STATE OF SOUTH DAKOTA
Archie Gubbrud, Governor

STATE GEOLOGICAL SURVEY
Allen F. Agnew, State Geologist

SPECIAL REPORT 17

GROUND WATER SUPPLY FOR THE CITY OF MILLER

by
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INTRODUCTION

Present Investigation

This report contains the results of a special investigation made by the South Dakota State Geological Survey during the summer of 1961 in and around the city of Miller, Hand County, South Dakota (fig. 1), for the purpose of assisting the city in locating future water supplies. Miller now receives its water from two artesian wells which in recent years have not produced the quantity of water needed by the city. The two wells produce from the Dakota Sandstones, at a depth of about 1,250 feet, and are located within the city limits (fig. 2).

A survey of the ground water possibilities was made of a 63 square mile area around the city; this consisted of geologic mapping, a well inventory, the drilling of 24 test holes, and the taking of 9 water samples for analysis.

The performance of the field work and the preparation of this report were done under the supervision of Merlin J. Tipton, geologist in charge of ground water studies for the South Dakota State Geological Survey. The writer was assisted in the field by Robert Schoon, geologist-driller, James McMeen, Steve Pottratz, and Mike Clancy. The cooperation of the residents of Miller, especially Mayor J. C. Hagan, M. D., Utilities Superintendent R. P. Deardorff, and the employees of the City Street Department is greatly appreciated.

Location and Extent of Area

The city of Miller is located in east-central South Dakota, and has a population of 2,081 (1960 census). The area is in the James Basin of the Central Lowland physiographic province (fig. 1).

Climate

The climate is continental temperate, with large daily fluctuations in temperature. The average yearly temperature is 46.4° F. and the average annual precipitation is 18.31 inches, at the U. S. Weather Bureau Station in Miller.

Topography and Drainage

The topography of the area is typically glacial moraine--gently rolling hills and valleys. The drainage southwest of Miller is controlled by the steep northeast-facing escarpment of the Ree Hills part of the Coteau du Missouri which rises about 300 feet within 25 miles of Miller; consequently, most streams flow in a northeasterly direction and have narrow V-shaped valleys.

The two main streams in the area mapped are Ree Creek and Turtle Creek (fig. 3) which have slightly broader valleys and follow more meandering paths than the smaller streams.

