STATE OF SOUTH DAKOTA
Nils Boe, Governor

STATE GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Special Report 33

GROUND WATER SUPPLY FOR THE CITY OF BRITTON, SOUTH DAKOTA

by
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Science Center
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Vermillion, South Dakota
1965

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INTRODUCTION

Present Investigation

This report contains the results of a special investigation by the South Dakota State Geological Survey during the summer of 1964 in and around the city of Britton, Marshall County, South Dakota (fig. 1), for the purpose of assisting the city in locating a reliable future water supply. The city now receives its water from three artesian wells, each 1,000 feet deep, all located within the city limits (fig. 2). The wells, drilled in 1902, 1933, and 1946, can be pumped at only 50-75 gallons per minute. Both the quality and quantity of water produced from these wells is inadequate, and as a result, the South Dakota Geological Survey was requested to conduct a ground water survey in and around the city.

An investigation was made of the ground water possibilities of 80 square miles around the city between June 16 and July 16, 1964. This investigation consisted of geologic mapping, drilling 57 shallow test holes, an inventory of farm wells in the area, and collecting and analyzing 12 water samples.

The results of the survey showed that one small area 3 to 4 miles north of the city is the only area covered by this survey where a shallow ground water supply may be developed.

The field work and preparation of this report were performed under the supervision of Lynn S. Hedges and Cleo M. Christensen, staff ground water geologists. Geologic assistance was given by Dean Fickbohm and Keith Hansen who operated the drill. Nat Lufkin of the Survey performed partial chemical analyses of the water samples collected during the study, and complete analyses of selected samples were performed by the State Chemical Laboratory. The writer wishes to thank the residents of the Britton area for their cooperation, and especially Dick Wismer, geologist-well driller.

Location and Extent of Area

The city of Britton has a population of 1,443 (1960 census). The area studied is on the Lake Dakota Plain between the James Basin and the Coteau des Prairies sections of the Central Lowland physiographic province (fig. 1).

Climate

The climate is continental temperate, with large daily fluctuations in temperature. The mean annual temperature is 43.6 degrees F., and the average annual precipitation is 18.49 inches at the U. S. Weather Bureau Station in Britton.

Topography and Drainage

The topography of the Britton area varies from nearly flat lands in the Lake Dakota plain to rolling hills and valleys and undrained glacial

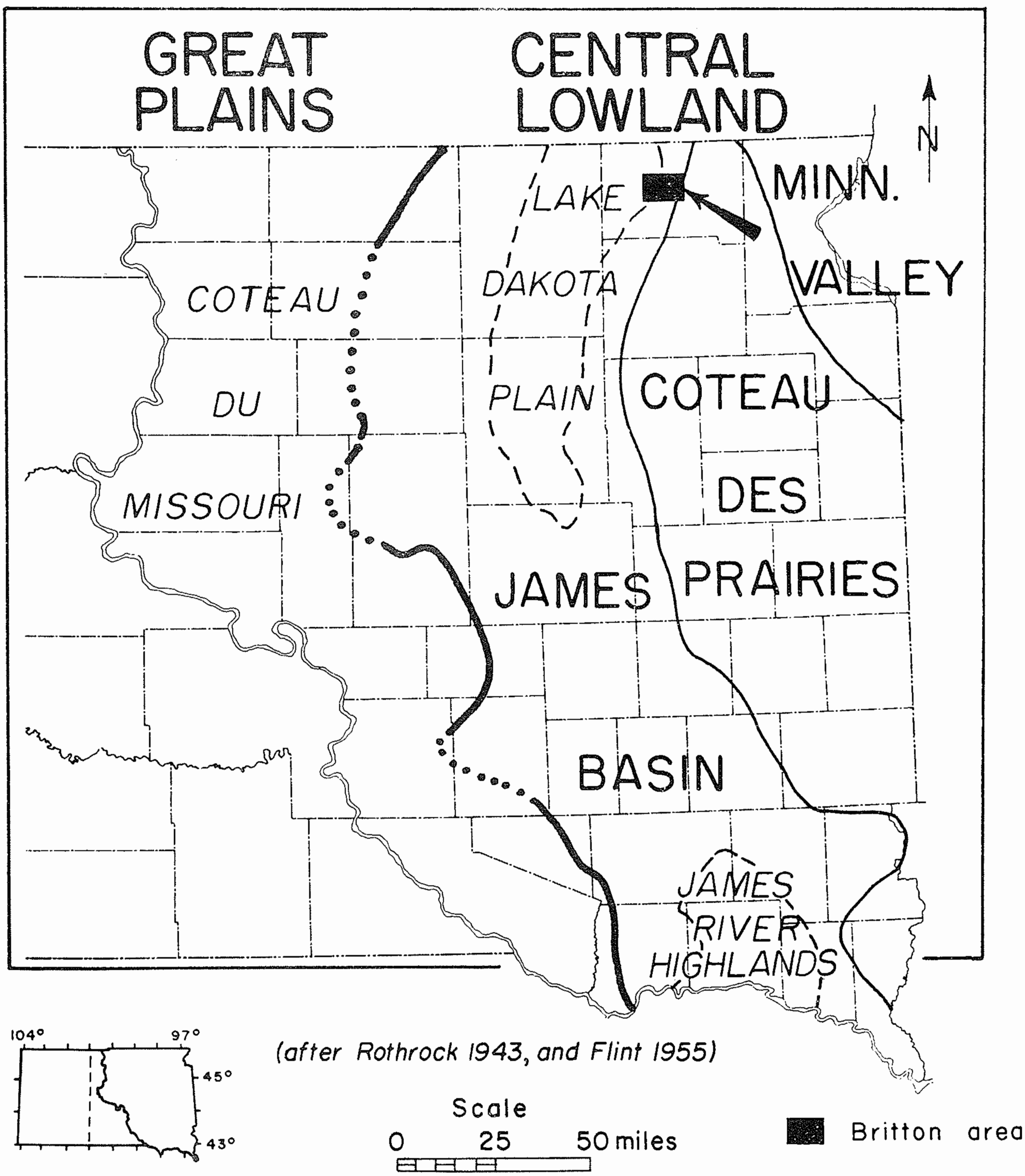
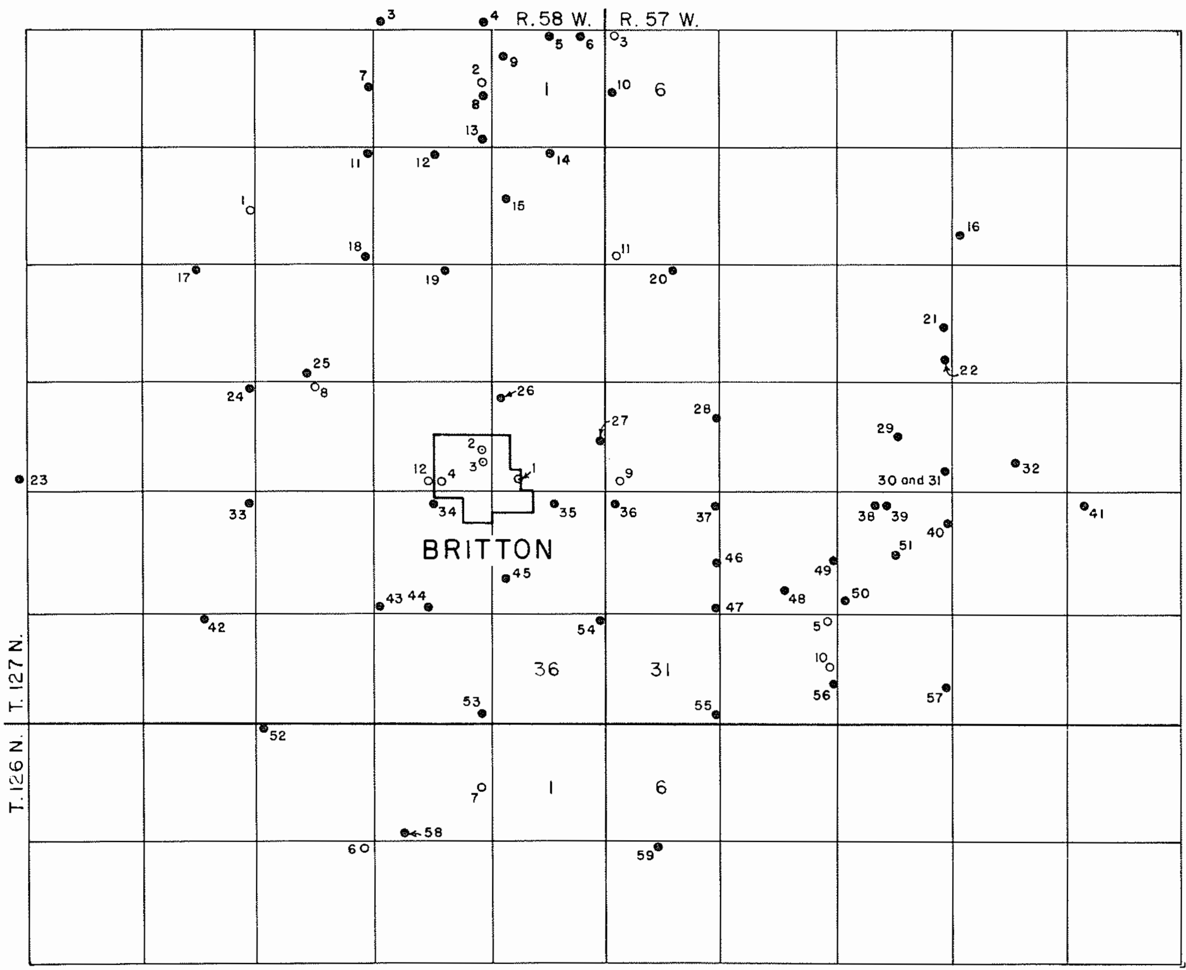


