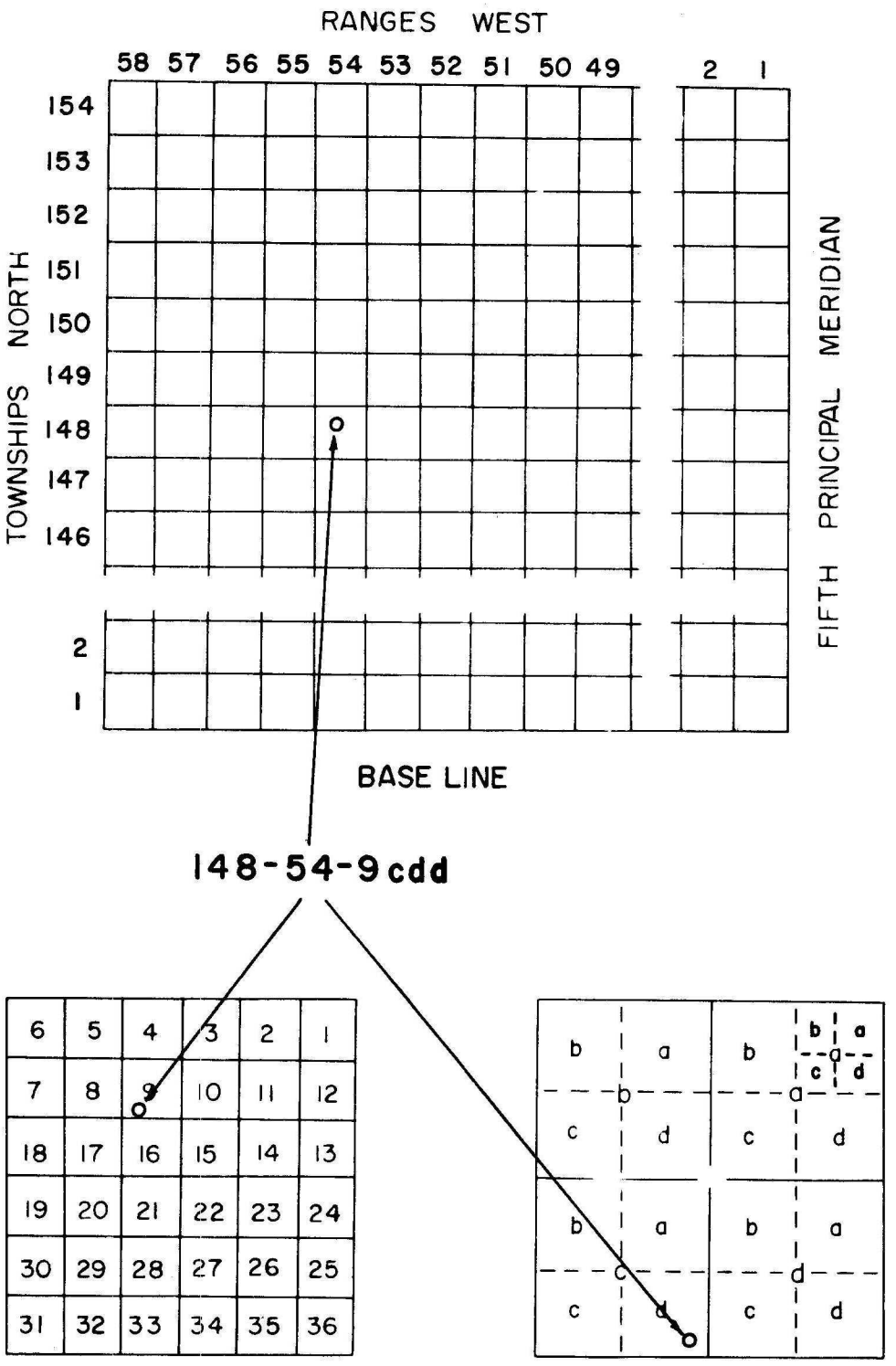

Figure 1 -- Sketch illustrating well-numbering system

Location of the Area and Physiography

The area described in this report includes all of T. 148 N., R. 53 and 54 W., and parts of T. 148 N., Rs. 52 and 55 W., in Traill and Steele Counties. It is in the Red River Valley section of the Central Lowland physiographic province of Fenneman (1938, p. 559). Figure 2 shows Simpson's (1929, p. 5) classification of physiographic provinces in North Dakota and location of the Hatton area. Hatton, which has a population of 856 (1960 census), is the only town in the area.

The topography of the Red River Valley is characterized by a flat glacial-lake plain and is modified by deltas and low beach or shoreline ridges. The Hatton area lies largely on the Elk Valley delta, and is crossed by several beach ridges. The Goose River and its tributaries have dissected relatively deep narrow valleys in the deposits of the Elk Valley delta (fig. 3). The average annual discharge of the Goose River for the period 1939 to 1959 at a gaging station 7 miles south of Hatton is 24.3 cubic feet per second (Wells, 1961, p. 67). However, it is an intermittent stream and periods of no flow lasting several months are common each year. The average annual precipitation at Mayville, which is about 10 miles southeast of Hatton, for the period from 1896 to 1961 is 17.98 inches.