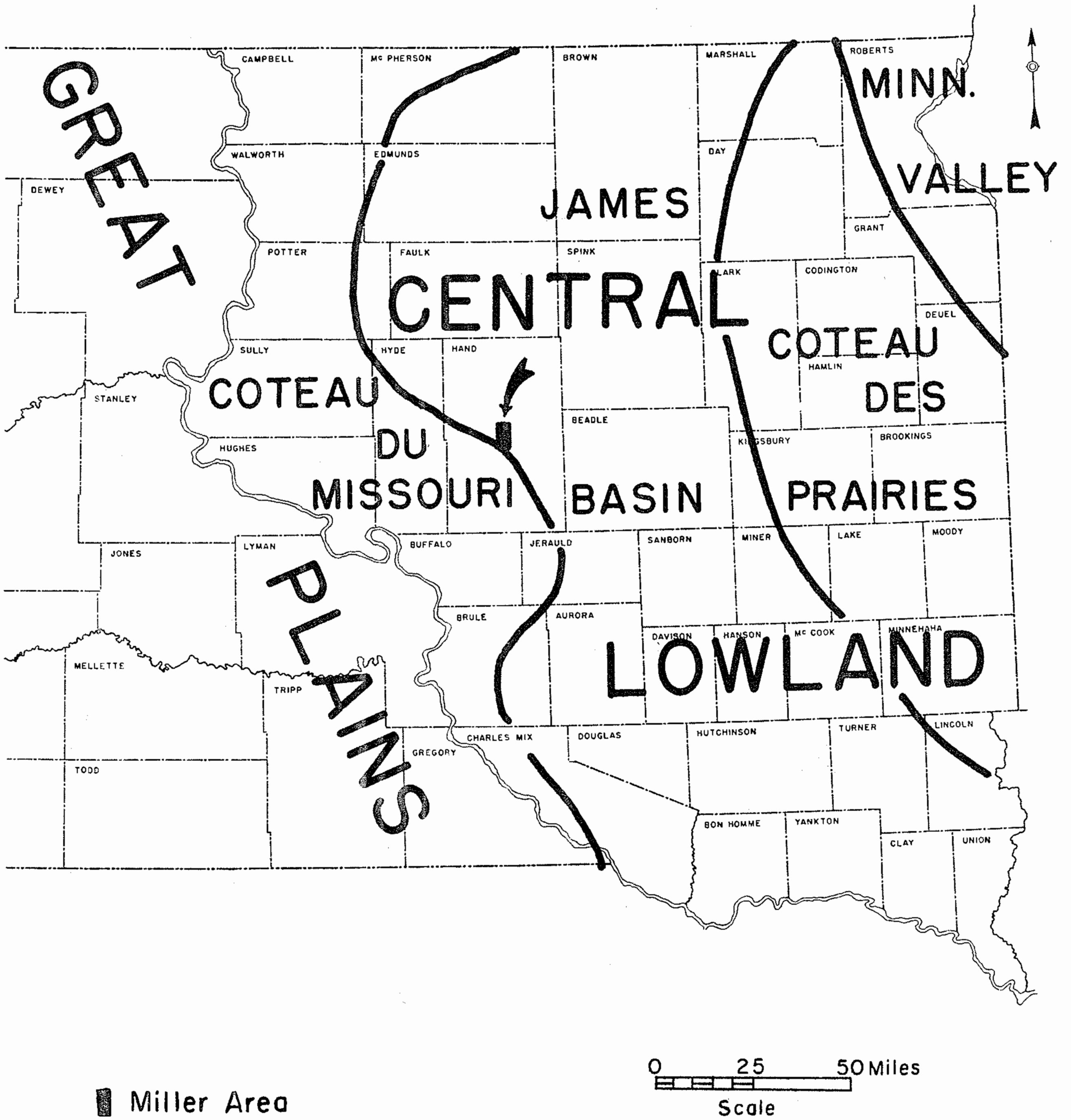

Figure I. Major Physiographic Divisions of Eastern South Dakota.