Figure 1. Map of eastern South Dakota showing major physiographic divisions and location of the Britton area.

Figure 2. Data Map of the Britton Area showing locations of test holes, wells and water samples.



SCALE

2 3 miles

N

EXPLANATION

•16 SDGS test hole

o9 Water sample (well), number corresponds to sample number in Table 1.

⊙3 Water sample (city well) number corresponds to city well number.

Drafted by D. Johnson

topography in the James Basin and Coteau des Prairies. East of Britton the land surface rises abruptly and is dissected by youthful V-shaped valleys which are separated by broad, flat-topped, intervening east-west interfluves. In the Britton area the topography is gently rolling to nearly flat where the till merges into the sediments from glacial Lake Dakota (fig. 3).

The drainage in the area is controlled by Crow Creek, which flows generally southwestward, and by the western escarpment of the Coteau des Prairies. The streams, which are intermittent, ultimately drain westward into the James River.

Well-Numbering System

Wells in this report are numbered in accordance with the U. S. Bureau of Land Management's system of land subdivision. The first numeral of a well designation indicates the township, the second the range, and the third the section in which the well is situated. Lower case letters after the section number indicate the well location within the section. The letters a, b, c, d, are assigned in a counterclockwise direction, beginning in the northeast corner of each tract. The first letter denotes the 160-acre tract, the second the 40-acre tract, the third the 10-acre tract, and the fourth the $2\frac{1}{2}$-acre tract. Auger Test Hole 16 (fig. 2), 127-57-10ccbb, is located in the NW$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 10, T. 127 N., R. 57 W. The method of designation is shown in figure 4.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Britton area are chiefly the result of glaciation during the Pleistocene Epoch. These glacial deposits are collectively termed drift and can be divided into till, outwash, and lake sediments.

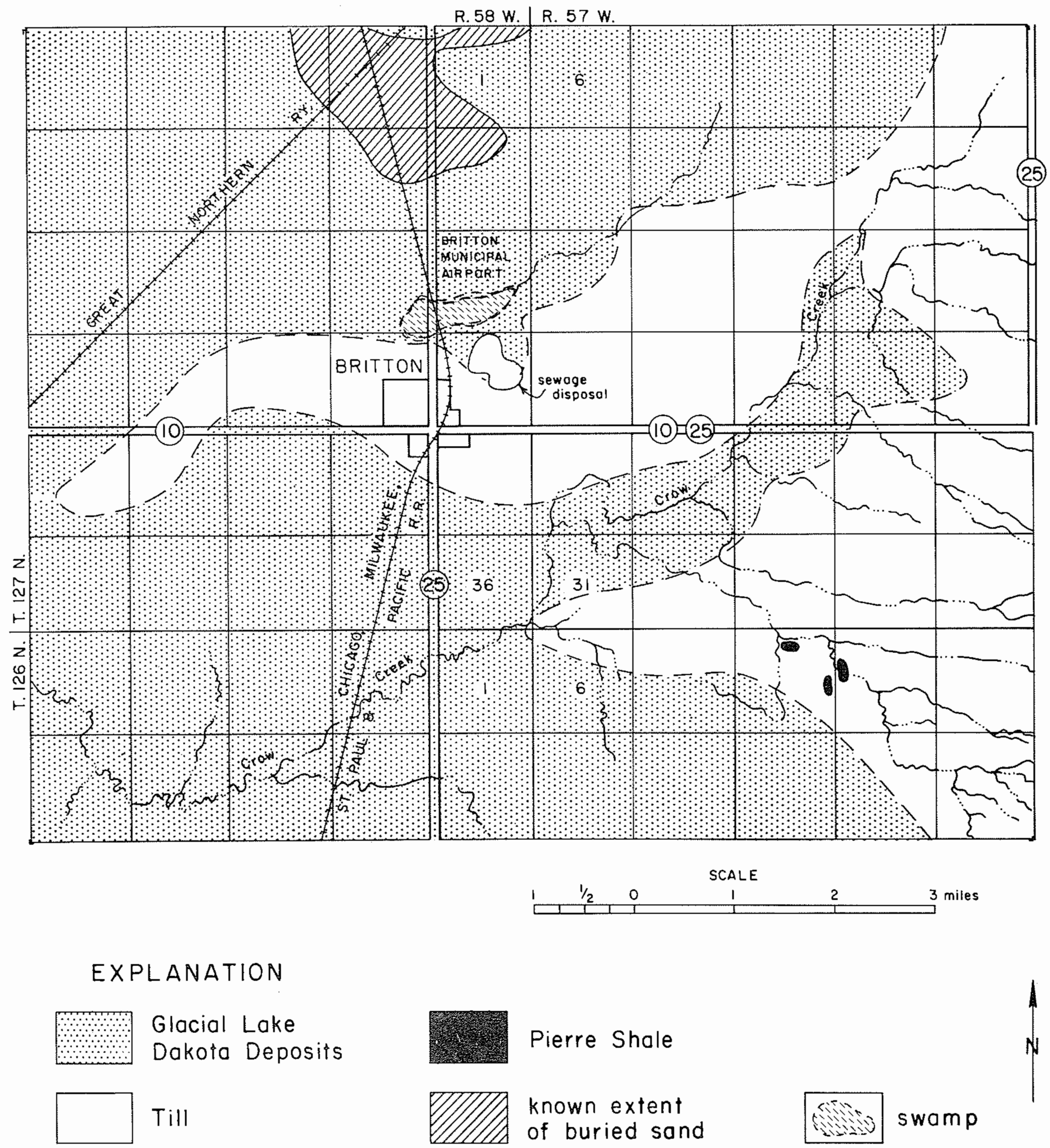
Till consists of a random mixture of clay, silt, sand, pebbles, and boulders, carried and deposited by the ice itself (fig. 3).

Outwash sediments consist chiefly of sand and gravel with minor amounts of silt and clay, and were deposited by meltwaters from the wasting glaciers. If these deposits are buried by later glacial advances, they are called buried outwash. No buried or surficial outwash deposits were found in the Britton area other than small isolated deposits too small for mapping.

The lake sediments (fig. 3) consist of clay, silt, and fine- to medium-grained sand. Where the till joins the lake sediments, the till may be partly or wholly covered with windblown silts and sands derived from lake sediments.

A buried deposit of fine- to medium-grained sand occurs about 4 miles north of Britton (fig. 3). This deposit may be outwash, lake sediments, or it may possibly be windblown material laid down before the uppermost lake sediments were deposited. Since the exact origin of this deposit is unknown at this time, it will be referred to as the buried sand.

Figure 3. Generalized Geologic Map of the Britton Area.