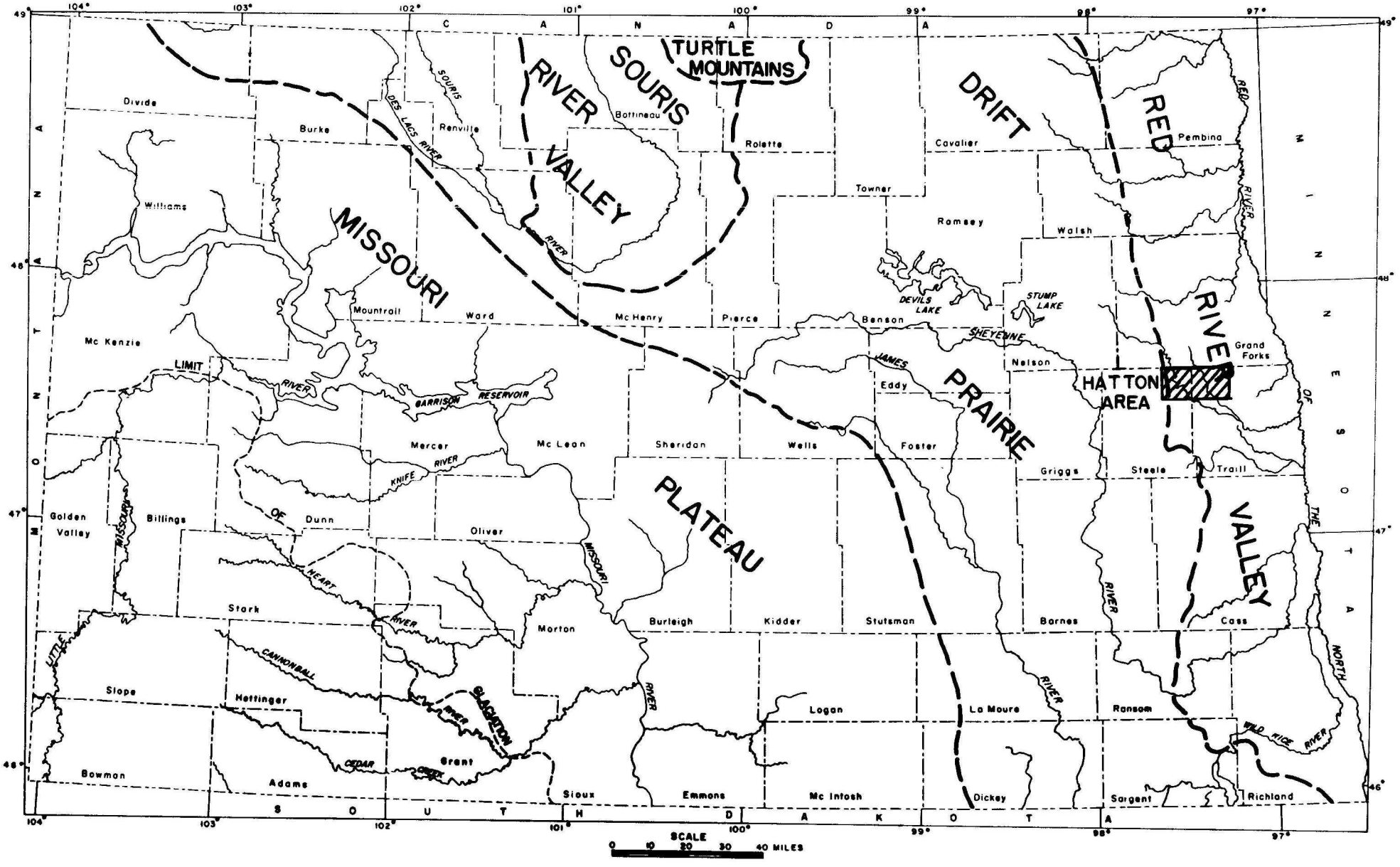

FIGURE 2--PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA (MODIFIED FROM SIMPSON, 1929) AND LOCATION OF THE HATTON AREA.

Geology and Ground-Water Conditions

During the Pleistocene Epoch ice sheets advanced over the Red River Valley several times. In the last part of glacial time a marginal glacial lake, Lake Agassiz, covered most of the valley. The glacial deposits in the Hatton area are sediments of the Elk Valley delta, sediments of glacial Lake Agassiz, and till and associated sand and gravel. Recent alluvial deposits occupy much of the valley of the Goose River and its tributaries.

Test drilling indicated that the glacial deposits are underlain by shale and soft sandstone of Cretaceous age. One test hole penetrated shale of probably Cambrian and Ordovician age.

Alluvium of Recent age.--The most recent deposits in the area are thin alluvial sands, silts, and clays in the valley of the Goose River and its tributaries. The deposits are not known to contain productive aquifers; they act only as transmitting bodies through which precipitation and streamflow may reach underlying aquifers.