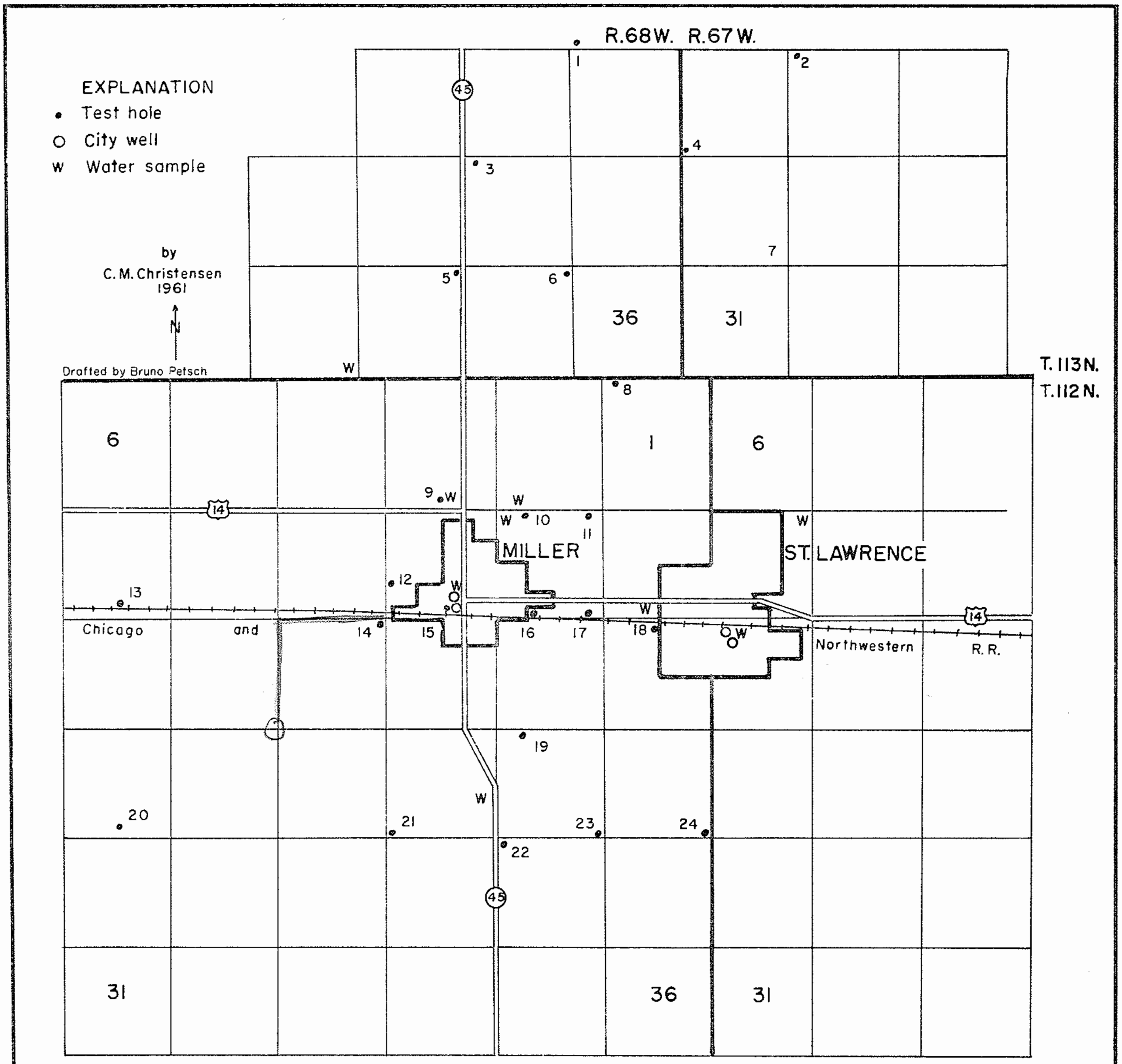

Figure 2. Data Map of Miller Area.