Drafted by D. Johnson

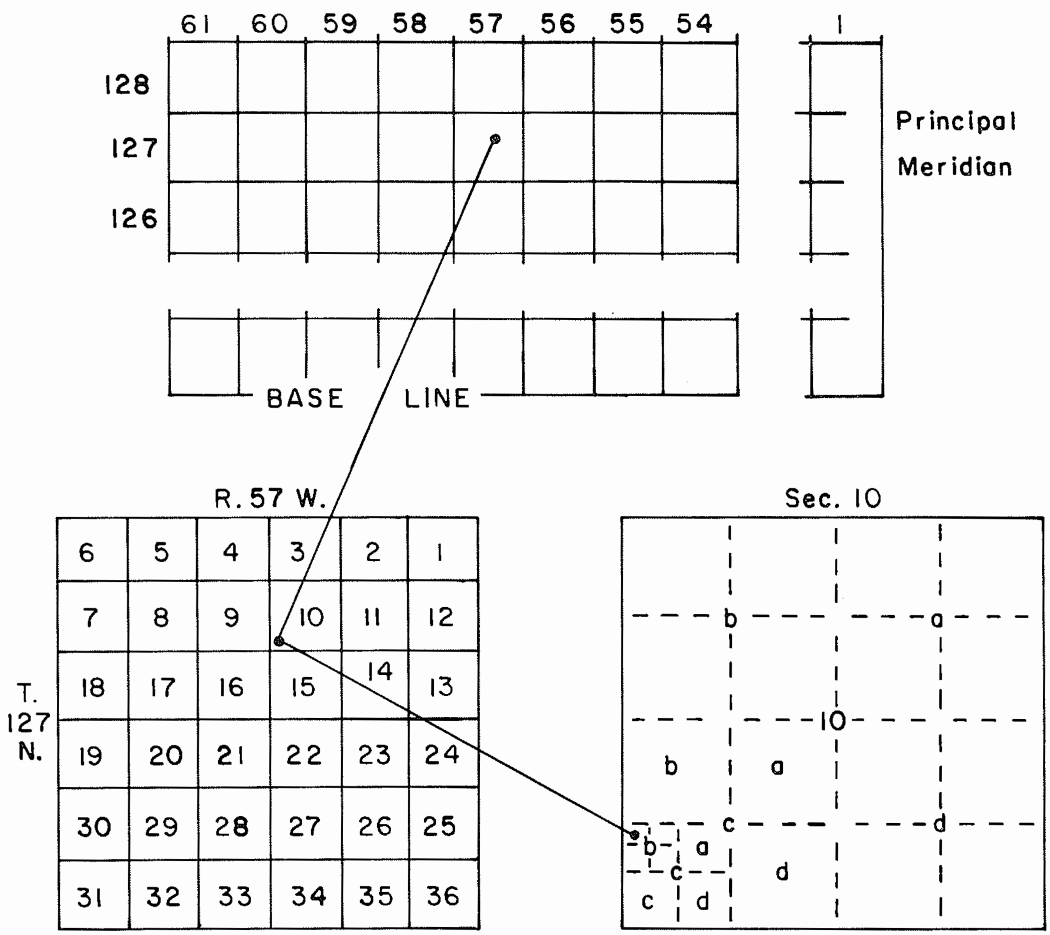


Figure 4 Well-Numbering System

Alluvium occurs along some of the small intermittent streams emerging from the Coteau des Prairies to the east of Britton (fig. 3). The alluvium consists mostly of silt and clay with some sand and locally may consist of gravel.

Subsurface Rocks

Stratified sedimentary rocks of Cretaceous age lie beneath the surficial deposits in the Britton area. The Pierre Shale immediately underlies the surficial deposits and crops out along a stream 4 miles east and 2 miles south of Britton (fig. 3). The Pierre is underlain in descending order by the Niobrara Marl, Carlile Shale, Greenhorn Limestone, and Graneros Shale, and sandstones of the Dakota Group.

Figure 5 is a contour map showing the configuration of the surface of the Pierre Shale as it would appear if all glacial deposits were removed. This map shows that the surface of the shale rises gradually eastward onto the Coteau des Prairies, and appears to have at least two east-west trending valleys cut into the shale.

The Pierre Shale is light to very dark bluish-gray bentonitic sandy shale, and is characterized by clay-ironstone and lime concretions. The thickness of the Pierre in this area is about 100 feet.

The Niobrara Marl consists of bluish-gray marl with a high percentage of calcium carbonate, and is sometimes highly fractured. At least 60 feet of Niobrara is present near Britton.

The Carlile Shale is medium- to dark-gray bentonitic shale with pyrite concretions and layers of fine brown siltstone, and is about 225 feet thick.

The Greenhorn Limestone is a gray, dense, and sometimes fractured limestone containing numerous fossil fragments. The thickness of the Greenhorn in this area is about 50 feet.

The Graneros Shale is a hard light- to dark-gray siliceous shale, and is about 150-200 feet thick.

The Dakota Group consists chiefly of fine to coarse light-colored sandstone interbedded with gray shales, and is at least 250 feet thick in the Britton area.

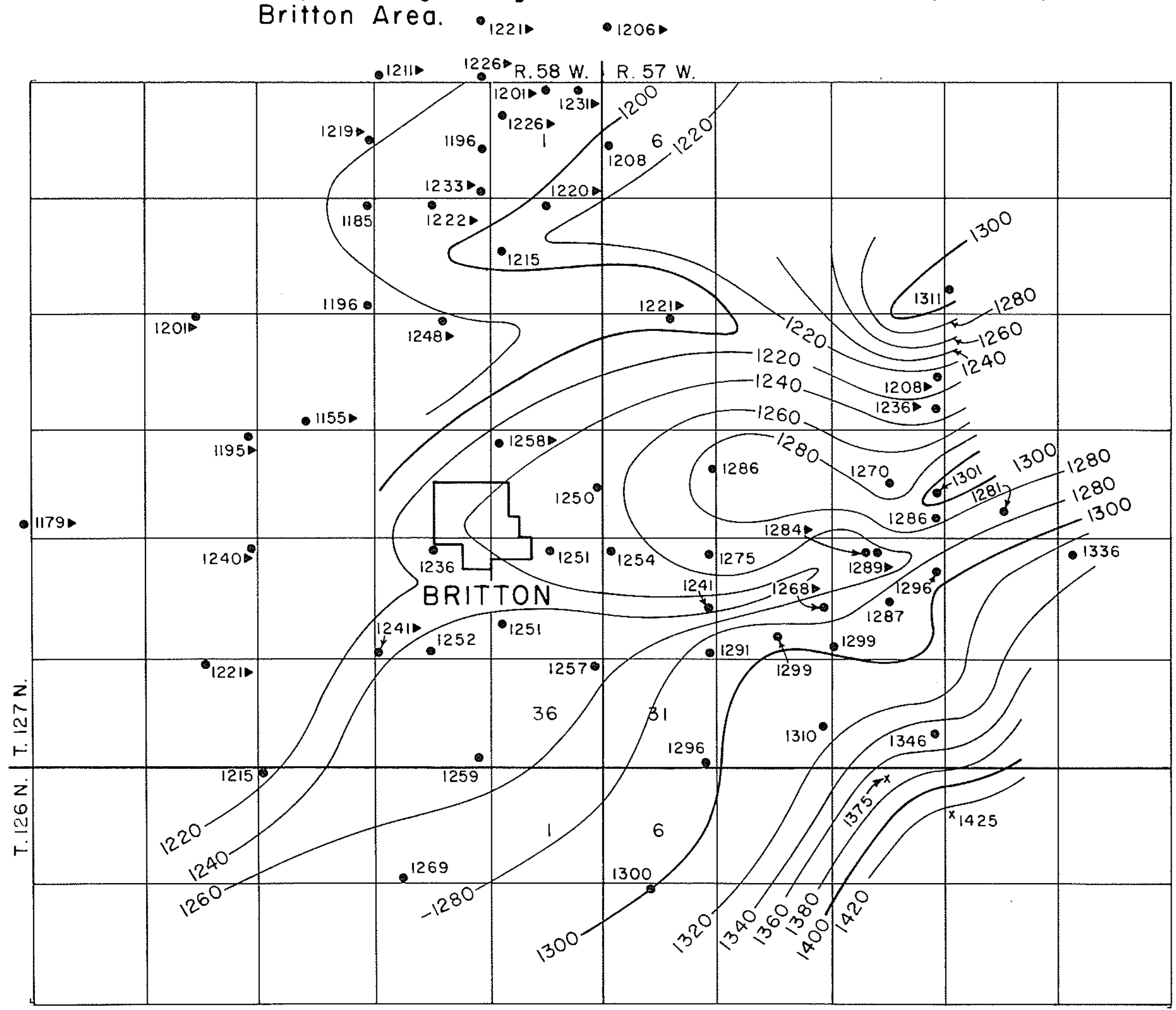
OCCURRENCE OF GROUND WATER

Principles of Occurrence

Ground water may be defined as water contained in the voids or openings of rock or sediments below the water table. Therefore, the water table marks the upper surface of the saturated zone of the water-bearing formation. This is not a static level but fluctuates and in a general way reflects the surface topography. The water level can range from a few feet to many tens of feet below the surface.