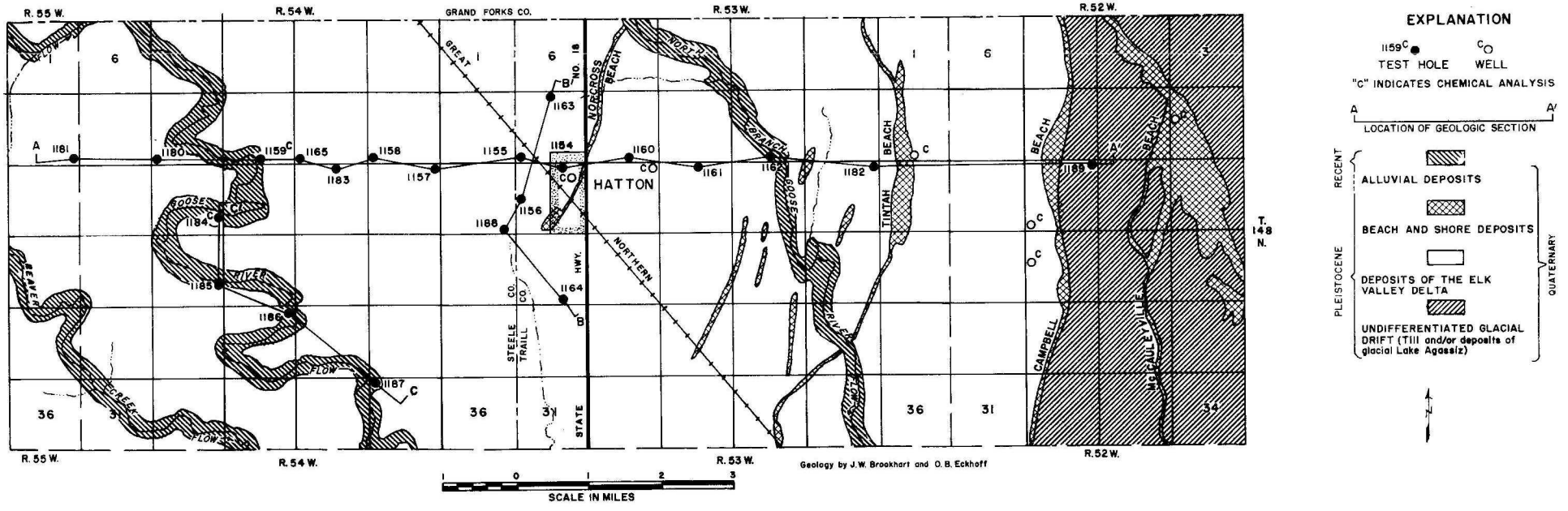

FIGURE 3--MAP OF THE HATTON AREA SHOWING GEOLOGY AND LOCATIONS OF TEST HOLES AND GEOLOGIC SECTIONS.

Beach and shore deposits.--The Norcross, Tintah, Campbell, and McCauleyville beaches (Upham, 1895, pl. 29) are present in the Hatton area (fig. 3). The beaches and shore deposits are usually in the form of low-rounded north-northwest to south-southeast-trending ridges. The Norcross and Tintah beaches lie on the Elk Valley delta and are low discontinuous ridges. The Campbell beach marks the eastern edge of the delta as a well-defined scarp. The McCauleyville beach, which contains considerable quantities of gravel, occurs as a narrow ridge with a pronounced scarp at the northern end of the report area but is a low wide ridge at the southern end.

Where saturated sand and gravel occur in the beach and shore deposits, they constitute a readily available source of water for shallow wells. The sand deposits in the Tintah beach about 4 miles east of Hatton and the gravel deposits in the McCauleyville beach about 8 miles east of Hatton contain aquifers that may yield small to moderate amounts of water to wells. At present (1961) most of the beaches are used as sources of ground water only for farm and domestic purposes. A well owned by A. C. Sorenson (148-52-10bcc, table 1) withdraws relatively large supplies of water from the aquifer in the McCauleyville beach. The water is bottled and sold for domestic use.

Deposits of the Elk Valley delta.--The deposits of the Elk Valley delta consist of clay, silt, and sand. They range in thickness from 0 to 100 feet. In areas where a sufficient saturated thickness of sand is penetrated by a well, small to moderate supplies of water can be obtained; however, at some places the sediments are so fine grained that only small yields are available. Most farms on the delta obtain water from shallow large-diameter wells in saturated deposits of silt and sand. A sandy zone in the deposits of the Elk Valley delta was penetrated at relatively shallow depths by test holes 1155, 1157, 1158, and 1165 (fig. 4) west of Hatton and may yield sufficient ground water to augment the present (1961) municipal water supply.

Till and associated sand and gravel deposits.--Till underlies the deposits of the Elk Valley delta and (or) beaches and shoreline deposits. The till consists largely of blue silt and clay containing fragments of igneous, metamorphic, and sedimentary rocks. At some places shale fragments and gypsum crystals also are present.