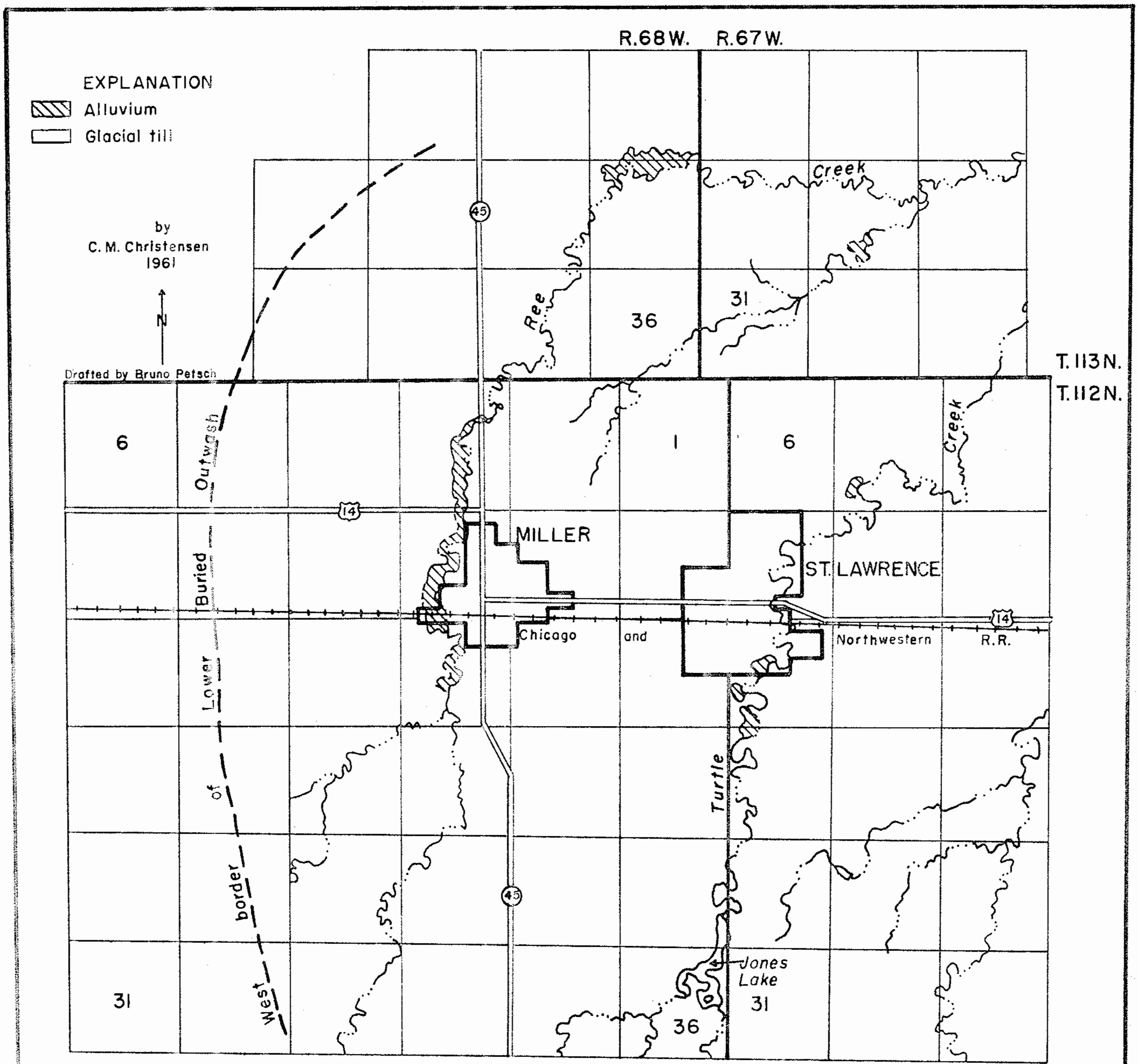

Figure 3. Generalized Geologic Map of the Miller Area.

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Miller area are chiefly the result of glaciation late in the Pleistocene Epoch. The glacial deposits, collectively termed drift, can be divided into till and outwash. Till consists of a mixture of clay, silt, sand, pebbles, and boulders which were carried and deposited by the ice itself. Outwash is better sorted than till, consisting mainly of sand and gravel with minor amounts of silt and clay and only a few cobbles and boulders. The outwash material was deposited by meltwater streams from the ice. Outwash deposits are not present at the surface in the mapped area; however, several outwashes covered by 50-200 feet of till were penetrated in test holes. These buried outwashes were presumably deposited by glaciation prior to the last ice sheet that covered this area.

Alluvial material (fig. 3) has been locally deposited on the glacial deposits by several large streams since the retreat of the ice. The alluvium consists of clay and silt with minor amounts of fine sand.

Subsurface Bedrock

Stratified sedimentary rocks of Cretaceous age are found beneath the surficial deposits in the Miller area. The Pierre Shale lies directly under the glacial deposits and rests on the Niobrara, Carlile, Greenhorn and Graneros Formations, and the Dakota Group, in descending order.

The Pierre consists of light-gray fissile shale with bands of iron concretions.

The Niobrara consists of light to medium blue-gray shale which contains numerous microscopic white calcareous specks.

The Carlile is medium- to dark-gray bentonitic shale with pyrite concretions and layers of fine brown siltstone.

The Greenhorn consists of a hard layer of white to cream limestone containing numerous fossil fragments. This limestone layer is overlain (and possibly underlain) by a layer of dark-gray shale containing numerous small, white calcareous specks.

The Graneros is hard light- to dark-gray siliceous shale.

The Dakota Group consists of alternating layers of sandstones and shales. These sandstones and shales are 1100-1400 feet below the surface in this area.

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Contrary to popular belief, ground water does not occur in "veins" that criss-cross the land at random. Instead, water occurs nearly everywhere beneath the surface, but at varying depths. The top of this zone of water saturation is known as the water table.

Nearly all ground water is derived from precipitation. Rain or melting snow either percolates downward to the water table and becomes ground water, or drains off as surface water. Surface water may percolate downward and become ground water, or may evaporate or drain to the sea by means of streams. In general, ground water moves laterally down the hydraulic gradient, and is thus said to be in transient storage.