The common belief that water occurs in "veins" which criss-cross the land in a disconnected maze is not true; water occurs nearly everywhere below the surface.

Figure 5. Map showing configuration of the buried bedrock in the Britton Area.



SCALE

2 3 miles

N

EXPLANATION

●1251 Test hole showing elevation at which bedrock was encountered.

●1221▸ Test hole in which no bedrock was penetrated. The (▸) indicates that bedrock is "deeper than" the elevation listed.

x1425 Bedrock outcrop with approximate elevation above sea level.

Contour line showing equal elevation above sea level.

Contour interval = 20 feet

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The amount of water that is contained in the reservoir rock or aquifer is controlled by the size of the reservoir and by the porosity and permeability of the rock. Porosity is a measure of the number of voids in a rock, and is expressed as the ratio of pore space to the total volume of rock.

Porosity is dependent upon (1) the shape and arrangement of individual particles, (2) the degree of sorting of the particles, (3) the degree of cementation and compaction of the particles, and (4) the amount of material that has been removed by percolating ground water. Sands and gravels usually have porosities that range from 20-40 percent, depending upon the above conditions, whereas cemented sandstones have porosities of 15-25 percent. Sandstones usually have lower porosities owing to their higher degree of compaction and cementation.

Permeability is a measure of the rate at which a fluid under pressure will pass through a material. A material that has a high percentage of interconnected pores likewise has a high permeability, whereas a material that is high in porosity but in which the pores are not connected will have low permeability. Therefore, it can be seen that porosity and permeability are not synonymous, but are nevertheless related.

Nearly all ground water is derived from precipitation. Rain and melting snow either percolate directly downward to the water table and become ground water, or drain off as surface water. Surface water either evaporates, escapes to the ocean by streams, or percolates downward to the ground-water table. In general, ground water moves laterally down the hydraulic gradient, and is said to be in transient storage.

Recharge is the addition of water to an aquifer and is accomplished in three ways: (1) by downward percolation of precipitation from the ground surface, (2) by downward percolation from surface bodies of water, and (3) by lateral underflow of water in transient storage.

Discharge, or the removal of ground water from an aquifer, is accomplished in four main ways: (1) by transpiration by plants and evaporation, (2) by seepage upward or laterally into surface bodies of water as springs, (3) by lateral underflow of water in transient storage, and (4) by pumping or flowing wells.

Ground Water in Glacial Deposits

As mentioned earlier, the glacial deposits in the Britton area consist of till, minor amounts of outwash, and glacial lake deposits. Till, because of its unsorted nature and larger percentage of clay, usually does not yield water readily.

The outwash deposits near Britton are thin, discontinuous lenses in the till or small surface deposits which may or may not be saturated. In either case the long-term yield of water to a well in these deposits would not be sufficient to maintain a city supply.

Many of the test holes drilled in the mapped area during this study (see fig. 2 for locations) penetrated lake deposits. These test holes showed that the lake deposits are chiefly silt and clay with minor amounts of sand and some gravel. Although many of the stock and domestic wells obtain their supply from these deposits (App. B, Table 2) the yield to wells would be too small for a municipal water supply.

A buried sand of undetermined origin was located 3 to 4 miles north of Britton (fig. 3). Test holes 3, 5, 6, 7, 8, 12, 13, and 14 penetrated this sand. The thickness of the sand varied from 18 feet in test hole 12 to 90 feet in test hole 8 (fig. 6a). The sand is fine to coarse and contains up to about 50 percent clay and silt. The sand in test holes 5 and 8 appears to contain the least amount of clay, while the remainder of the tests contains increasing amounts up to 50 percent. Thus, it appears that the clay content increases rapidly as the margin of the aquifer is approached. Several test holes outside the boundary of the aquifer, such as 4, 9, and 11, showed an interval of sandy clay which may in fact be a continuation of the buried sand aquifer. Where present, the sandy clay probably would not be adequate for producing wells, but would be an important factor in consideration of recharge to the main part of the aquifer.

Figure 6b shows contours constructed on top of the buried sand. Used in conjunction with figure 6a it can be seen that at least the main part of the aquifer is an ovate, northwest-southeast trending body with upward sloping sides from an elevation of approximately 1,240 feet at the base to the highest point, 1,306 feet, near the center of the aquifer. These figures are an actual representation of the configuration of the buried sand. Thus it appears to be a buried, elongate "hill" of sand.

A buried "hill" of sand such as that described in the preceeding paragraph would probably be dewatered quite rapidly by large-capacity wells if recharge to the aquifer were not sufficient.

Ground Water in Alluvium

Alluvium is present along some of the small intermittent streams. This alluvium often contains large amounts of water where it is below the water table, but because of the low permeability of the silt and clay it does not yield water readily. Where sand and/or gravel occurs, the areal extent is restricted to such a degree that long-term, high-yield wells could not be constructed in it.

Ground Water in Bedrock

Both the Pierre Shale and the Dakota Group supply water to wells in the Britton area.

The Pierre Shale, because of its low permeability, would not supply sufficient amounts of water for the city, but it does, however, supply limited amounts of water for stock and domestic use.

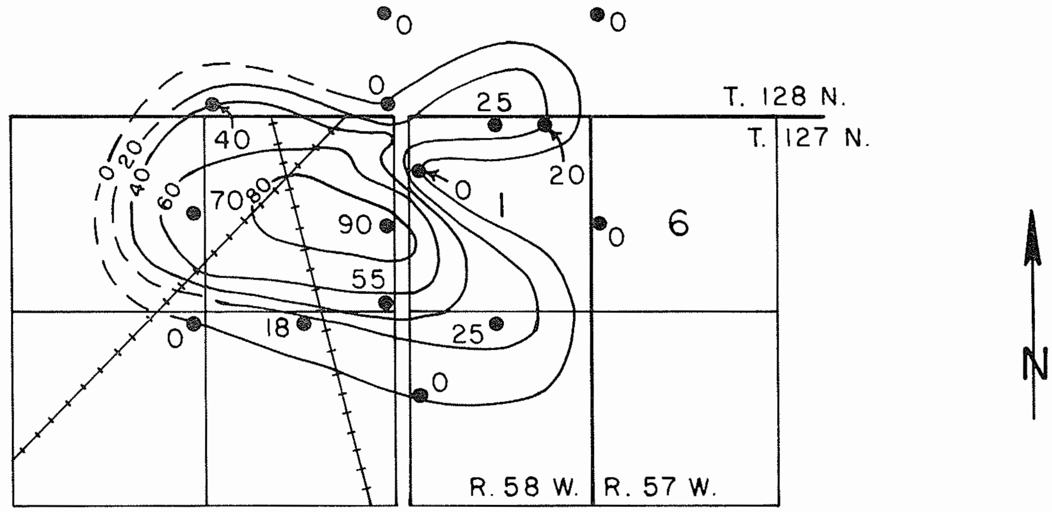
The sandstones of the Dakota Group are the only other bedrock from which water is readily obtained in the Britton area. These sandstones are at a depth of about 750-1,000 feet in the Britton area.

Quality of Ground Water

Precipitated water is nearly pure before it reaches the ground. However, all ground water contains minerals which are obtained: (1) from the atmosphere, (2) from soil and underlying deposits as the water percolates downward to the

Figure 6. Detailed Maps of the Aquifer north of Britton showing aquifer thickness and structure.

a. Isopach map of buried sand.