Large ground-water supplies are not found in the till because of its low permeability. However, isolated sand and gravel lenses ranging in thickness from less than 1 foot to about 20 feet are associated with the till at many places (figs. 4 and 5), and some of these lenses are sources of ground water. The lenses are ordinarily small in areal extent. In addition some ground water drains from these aquifers naturally; if more water escapes by the combination of withdrawal by pumping and natural discharge than is replenished, the ground-water in the aquifer may become progressively depleted. Therefore, sand and gravel lenses in the till not now tapped by wells probably would be only a relatively small source of additional ground water for Hatton.

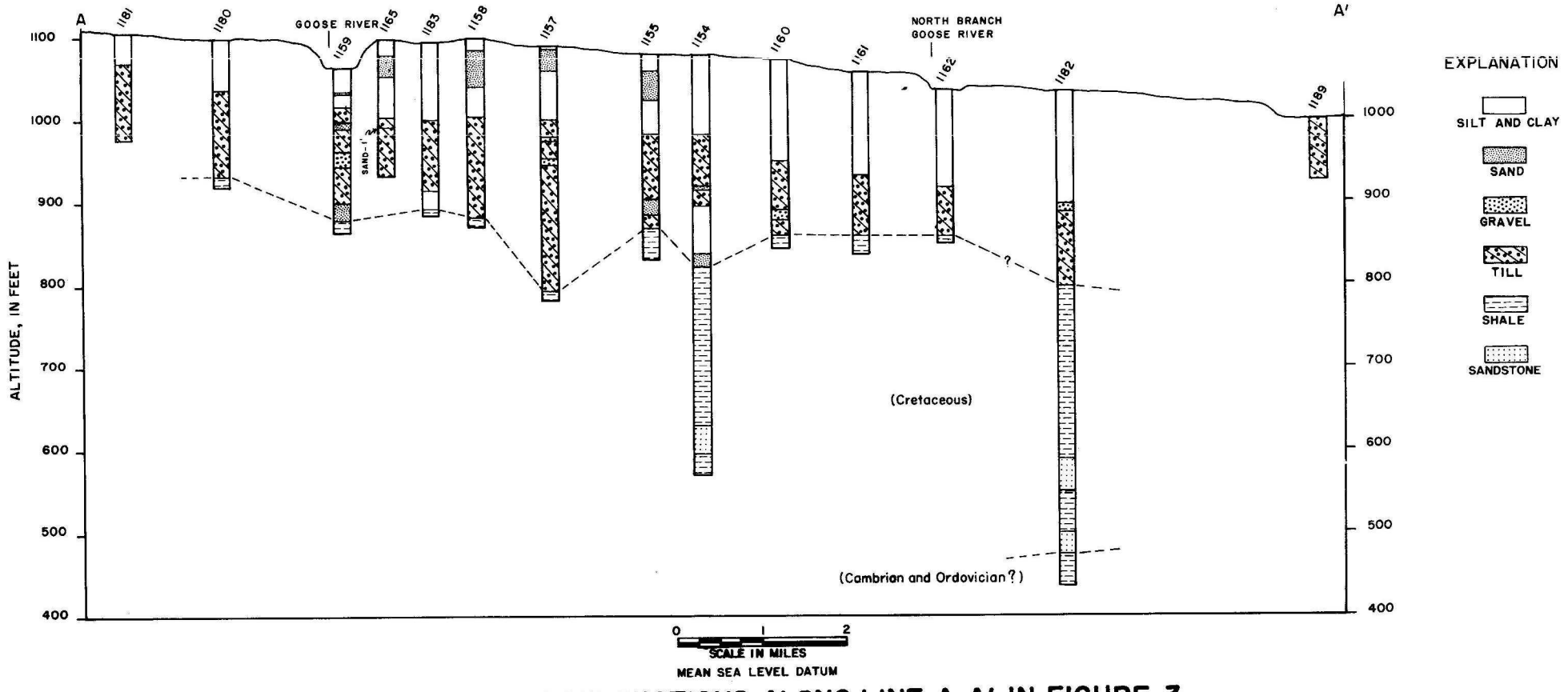

FIGURE 4--GEOLOGIC SECTIONS ALONG LINE A-A′ IN FIGURE 3.