Recharge is the addition of water to an aquifer (water-bearing material) and is accomplished in a number of ways: (1) by downward percolation of precipitation from the land surface, (2) by downward percolation from surface bodies of water such as lakes and streams, and (3) by lateral movement of water in transient storage.

Discharge of ground water from an aquifer is accomplished in four main ways: (1) by evaporation and transpiration from plants, (2) by seepage upward into surface bodies of water, (3) by lateral movement of water in transient storage, and (4) by pumping.

The amount of water that can be stored in a saturated material is equal to the amount of voids or pore spaces in the material. A measurement of the capability of a material to store water (or any other fluid) is called porosity. Porosity depends entirely on the shape and arrangement cf the particles in a material, and is not affected by the size of the particles. Sands and gravels usually have porosities of 20-40 percent, whereas sandstones normally have porosities of 15-25 percent; this lower porosity of sandstones id due to closer packing and the cementation of the particles.

Permeability is the rate at which a fluid will pass through a substance. If the pore spaces of a material are connected, the permeability of that material will be high. If the pore spaces are not conected the permeability will be low. Thus, a material may have high porosity and still not yield water readily because of low permeability. Sands and gravels, however, tend to have both high porosity and high permeability. Thus the geologist is not concerned with finding a "vein" when looking for a good water supply. Instead, because water occurs almost everywhere in the ground, he is searching for a sand or gravel deposit that lies beneath the water table.

Ground Water in Alluvium

A small amount of alluvium is present along Ree Creek and Turtle Creek in the Miller area (fig. 3). This alluvium contains large amounts of water where it is beneath the water table, but because of its low permeability it does not yield water readily.

Ground Water in Glacial Deposits

Glacial outwash deposits, because they are better sorted, yield water much more readily than till. The outwash deposits of the Miller area include several small shallow buried outwashes, and a more extensive lower buried outwash.

These buried outwashes were test-drilled with the State Geological Survey's rotary drilling rig. The test holes were drilled with natural mud using a $4\frac{1}{2}$-inch drag bit.

The first (highest) upper buried outwash occurs five miles northeast of Miller (Test Holes 1, 2, and 4, Appendix A and fig. 2) at a depth of about 65 feet, and averages about 10 feet in thickness. The second upper buried outwash underlies the area just west of Miller (Test Hole 12) and is at a depth of about 90 feet, and has an average thickness of about 11 feet. The third upper buried outwash underlies the area in and just east of Miller (Test Holes 15 and 16) and is at a depth of about 50 feet, and has a thickness of about 20 feet. None of the upper buried outwashes is as extensive as the lower buried outwash.

The lower buried outwash is covered by 100-200 feet of till, and fills a buried valley that trends north-south across the mapped area (fig. 3).

The thickness and distribution of the lower buried outwash in the Miller area is shown on the isopach map (fig. 4). From the isopach map it can be seen that the thickest part of the buried outwash is east and north of the town of St. Lawrence. These lower buried outwash sediments average about 15 feet in thickness and attain a maximum thickness of 25 feet (Test Hole 18). The thickness of the lower buried outwash sediments in some key wells in the area is shown by the geologic cross-section (fig. 5). The areal extent of this lower buried outwash in the mapped area (fig. 4) is at least 35 square miles.

Ground Water in Bedrock

The sandstones of the Dakota Group are the only known bedrock in the Miller area from which water is being produced. These artesian sandstones are at a depth of 1100-1400 feet. Many farm wells and the two Miller city wells are producing from these sandstone layers. The amount of water yielded by the Dakota varies with the permeability of the sandstone. Some of these artesian wells in the Miller area flow and others do not, depending on the surface elevation of the wells.

The recharge of these sandstones in South Dakota is said to come from the Rocky Mountains or the Black Hills where they are exposed at the surface and are at a much higher elevation than in the Miller area. This difference in elevation provides the contained ground water with a pressure causing the water to rise in the wells in the Miller area and to flow in some of them. The overlying Cretaceous shales provide the impervious material which confines the water to the sandstones.