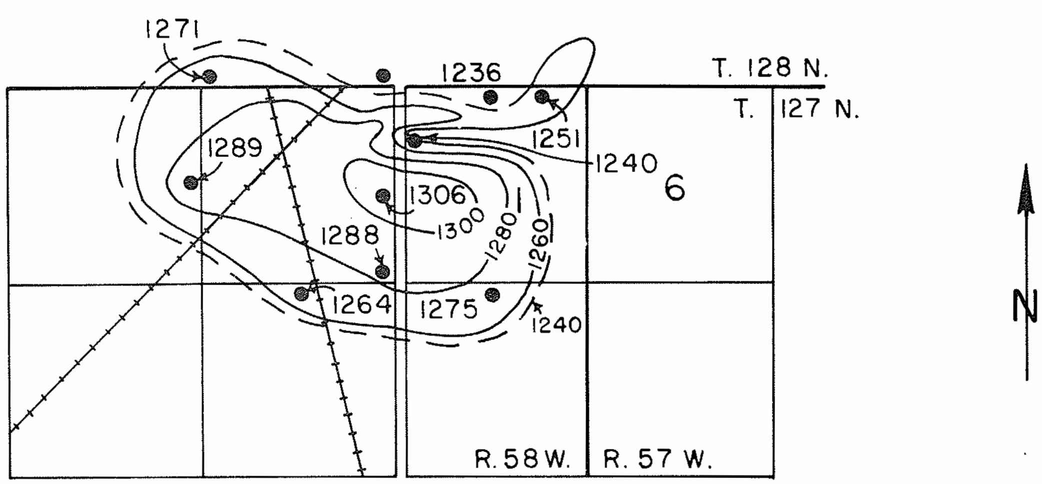
EXPLANATION

●70 Test hole showing minimum thickness of buried sand.

Contour line through points of equal thickness.

Contour interval = 20 feet

b. Structure map of buried sand.



EXPLANATION

●1236 Test hole showing elevation above sea level of the buried sand.

Contour line on top of buried sand showing equal elevation above sea level.

Contour interval = 20 feet

water table, and (3) from deposits in the water table in which the water is circulating. In general it can be said that the more dissolved minerals a water contains, the poorer its quality.

Table 1 shows the chemical properties of various waters in the Britton area compared to the present city water and to the standards for drinking water established by the U. S. Department of Public Health and modified for South Dakota. Water samples B, C, D, E, and 1 are from the sandstones of the Dakota Group. The analyses indicate the water is rather uniform in quality and as compared with the Department of Health recommendations is high in chloride, sulfate, iron, fluoride and total solids. The excessive high concentration of fluoride (7 ppm) is reduced by treatment to 1.6 ppm (sample E, table 1).

Water samples 8, 9, 10, 11, and 12 are from sand lenses in the till, and may vary erratically in chemical quality. Generally, all water samples from the sand lenses are high in sulfate, iron, hardness and total solids; in addition, the manganese content may be high, although no test was made for manganese in these samples.

Water samples 4, 5, 6, and 7 from sandy layers within the Lake Dakota sediments show varying ranges of quality. This erratic range in quality is common in water from small lenses of sand in the lake sediments.

Water samples 2 and 3 (?) are from the buried sand aquifer north of Britton. Sample 2 is slightly over the recommended limits in magnesium and total solids, and contains an excessive amount of iron. Sample 3 is high in magnesium and iron. These two samples indicate the water from the buried sand should be of acceptable quality with the exception of the probably high iron content.

Both samples 2 and 3 indicate that the water from the buried sand would probably be hard in comparison to the present city supply (about 65 ppm). However, hardness is not as important an element of water quality as the other minerals mentioned as can be seen by the fact that the U. S. Public Health Service sets no limits on hardness. Also, with modern detergents and softening processes, hardness has become less of a problem than in the past.

CONCLUSIONS AND RECOMMENDATIONS

The city of Britton has two possibilities for development of a municipal water supply from ground water sources within the area covered in this report. The first possibility is further development of their present supply from the sandstones of the Dakota Group. A new well or wells in the Dakota Group would probably supply the city with an additional quantity of water for many years. However, the chance of obtaining water from the Dakota Group of better quality than the present city supply is unlikely.

If the city should decide to develop their future needs for water from the Dakota Group, new wells should completely penetrate the Dakota Group, and tests should be made at different intervals to determine the quantity and quality of water. The final well design and construction could then be determined from the results of these tests.

The second possibility the city has for a ground water supply is from the buried sand about 3½ miles north of town (fig. 3). Test holes in this area

Table 1.--Chemical analyses of water samples from the Britton area.

Sample	Source	Parts Per Million											
		Calcium	Sodium	Magne-sium	Chlorides	Sulfate	Iron	Manga-nese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
A		---	---	50	250	500*	0.3	0.05	10.0	0.9-1.7**	---	----	1000*
B	D	18	842	5	325	1144	2.0	0.0	1.5	7.0	8.2	70	2614
C	D	20	842	5	320	1155	0.6	0.0	1.5	7.0	8.4	70	2555
D	D	20	842	5	318	1207	0.3	0.0	1.5	6.7	7.9	69	2547
E	Treated	19	842	4	325	1179	0.1	0.0	1.5	1.6	8.5	64	2553
1	D	24	---	6	296	779	.15	---	----	---	7.7	50	2705
2	BS	189	12	66	85	467	13.4	0.0	0.0	0.6	---	744	1078
3	BS(?)	96	30	350	0.0	119	2.2	---	0.0	0.0	---	384	864
4	LS	55	10	447	---	22	1.2	.66	0.1	0.7	---	321	526
5	LS	203	---	63	54	324	.15	---	----	---	7.5	760	1300
6	LS	2820	---	---	950	4140	.008	---	----	---	---	3900	8904
7	LS	550	---	---	120	1262	2.6	---	----	---	---	970	4014
8	SL	508	---	---	20	778	.02	---	----	---	---	920	1920
9	SL	522	---	---	32	827	.008	---	----	---	---	800	2162
10	SL	191	---	50	72	308	0.0	---	----	---	7.4	680	1190
11	SL	522	---	---	24	682	2.2	---	----	---	---	820	1762
12	SL	191	371	---	---	764	3.6	---	0.0	0.0	---	629	2120

Geologic source: D, Dakota sandstone; BS, buried sand; LS, Lake sand; SL, sand lens

* Modified for South Dakota by the Department of Health (written communication, February 5, 1962)

** Optimum

Locations of Water Samples

A. U. S. Dept. of Public Health Drinking Water Standards (1961)
B. Britton City Well #1
C. Britton City Well #2
D. Britton City Well #3
E. Treated city water
1. N. Marlow, 127-58-9da
2. H. Stokes, 127-58-2ad
3. W. Lewis, 127-57-6bb
4. L. Collingnon 127-58-23dc
5. C. Price, 127-57-32aa
6. R. Miller, 126-58-10aa
7. R. Sasse, 126-58-2da
8. K. Stanley, 127-58-22ba
9. R. Tom, 127-57-19cc
10. S. Stiegelmeier 127-57-32da
11. F. Bauer, 127-57-7cc
12. D. Wismer, 127-58-23cd

Samples B, C, D, and E were analyzed by the South Dakota Department of Public Health. Samples 1, 5, 6, 7, 8, 9, 10, and 11 were analyzed by the State Geological Survey, Vermillion. Samples 2, 3, 4, and 12 were analyzed by the State Chemical Laboratory.

indicate up to 90 feet of sand (Test hole 8, Appendix A), of which at least 55 feet is saturated. Water samples from wells in that area indicate the quality would be a considerable improvement over the present supply, with the exception of a possible high iron content.

If the city decides to further test the buried sand, additional test holes should be drilled to more closely delineate the extent, thickness, and shape of the deposit. Furthermore, if additional testing shows the extent, thickness and shape of this deposit to be essentially as described in this report, a pumping test should be conducted in which the duration of the test is of sufficient time to allow the drawdown to approach at least one of the mapped boundaries. This procedure would allow the best evaluation of the aquifer for a municipal water supply.

It is suggested that the city contact a commercial drilling company licensed by the State of South Dakota to test-drill the areas recommended. The city officials should consult the State Water Resources Commission with regard to obtaining a water right and a permit to drill a city well, and the State Department of Public Health with regard to the biological and chemical suitability of the water. A consulting engineering firm licensed in South Dakota should be hired to design the well and the water system.

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Flint, R. F., 1955, Pleistocene geology of eastern South Dakota: U. S. Geol. Survey Prof. Paper 262, fig. 1.

Rothrock, E. P., 1943, A geology of South Dakota, Part I: The surface: S. Dak. Geol. Survey Bull. 13, pl. 2.