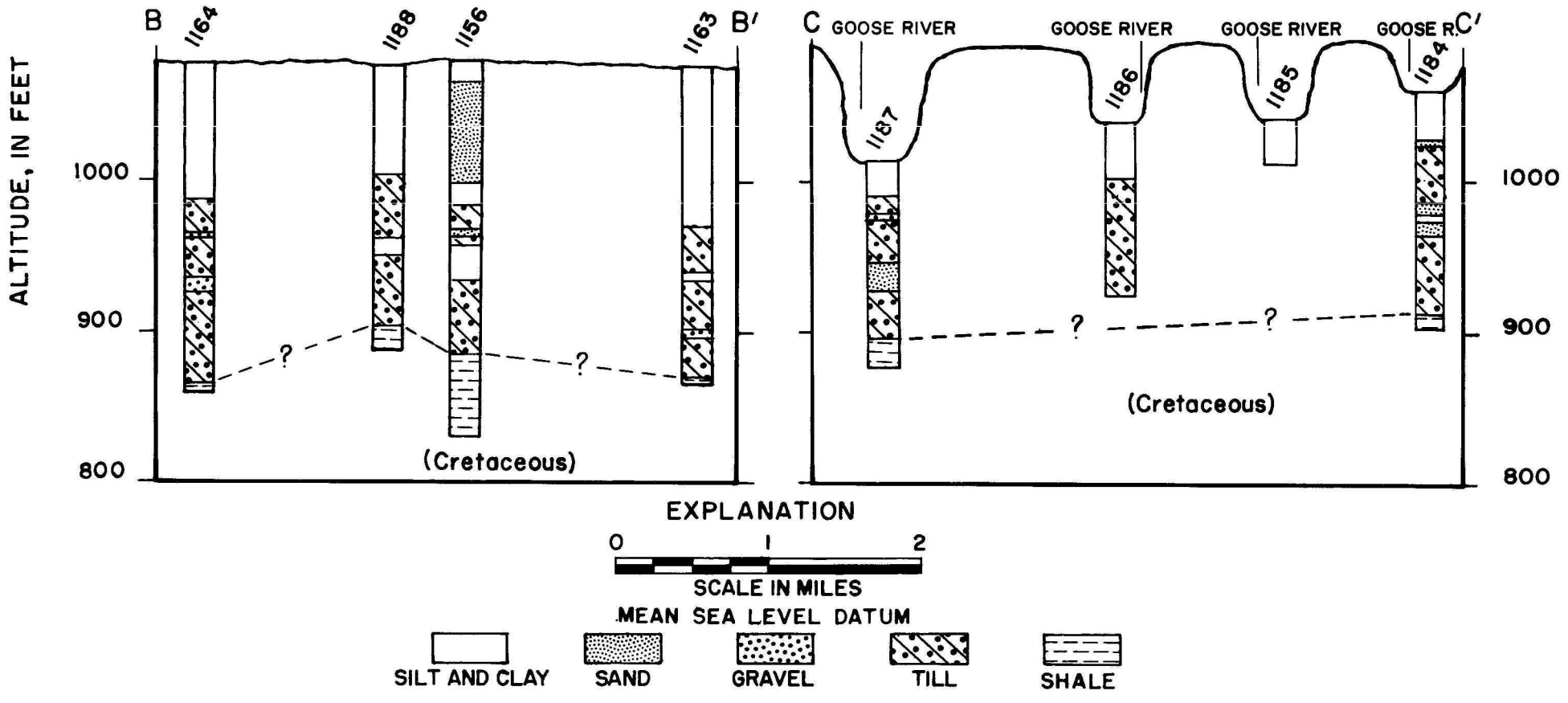

FIGURE 5 --GEOLOGIC SECTIONS ALONG LINES B-B′ AND C-C′ IN FIGURE 3.

Deposits of glacial Lake Agassiz(?).--Deposits of glacial lake Agassiz(?) may occur in the Hatton area (test hole 1189, table 2). It is not definitely established from the rotary drilling samples whether the silt and clay in this test hole were deposited as till or in a lacustrine environment. The deposits are not a source of ground water in the area.

Bedrock.--Rocks of Cretaceous, probably Cambrian and Ordovician, and Precambrian age underlie the glacial drift in the Hatton area. Aquifers in rocks of the Dakota Sandstone of Early Cretaceous age yield small to moderate supplies of water to wells. Such wells tap the aquifers at depths of about 300 to 500 feet in parts of Traill County. Many of them flow at the land surface.

Chemical Quality of Ground Water

The chemical composition of ground water in the Hatton area is indicated by results of chemical analyses from 8 wells (table 1). The wells sampled range in depth from 9 to 425 feet and tap aquifers in the deposits of the Elk Valley delta, the beach deposits, the sand and gravel deposits associated with till, and the Dakota Sandstone.

The ground water in the Hatton area varies greatly in chemical composition. The dissolved-solids content in water from the sampled wells ranges between 342 and 4,160 ppm (parts per million) and the hardness of the water as $CaCO_3$ ranges between 110 and 2,230 ppm. Samples from the beach deposits have fairly low dissolved-solids content but their hardness is high. Waters from two wells (148-52-20bcc and 148-53-18a) in the till and associated sand and gravel deposits have moderately high dissolved-solids content but lower amounts of calcium and magnesium. The sample from the Melvin Bjerke well (148-53-17aaa), which has a high dissolved-solids content, comes from an aquifer in the fine sands of the delta. Dennis and Akin (1950, p. 31-32), however, report that the dissolved solids and hardness are fairly low in water samples from similar aquifers in the Elk Valley delta in the Portland area. The water from the Edward Soliah well (148-52-17ccc) is derived from the Dakota Sandstone. It is high in dissolved-solids content, has much sodium, sulfate, and chloride, and has a hardness of 972 ppm as $CaCO_3$. The Dakota may become an important source of ground water in this area if economical methods for demineralization of water are developed.