U. S. Public Health Service, 1961, Drinking water standards: Am. Water Works Assoc. Jour., v. 53, no. 8, p. 935-945.

APPENDIX A

Logs of South Dakota Geological Survey Auger Test Holes in the Britton Area

(for locations see figure 2)

Test Hole No. 1
Location: 128-58-35addd
Elevation: 1,310 feet

0-19	clay, buff, silty, moist
19-49	clay, olive-gray, saturated
49-79	same, only gray
79-84	clay, gray, some sand
84-89	clay, gray, pebbly

* * * * *

Test Hole No. 2
Location: 128-57-31bccc
Elevation: 1,305 feet

0- 9	clay, dark-brown, dry
9-34	clay, buff, moist
34-49	clay, olive-gray, moist
49-94	clay, gray; saturated at 94 feet
94-99	clay, gray, moist; pebbles

* * * * *

Test Hole No. 3
Location: 128-58-35cccc
Elevation: 1,310 feet

0-24	clay, buff, moist
24-39	clay, gray, saturated; 20% fine sand
39-79	sand, gray fine; 25% clay
79-99	clay, gray; some sand

* * * * *

Test Hole No. 4
Location: 128-58-35dddd
Elevation: 1,310 feet

0-24	clay, buff, moist
24-44	clay, gray, saturated
44-79	clay, gray, saturated; 15-35% fine to medium sand
79-84	clay, gray; small pebbles

* * * * *

Test Hole No. 5
Location: 127-58-1abbb
Elevation: 1,310 feet

0- 9	clay, buff, dry
9- 24	clay, buff, moist; few pebbles
24- 44	clay, olive-gray; some sand
44- 74	clay, gray; 15% fine to coarse sand
74- 99	sand, coarse, some clay, saturated
99-109	clay, gray, hard; pebbles

* * * * *

Test Hole No. 6
Location: 127-58-1aabb
Elevation: 1,310 feet

0-19	clay, buff, moist
19-34	clay, olive-gray, moist
34-59	clay, gray, moist
59-79	sand, medium, 50%; clay, gray

* * * * *

Test Hole No. 7
Location: 127-58-3addd
Elevation: 1,308 feet

0- 9	clay, buff, moist
9-19	clay, gray, moist
19-74	sand, saturated; 25% gray clay
74-89	sand, saturated; 30% gray clay

* * * * *

Test Hole No. 8
Location: 127-58-2daaa
Elevation: 1,315 feet

0- 9	clay, buff, moist
9- 34	sand, coarse, moist; 10% clay
34- 99	sand, coarse, saturated; 5% clay
99-119	clay, gray
119-124	Pierre Shale

* * * * *

Test Hole No. 9
Location: 127-58-1bbcc
Elevation: 1,310 feet

0-24	clay, buff, moist
24-34	clay, buff, saturated
34-64	clay, gray, saturated
64-84	clay, gray, saturated; 25% fine sand

* * * * *

Test Hole No. 10
Location: 127-57-6cbbb
Elevation: 1,306.5 feet

0- 9	clay, buff, dry
9- 19	clay, buff, moist
19- 37	clay, gray, moist; 5% sand
37- 99	clay, gray, saturated; 5% sand
99-104	Pierre Shale

* * * * *

Test Hole No. 11
Location: 127-58-10aaaa
Elevation: 1,304 feet

0- 9	clay, buff, moist
9- 19	clay, olive-gray, moist
19- 34	clay, gray, saturated; 5% fine sand
34- 59	clay, gray, saturated; 30% medium sand
59-119	clay, gray, saturated; 5% fine sand; scattered rocks from 74 to 89 feet
119-124	Pierre Shale

* * * * *

Test Hole No. 12
Location: 127-58-11baaa
Elevation: 1,312 feet

0-14	clay, buff, moist
14-34	clay, olive-gray, moist
34-48	clay, olive-gray, saturated; 5% sand
48-64	sand, 5%, clay, olive-gray; many scattered small rocks
64-90	sand, fine; 25% olive-gray clay

* * * * *

Test Hole No. 13
Location: 127-58-2dddd
Elevation: 1,312 feet

0-24	clay, buff, moist
24-44	sand, fine to medium, buff, saturated
44-54	sand, medium, olive-gray, saturated
54-64	sand, gray saturated; few scattered rocks
64-79	sand, 20% clay

* * * * *

Test Hole No. 14
Location: 127-58-12baaa
Elevation: 1,309 feet

0- 3	topsoil, black, moist
3-14	clay, buff, moist
14-24	clay, olive-gray, moist
24-34	clay, gray, moist
34-39	sand, medium, saturated
39-44	sand, medium; 10% clay
44-59	sand, medium, olive saturated; 50% clay
59-89	clay, gray; 25% medium sand

* * * * *

Test Hole No. 15
Location: 127-58-12bccc
Elevation: 1,309 feet

0-24	clay, buff, silty, moist
24-29	clay, olive-gray, saturated; 5% sand
29-94	clay, gray, saturated; 5% sand
94-99	Pierre Shale

* * * * *

Test Hole No. 16
Location: 127-57-10ccbb
Elevation: 1,365 feet

0- 9	clay, buff, dry; pebbles
9-14	clay, buff, moist; pebbles
14-24	clay olive-gray, moist; pebbles
24-47	clay, gray, moist; pebbles
47-54	clay, sandy, gray, moist
54-69	Pierre Shale

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Test Hole No. 17
Location: 127-58-16baaa
Elevation: 1,300 feet

0- 4	sand, fine, moist; 25% gray clay
4-14	clay, buff, moist
14-29	clay, olive-gray, moist
29-99	clay, gray, saturated; 5% fine sand

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Test Hole No. 18
Location: 127-58-10dddd
Elevation: 1,305 feet

0- 14	clay, buff, moist
14- 29	clay, olive-gray, moist
29- 89	clay, olive-gray, saturated
89-109	clay, gray, saturated; 5% sand
109-119	Pierre Shale

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Test Hole No. 19
Location: 127-58-14abbb
Elevation: 1,312 feet

0-19	clay, buff, moist
19-44	clay, gray, moist
44-59	clay, gray, saturated; 10% fine sand
59-64	clay, gray; pebbles

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Test Hole No. 20
Location: 127-57-18abbb
Elevation: 1,305 feet

0-17	clay, buff, moist
17-27	clay, olive-gray, moist
27-44	clay, gray, saturated; scattered rocks
44-77	clay, gray, saturated; 5% sand
77-84	clay, gray, moist; small pebbles

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Test Hole No. 21
Location: 127-57-16daaa
Elevation: 1,348 feet

0- 14	clay, buff, moist
14- 24	clay, olive-gray, moist
24- 39	clay, gray-brown, moist; pebbles
39- 74	clay, gray, moist; pebbles
74-140	clay, gray, moist; pebbles

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Test Hole No. 22
Location: 127-57-16ddaa
Elevation: 1,345 feet

0- 34	clay, buff, moist
34- 89	clay, gray, saturated; 5% sand; scattered rocks
90-109	clay, gray; pebbles

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Test Hole No. 23
Location: 127-58-19dddd
Elevation: 1,293.5 feet

0- 9	sand; 15% buff clay
9- 19	clay, gray; 50% fine sand
19-115	clay, gray, silty; some fine sand

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Test Hole No. 24
Location: 127-58-21aaaa
Elevation: 1,305 feet

0- 25	clay, buff, unsaturated
25- 95	clay, silty, dark-gray, saturated; little sand
95-110	clay, silty, dark-gray, saturated

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Test Hole No. 25
Location: 127-58-15cddd
Elevation: 1,305 feet

0- 20	clay, buff, moist
20- 32	clay, silty, dark-gray, moist
32- 75	clay, silty, dark-gray, saturated; 5-30% sand
75- 85	clay, silty, dark-gray, saturated; some rocks
85-130	clay, silty, dark-gray; 50% medium sand
130-150	clay, sandy, gray, saturated

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Test Hole No. 26
Location: 127-58-24bbbc
Elevation: 1,308 feet

0- 2	topsoil, black
2-14	clay, buff, moist; fine to coarse sand
14-34	clay, silty, gray; fine sand
34-50	clay, gray, saturated; 50% sand

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Test Hole No. 27
Location: 127-58-24daaa
Elevation: 1,324 feet

0-12	clay, buff, moist; 25% sand
12-24	clay, buff, saturated; 50% medium sand
24-34	clay, olive; 25% fine sand
34-49	clay, gray, saturated; 5% sand
49-74	clay, gray, moist; 5% sand
74-84	Pierre Shale

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Test Hole No. 28
Location: 127-57-19adaa
Elevation: 1,350 feet

0- 9	clay, olive-gray, moist; pebbles
9-24	clay, buff, moist; 5% sand
24-64	clay, gray, saturated; 5% sand
64-69	Pierre Shale

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Test Hole No. 29
Location: 127-57-21 (center)
Elevation: 1,344 feet

0-24	clay, olive-gray, moist; pebbles
24-34	clay, gray, saturated; 20% sand
34-44	clay, gray; 50% coarse sand
44-74	clay, gray; coarse sand with scattered rocks
74-89	Pierre Shale

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Test Hole No. 30
Location: 127-57-21dadd
Elevation: 1,355 feet

0- 9	clay, buff, moist, pebbles
9-19	clay, buff, saturated; 20% sand
19-54	clay, gray; scattered rocks
54-59	Pierre Shale

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Test Hole No. 31
Location: 127-57-21ddda
Elevation: 1,355 feet

0- 9	clay, buff, moist; pebbles
9-19	sand, medium to coarse; 25% buff clay
19-54	clay, gray, many pebbles
54-69	sand, fine to medium, silty
69-74	Pierre Shale

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Test Hole No. 32
Location: 127-57-22dcbb
Elevation: 1,370 feet

0- 4	topsoil
4- 6	gravel, fine
6-24	clay, gray, moist; 50% coarse sand
24-39	clay, buff to olive-gray, saturated; 10% sand
39-69	clay, gray, saturated; 5% sand; scattered rocks
69-89	clay, gray; pebbles

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Test Hole No. 33
Location: 127-58-28aaaa
Elevation: 1,330 feet

0- 4	sand, medium, light-brown, saturated; some clay
4-13	sand, medium, light-brown, unsaturated
13-30	sand, gravel, dry; some clay
30-50	sand, medium, clayey, brown, saturated
50-70	sand, medium, silty and clayey
70-90	silt, some sand

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Test Hole No. 34
Location: 127-58-26baaa
Elevation: 1,355 feet

0- 4	clay, buff, dry
4- 19	clay, buff, moist
19- 34	clay, olive-gray, moist; pebbles
34-109	clay, gray, moist; pebbles
109-119	clay, gray, saturated
119-129	Pierre Shale

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Test Hole No. 35
Location: 127-58-25baaa
Elevation: 1,355 feet

0- 34	clay, buff, moist
34- 54	clay, gray, saturated; 5% sand
54-104	clay, gray, 10% sand
104-109	Pierre Shale

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Test Hole No. 36
Location: 127-57-30bbbb
Elevation: 1,358 feet

0- 9	clay, gray, moist; pebbles
9- 24	clay, buff, moist; pebbles
24- 39	clay, dark-gray; few pebbles
39- 79	clay, gray, moist
79-104	clay, gray, saturated; 10-20% fine sand
104-114	Pierre Shale

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Test Hole No. 37
Location: 127-57-30aaaa
Elevation: 1,338.5 feet

0- 9	clay, olive to buff, moist; 5% sand
9-19	clay, buff, moist
19-24	clay, olive-gray
24-59	clay, gray, moist; pebbles
59-64	clay, gray, saturated; 5% sand
64-69	Pierre Shale

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Test Hole No. 38
Location: 127-57-28baab
Elevation: 1,343 feet

0- 9	clay, buff to olive-gray, moist
9-14	clay, gray, moist; pebbles
14-29	clay and fine sand
29-39	sand, coarse, clayey
39-59	gravel and clay

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Test Hole No. 39
Location: 127-57-28baab
Elevation: 1,343 feet

0-19	clay, silty, buff, moist
19-29	clay, sandy, silty, gray, moist
29-34	clay, silty, gray, saturated; more sand
34-44	gravel, silty; gray clay
44-54	clay, dark-gray; pebbles

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Test Hole No. 40
Location: 127-57-28aadd
Elevation: 1,365 feet

0- 9	clay, buff, moist
9-29	clay, buff to olive-gray, moist; pebbles
29-64	clay, gray, dry; pebbles
64-69	clay, gray, saturated; 5% sand
69-79	Pierre Shale

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Test Hole No. 41
Location: 127-57-26bbba
Elevation: 1,400 feet

0- 6	clay, dark-gray, pebbles
6- 9	clay, gray, rocks
9-19	clay, buff, moist, 25% sand
19-49	clay, gray, moist, pebbles
49-51	clay, gray, rocks
51-64	clay, gray, pebbles
64-69	Pierre Shale

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Test Hole No. 42
Location: 127-58-33abbb
Elevation: 1,320 feet

0- 4	topsoil, black
4- 9	clay, dark-brown, dry
9-14	clay, brown, mist
14-19	clay, yellow-brown, moist; pebbles
19-29	clay, olive-gray, moist; pebbles
29-64	clay, gray, moist
64-89	clay, gray, saturated, some fine sand
89-99	clay, gray, saturated; 40% fine sand

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Test Hole No. 43
Location: 127-58-26cccc
Elevation: 1,330 feet

0-24	clay, buff, moist, pebbles
24-29	clay, olive-gray, moist; pebbles
29-64	clay, gray, moist
64-89	clay, gray, moist, 5% sand
89-94	Pierre Shale

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Test Hole No. 44
Location: 127-58-26cddd
Elevation: 1,331 feet

0-14	clay, buff, dry; pebbles
14-24	clay, olive-gray, moist
24-64	clay, dark-gray, moist; 5% sand
64-79	clay, dark-gray, saturated; 20% sand
79-90	Pierre Shale

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Test Hole No. 45
Location: 127-58-25cbcc
Elevation: 1,340 feet

0- 24	clay, buff, moist
24- 44	clay, buff, saturated
44- 49	clay, dark-gray, moist
49- 89	clay, dark-gray, saturated; 25% sand
89-104	Pierre Shale

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Test Hole No. 46
Location: 127-57-30daaa
Elevation: 1,335 feet

0- 19	clay, buff, moist
19- 34	clay, olive-gray, moist
34- 59	clay, gray
59- 94	clay, gray, moist; pebbles
94-115	Pierre Shale

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Test Hole No. 47
Location: 127-57-30dddd
Elevation: 1,335 feet

0-14	clay, olive-gray, moist
14-44	clay, gray, moist; 5% sand
44-59	Pierre Shale

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Test Hole No. 48
Location: 127-57-29dcbb
Elevation: 1,334 feet

0- 9	clay, buff, moist
9-14	clay, olive-gray, moist; pebbles
14-35	clay, gray, saturated; 10-20% sand
35-44	Pierre Shale

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Test Hole No. 49
Location: 127-57-29daaa
Elevation: 1,336.5 feet

0- 9	clay, buff, moist; 5% sand
9-14	clay, olive-gray, moist; pebbles
14-19	clay, gray, moist
19-24	clay, gray, saturated; 5% sand
24-44	clay; medium gravel
44-69	clay, gray, moist; pebbles

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Test Hole No. 50
Location: 127-57-28cccb
Elevation: 1,345 feet

0- 4	clay, dark-gray, moist; pebbles
4- 9	clay, buff, moist; 10% sand
9-19	sand, medium, clayey, moist
19-29	clay, sandy, gray, moist; pebbles
29-44	clay, gray, moist; pebbles
44-46	clay, bright-green, moist
46-54	Pierre Shale

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Test Hole No. 51
Location: 127-57-28 (center)
Elevation: 1,346 feet

0- 9	clay, buff, moist; pebbles
9-24	clay, olive-gray, moist; pebbles
24-59	clay, gray, moist; pebbles
59-64	Pierre Shale

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Test Hole No. 52
Location: 126-58-3bbb
Elevation: 1,314 feet

0-29	clay, buff, moist
29-94	clay, gray, moist; 10% sand
94-99	clay, gray; pebbles

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Test Hole No. 53
Location: 127-58-35dddd
Elevation: 1,323 feet

0-24	clay, buff, moist
24-59	clay, olive-gray, moist; pebbles
59-64	clay, gray, saturated; 15% sand
64-74	Pierre Shale

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Test Hole No. 54
Location: 127-58-36aaaa
Elevation: 1,325 feet

0-24	clay, buff, moist
24-59	clay, dark-gray; moist
59-68	clay, dark-gray, 20% sand
68-74	Pierre Shale