Conclusions and Recommendations

The study shows that small to medium quantities of ground water may be available from the Tintah and McCauleyville beach deposits and from the Elk Valley delta deposits west of Hatton. The quality of the water in the beach deposits is generally good. More data are needed to make an adequate appraisal of the quality of water in the delta deposits. Aquifer tests to determine the hydrologic characteristics of the water-bearing deposits should be made before development of municipal wells.

The aquifers in the bedrock formations are not considered sources of water for domestic or irrigation purposes because of their poor quality. However, some farm wells in the area tap these aquifers because they are the only available source of water.

TABLE 1.--Chemical

Results in parts per million except as indicated

Location No.	Owner or name	Aquifer	Depth of well (feet)	Date of collection	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
148-52									
10bcc	A. C. Sorensen	Beach and shore deposits	9	8-30-56 a/	0.3	61	28	5	3
17ccc	Edward Soliah	Bedrock (Dakota Sandstone)	425	..do...	1.4	566	406	770	54
20bcc	Andrew Lee	Till and associated sand and gravel deposits	162	..do...	1.8	30	78	235	10.0
148-53									
12dcc	Art Lillemeen	Beach and shore deposits	10	3-26-59 b/	.22	105	32	5.4	1.2
17aaa	Melvin Bjerke	Deposits of the Elk Valley delta	24.8	9-13-56 a/	1.0	460	260	88	13.2
18a	City well 1	Till and associated sand and gravel deposits	240	9-19-56 a/	.8	15	18	220	8.0
148-54									
9cdd	Test hole 1159	.....do.....	200	..do...a/	.8	71	26	210	13
17dad	Test hole 1184	.....do.....	157	9-27-57	.38	163	48	41.3	5

a/Analyses by State Laboratories, Bismarck
b/Analyses by U.S. Geological Survey
c/Includes 25 ppm of silica (SiO_2)

analyses of ground water

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calc. from determined constituents	Hardness as $CaCO_3$	Percent sodium	pH
222	0	29	0	0.3	2.6	0.6	342	239	267	4	7.7
102	0	1,290	1,130	1.5	.3	2.3	4,160	3,630	972	58	7.8
396	0	144	86	.7	1.0	2.0	846	707	108	84	7.9
374	0	65	7.7	.4	24	.12	459	450 c/	392	3	7.2
338	0	1,660	61	.4	36	.1	3,480	2,750	2,230	15	7.7
494	0	48	94	.5	.4	1.3	807	628	110	80	8.0
381	22	324	54	.1	.6	1.28	1,020	911	287	42	---
330	0	300	28	.5	.24	.05	926	749	606	9	7.9

TABLE 2.--Logs of test holes

148-52-17aaa
Test hole 1189

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Agassiz(?):			
	Topsoil, black.....	2	2
	Clay, yellow, smooth, (a few feet of discontinuous deposits of clay mixed with sand, gravel, and boulders at the surface).....	14	16
	Clay, light-gray, smooth; scattered rounded sand grains.....	57	73

148-53-7baa
Test hole 1163

Deposits of the Elk Valley delta:			
	Topsoil, black.....	2	2
	Clay, sandy, brown.....	1	3
	Clay, sandy, yellow.....	13	16
	Clay, gray, sandy.....	88	104
Till and associated sand and gravel deposits:			
	Clay, gray; fine gravel; shale pebbles, (till).....	31	135
	Clay, sandy, gray.....	5	140
	Clay, gray; fine gravel; shale pebbles, (till).....	32	172
	Gravel, fine, composed of about 90% shale pebbles.....	5	177
	Clay, gray; fine gravel; shale pebbles, (till).....	28	205
Bedrock (Cretaceous):			
	Shale, dark-blue gray, highly calcareous.....	5	210

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

148-53-7ccc
Test hole 1155

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black	2	2
	Clay, very sandy, light-brown	2	4
	Clay, very sandy, gray	16	20
	Sand, very fine	25	45
	Clay, very sandy, gray	51	96
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel, (till)	78	174
	Sand, medium to coarse; fine to medium gravel	19	193
	Clay, gray; fine to medium gravel, shale pebbles (till)	17	210
Bedrock (Cretaceous):			
	Shale, smooth, blue-gray	40	250

148-53-8dcc
Test hole 1160

Deposits of the Elk Valley delta:			
	Topsoil, black	1	1
	Clay, sandy, yellow	16	17
	Clay, gray, sandy	105	122
Till and associated sand and gravel deposits:			
	Clay, gray; fine gravel; shale pebbles (till)	60	182
	Gravel, fine to medium; shale pebbles (wood fragments indicate a possible buried soil zone in this interval)	11	193
	Clay, gray, fine to medium gravel; shale pebbles (till)	20	213
Bedrock (Cretaceous):			
	Shale, smooth, blue-gray, highly calcareous	17	230