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Test Hole No. 55
Location: 127-57-31dddd
Elevation: 1,335 feet

0- 4	clay, gray, dry; small pebbles
4- 9	clay, buff, dry; pebbles
9-14	clay; 20% sand
14-29	clay, moist; 50% coarse sand
29-39	clay, buff to olive-gray, saturated
39-49	Pierre Shale

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Test Hole No. 56
Location: 127-57-32daaa
Elevation: 1,360 feet

0- 4	topsoil, black
4-19	clay, black to brown, moist; pebbles
19-29	clay, buff, saturated; 30% medium sand
29-50	clay, gray; 5% sand; many pebbles
50-59	Pierre Shale

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Test Hole No. 57
Location: 127-57-33dadd
Elevation: 1,395 feet

0- 9	clay, olive-gray, moist; pebbles
9-14	clay, gray, moist; 10% coarse sand
14-24	clay, gray, saturated; 50% medium gravel
24-39	clay, gray, saturated; 5% sand
39-49	sand, fine, saturated; some clay
49-59	Pierre Shale

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Test Hole No. 58
Location: 126-58-2ccdd
Elevation: 1,318 feet

0- 9	clay, dark-brown, moist
9-24	clay, buff, moist
24-49	clay, gray, moist
49-54	Pierre Shale

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Test Hole No. 59
Location: 126-57-7abbb
Elevation: 1,335 feet

0- 6	clay, buff, moist
6-11	sand, brown, moist
11-24	clay, buff, moist; some sand
24-34	clay, gray; pebbles
34-35	Pierre Shale

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APPENDIX B

Table 2.--Records of wells in the Britton area.

Type of well: Du, dug; D, drilled; B, bored
Geologic source: G, glacial; P, Pierre; D, Dakota
Character of Material: G, gravel; S, sand; S+G, sand and gravel; SS, sandstone; SH, shale
Use of water: D, domestic; S, stock

Well Location	Owner or Tenant	Type of Well	Depth of Well (feet)	Geologic Source	Character of Material	Use of Water
126-57-1bc	Henry Hansen	D	447	G(?)	G	S,D
126-57-3da	Albert Mettler	B	40	G	G(?)	S,D
126-57-3da	Albert Mettler	D	120	G	S	S,D
126-57-3bc	Alvah Slater	B	40	G	S+G	S,D
126-57-5dd	Ivan Opp	D	900	D	SS	S,D
126-57-6cd	Russell Tank	D	1,029	D	SS	S,D
126-57-7ad	Clifford Freiss	D	1,100	D	SS	S,D
126-57-9ab	Jesse Voss	D	1,100	D	SS	S,D
126-57-15bb	Clarence Hartman	Du	60	P	SH	S,D
126-58-1cb	Lawrence Crowder	D	1,000	D	SS	S,D
126-58-2da	Ray Sasse	D	47	G	S	D
126-58-5cd	Darrell Wallace	D	965	D	SS	S
126-58-9bb	Eerko Aeilts	D	1,200	D	SS	S,D
126-58-10aa	Raymond Miller	B	35	G	S	S,D
126-58-10cb	Gerald Schneider	D	1,048	D	SS	S,D
126-58-11da	Clayton Bremmon	D	900	D	SS	S,D
127-57-2da	Junior Johnson	Du	20	G	S(?)	S,D
127-57-3ab	George Fiegel	B	37	G	S+G	S,D

Table 2.--Records of wells--continued

Well Location	Owner or Tenant	Type of Well	Depth of Well (feet)	Geologic Source	Character of Material	Use of Water
127-57-4ab	Ernest Anderson	D	100	G	S+G	S,D
127-57-6aa	Glenn Hook	D	1,000	D	SS	S,D
127-57-6bb	Wendell Lewis	D	135	G	S	S,D
127-57-7cc	Frank Bauer	D	105	G	S	S,D
127-57-8bb	Rodney Stiegelmeier	B	50	G	S	S
127-57-8cc	Lyle Sherburn	D	1,000	D	SS	S,D
127-57-9dc	Thomas Granseth	D	1,000	D	SS	S
127-57-9dc	Thomas Granseth	D	125	G	S+G	D
127-57-10aa	Marvin Granseth	D	54	G	G	S,D
127-57-12cc	Albert Hart	B	30	G	G	S,D
127-57-14ad	Giles Semple	Du	25	G	G	S,D
127-57-15dd	W. Mierkle	B	58	G	G(?)	S
127-57-17aa	Guerrin McLaughlin	B	22	G	S	D
127-57-19bb	Golf Course	D	80	G	S(?)	D
127-57-19cc	Rubin Tom	D	56	G	S	D
127-57-20bc	Pearl Patterson	D	80	G	S	S,D
127-57-21bc	Erving Behnke	D	60	G	S	D
127-57-21ab	Ronald Patterson	B	75-100	G	G(?)	D
127-57-21da	Marvin Bender	B	25	G	G	S
127-57-22aa	Ambrose Granseth	D	1,000	D	SS	S,D
127-57-22cc	H. J. Schneider	B	50	G	S	S,D

Table 2.--Records of wells--continued

Well Location	Owner or Tenant	Type of Well	Depth of Well (feet)	Geologic Source	Character of Material	Use of Water
127-57-22cc	H. J. Schneider	D	960	D	SS	S,D
127-57-24bb	Merlin Behnke	B	15	G	S+G	S,D
127-57-25bc	Arnold Damgaard	Du	40	G	S	S,D
127-57-26ab	Iva Smith	B	28	G	S	S,D
127-57-26bb	Frank Hinkler	Du	28	G	S(?)	S,D
127-57-27ad	Ray Freeman	B	30	G	S	S,D
127-57-27bb	Charles Rabenberg	B	30	G	S	S,D
127-57-27cb	Charles Behnke	Du	24	G	G(?)	S
127-57-29bb	Arthur Elsner	D	?	D	SS	D
127-57-32aa	Carol Price	B	25	G	G	S
127-57-32da	Sydney Stiegelmeier	B	18	G	G	S,D
127-57-33cc	Reiny Bender	B	49	G	S	S
127-57-33dd	John Andrews	B	18	G	S(?)	S,D
127-57-35cb	John Bender	B	40	(?)	(?)	S
127-58-3aa	William Stokes	D	1,000	D	SS	S,D
127-58-3cb	Myrtle Didrickson	D	42	G	S	S,D
127-58-9da	Norman Marlow	D	1,000	D	SS	S,D
127-58-9bc	Carl Mueller	D	960	D	SS	S,D
127-58-10ad	John Abels	D	930	D	SS	S,D
127-58-10cc	Archie Kilker	D	960	D	SS	S,D
127-58-11da	Vern Wampler	D	950	D	SS	S,D

Table 2.--Records of wells--continued

Well Location	Owner or Tenant	Type of Well	Depth of Well (feet)	Geologic Source	Character of Material	Use of Water
127-58-12bc	A. B. Christenson	D	900	D	SS	S,D
127-58-13cb	A. C. Aadland	Du	30	G	S	D
127-58-13dd	A. C. Bonham	D	900	D	SS	S,D
127-58-14cb	Herman Carlson	D	1,000	D	SS	S,D
127-58-15cc	Leslie Eberlein	D	960	D	SS	S,D
127-58-17cd	H. C. Freudenthal	D	980	D	SS	S,D
127-58-20cc	Welby Moeckly	D	90-125	G	S	D
127-58-21cc	Clifford Reyelts	D	960	D	SS	S,D
127-58-22ba	Kenneth Stanley	D	60	G	S	S,D
127-58-23dc	Luverne Collingon	D	52	G	S	D
127-58-23bd	Lee Johnson	D	50	G	S	S,D
127-58-23cd	Dick Wismer	D	105	G	S	D
127-58-23da	Don Franzen	D	67	G	S	D
127-58-25ab	Jesse Schneider	D	85	G	S	D
127-58-25ba	Willy Schneider	B	45	G	S	Not used
127-58-25bb	Hospital	D	120	P	SH	Dry hole
127-58-27bb	Clifford Reyelts	D	960	D	SS	S,D
127-58-32bb	Melvin Reyelts	D	960	D	SS	S,D
127-58-33cd	Loren Grupe	D	1,000	D	SS	S,D
127-58-35ba	Ben Brandt	D	800-900	D	SS	S,D
127-58-36cd	Elmer Andrews	D	900-1,000	D	SS	S,D