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

148-53-10dcc
Test hole 1162

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, smooth, yellow.....	2	3
	Clay, black, smooth.....	1	4
	Clay, sandy, yellow.....	9	13
	Clay, sandy, gray.....	19	32
	Clay, smooth, gray.....	85	117
Till and associated sand and gravel deposits:			
	Clay, gray, fine gravel, shale pebbles (till).....	61	178
Bedrock (Cretaceous):			
	Shale, dark-blue gray, highly calcareous.....	7	185

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

148-53-14aaa
Test hole 1182

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, silty, sandy, yellow.....	25	26
	Clay, silty, sandy, light-gray.....	111	136
Till and associated sand and gravel deposits:			
	Gravel, fine to medium, clayey.....	10	146
	Clay, gray; fine to medium gravel; fine sand; shale pebbles, (till).....	90	236
Bedrock (Cretaceous):			
	Shale, medium gray; interbedded with sandstone, very fine-grained, slightly calcareous.....	63	299
	Shale, silty to sandy, medium gray; interbedded with sandstone, very fine-grained.....	147	446
	Sand, very fine to medium, rounded quartz.....	37	483
	Shale, silty, light-gray to white, some fine to coarse sand, rounded quartz, cemented with kaolin.....	21	504
	Shale, and siltstone, very light-gray to white, bentonitic, some sand grains	31	535
	Sand, medium to coarse, rounded quartz, some shale.....	25	560
Bedrock (Cambrian and Ordovician?):			
	Shale, mottled, medium gray and reddish-brown, calcareous, with some sand grains; (crinoid stems and some poorly preserved pelecypod or brachiopod fragments, may be Deadwood Formation of Late Cambrian age and Early Ordovician age).....	38	598

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

148-53-16abb
Test hole 1161

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	2	2
	Clay, sandy, yellow.....	15	17
	Clay, very sandy, gray.....	106	123
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel; shale pebbles (till).....	74	197
Bedrock (Cretaceous):			
	Shale, dark-blue gray, highly calcareous	13	210

148-53-18abb
Test hole 1154

Deposits of the Elk Valley delta:			
	Topsoil, black.....	3	3
	Clay, sandy, yellow.....	13	16
	Clay, sandy, blue-gray.....	9	25
	Clay, very sandy, bluish-gray.....	55	80
	Clay, sandy, gray.....	17	97
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	63	160
	Sand, silty, fine to medium; shale pebbles.....	4	164
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	21	185
	Clay, sandy, dark-gray.....	56	241
	Sand, coarse, silty; fine gravel; shale pebbles.....	16	257
Bedrock (Cretaceous):			
	Clay, smooth, gray.....	28	285
	Clay, smooth, blue.....	75	360
	Clay, smooth, gray.....	90	450
	Sand, silty, clayey, gray with clay content decreasing with depth.....	35	485
	Shale, sand cemented with kaolin.....	5	490
	Shale, smooth, white grading to gray..	20	510

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

148-53-18bcc
Test hole 1156

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black	2	2
	Clay, gray, sandy	13	15
	Sand, very fine, clayey	65	80
	Clay, sandy, gray	15	95
Till and associated sand and gravel deposits:			
	Clay, gray, fine gravel, shale pebbles (till)	16	111
	Sand, medium to coarse, silty	6	117
	Clay, gray; fine gravel, shale pebbles (till)	5	122
	Clay, sandy, gray	24	146
	Clay, gray; fine gravel; shale pebbles (till)	47	193
Bedrock (Cretaceous):			
	Shale, smooth, dark-gray	57	250

148-53-19dcd
Test hole 1164

Deposits of the Elk Valley delta:			
	Topsoil, black	1	1
	Clay, sandy, yellow	13	14
	Clay, sandy, gray; or clayey sand, very fine	78	92
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel; shale and limestone pebbles, (till).	22	114
	Shale pebbles, fine; fine gravel	4	118
	Clay, gray, fine to medium gravel; shale and limestone pebbles, (till).	25	143
	Shale pebbles, fine; fine gravel	9	152
	Clay, gray; fine to medium gravel, shale and limestone pebbles, (till).	60	212
Bedrock (Cretaceous):			
	Shale, dark-blue gray, highly calcareous	8	220

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

148-54-8ccc
Test hole 1180

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	2	2
	Clay, yellow, smooth.....	5	7
	Clay, dark-gray, smooth.....	3	10
	Clay, yellow, smooth.....	7	17
	Clay, light-gray, smooth.....	45	62
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	105	167
Bedrock (Cretaceous):			
	Shale, dark-gray.....	13	180

148-54-9cdd
Test hole 1159

Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, sandy, brown.....	15	16
	Clay, sandy, blue.....	13	29
	Sand, fine, silty.....	3	32
	Clay, sandy, gray-green.....	14	46
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel; shale pebbles, (till).....	20	66
	Sand, medium to coarse; fine to medium gravel; shale pebbles.....	7	73
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	28	101
	Gravel, fine to medium; shale pebbles.	19	120
	Clay, gray, fine to medium gravel; shale pebbles (some shells in this interval), (till).....	43	163
	Sand, fine to medium, silty; shale pebbles.....	21	184
Bedrock (Cretaceous):			
	Shale, smooth, blue-gray.....	16	200

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

148-54-10ccc
Test hole 1165

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, sandy, brown.....	19	20
	Sand, fine, silty.....	16	36
	Clay, sandy, gray.....	59	95
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel, shale pebbles, (till).....	12	107
	Sand, fine, silty.....	1	108
	Clay, gray; fine to medium gravel, shale pebbles, (till).....	57	165

148-54-11ccc
Test hole 1158

Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, light-brown, gray.....	1	2
	Clay, sandy, yellow.....	14	16
	Sand, very fine, brown.....	4	20
	Sand, very fine, gray.....	40	60
	Clay, sandy, gray.....	36	96
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel, shale pebbles (a few small boulders), (till).....	121	217
Bedrock (Cretaceous):			
	Shale, smooth, blue-gray.....	13	230

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

148-54-13ddd
Test hole 1188

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Clay, brown, smooth.....	5	5
	Clay, light-gray, smooth.....	68	73
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel; shale pebbles, (till).....	42	115
	Clay, light-gray, sandy.....	11	126
	Clay, gray; fine to medium gravel; shale pebbles, (till).....	48	174
Bedrock (Cretaceous):			
	Shale, dark-gray.....	15	189

148-54-14aaa
Test hole 1157

Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, sandy, brown.....	2	3
	Sand, very fine.....	12	15
	Sand, very fine, clayey.....	15	30
	Clay, very sandy, gray.....	60	90
Till and associated sand and gravel deposits:			
	Clay, gray; fine gravel; shale pebbles, (till).....	20	110
	Gravel, fine, mostly shale pebbles....	4	114
	Clay, gray; fine gravel; shale pebbles, (till).....	22	136
	Shale pebbles with some fine gravel...	8	144
	Clay, gray; fine gravel; shale pebbles, (till).....	152	296
Bedrock (Cretaceous):			
	Shale, smooth, blue-gray.....	14	310

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

148-54-15abb
Test hole 1183

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	2	2
	Clay, yellow, smooth.....	17	19
	Clay, blue, sandy.....	45	64
	Clay, light-gray, smooth.....	27	91
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles (till).....	80	171
	Clay, gray, sandy.....	20	191
Bedrock (Cretaceous):			
	Shale, dark-gray.....	9	200

148-54-17dad
Test hole 1184

Deposits of the Elk Valley delta:			
	Clay, brown, (a few feet of alluvium undifferentiated).....	3	3
	Clay, yellow, smooth.....	19	22
	Clay, light-gray, sandy.....	11	33
	Sand, medium to coarse, fine to medium gravel.....	5	38
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	34	72
	Sand, medium to coarse.....	9	81
	Clay, gray, sandy.....	4	85
	Sand, medium to coarse.....	10	95
	Clay, gray; fine to medium gravel; shale pebbles and lignite fragments, (till).....	53	148
Bedrock (Cretaceous):			
	Shale, dark-gray.....	9	157

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

148-54-20dad
Test hole 1185

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, brown, smooth (a few feet of alluvium undifferentiated).....	18	19
	Clay, light-gray, sandy.....	3	22
	Clay, light-gray, medium to coarse gravel.....	8	30

148-54-28aaa
Test hole 1186

Deposits of the Elk Valley delta:			
	Topsoil, black.....	2	2
	Clay, light-brown, smooth, (a few feet of alluvium undifferentiated).....	21	23
	Clay, light-gray, sandy, fine to medium gravel.....	17	40
Till and associated sand and gravel deposits:			
	Clay, gray; fine to medium gravel; shale pebbles, (till).....	75	115

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

148-54-35bbb
Test hole 1187

Formation	Material	Thickness (feet)	Depth (feet)
Deposits of the Elk Valley delta:			
	Topsoil, black.....	4	4
	Clay, light-gray, smooth, (a few feet of alluvium undifferentiated).....	6	10
	Clay, light-brown, smooth.....	11	21
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	13	34
	Gravel, fine to coarse.....	4	38
	Clay, gray; fine to medium gravel; shale pebbles, (till).....	27	65
	Sand, medium to coarse, shale pebbles.	9	84
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	33	117
Bedrock (Cretaceous):			
	Clay, gray, smooth, may be shale.....	19	136

148-55-12ddd
Test hole 1181

Deposits of the Elk Valley delta:			
	Topsoil, black.....	1	1
	Clay, light-brown, smooth.....	4	5
	Clay, yellow, smooth.....	11	16
	Clay, light-gray, smooth.....	20	36
Till and associated sand and gravel deposits:			
	Clay, gray, fine to medium gravel; shale pebbles, (till).....	84	130

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