Quality of Ground Water

Precipitated water is nearly pure before it reaches the ground. However, all ground water contains minerals that are obtained: (1) from the atmosphere as the water vapor condenses and falls, (2) from soil and underlying deposits as the water percolates downward to the water table, and (3) from deposits below the water table in which the water is cir-

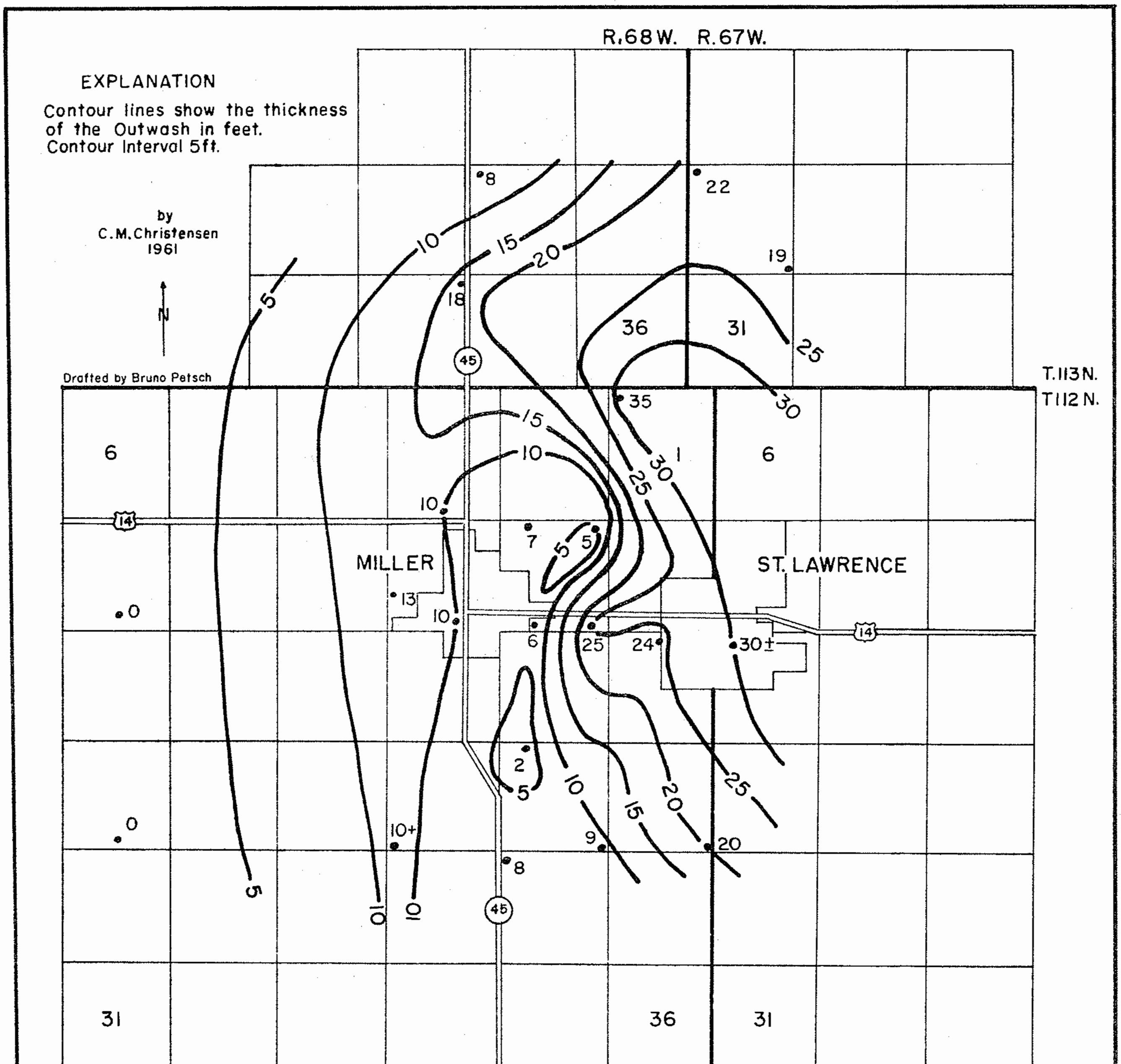

Figure 4. Isopach Map of Lower Buried Outwash Sediments in the Miller Area.

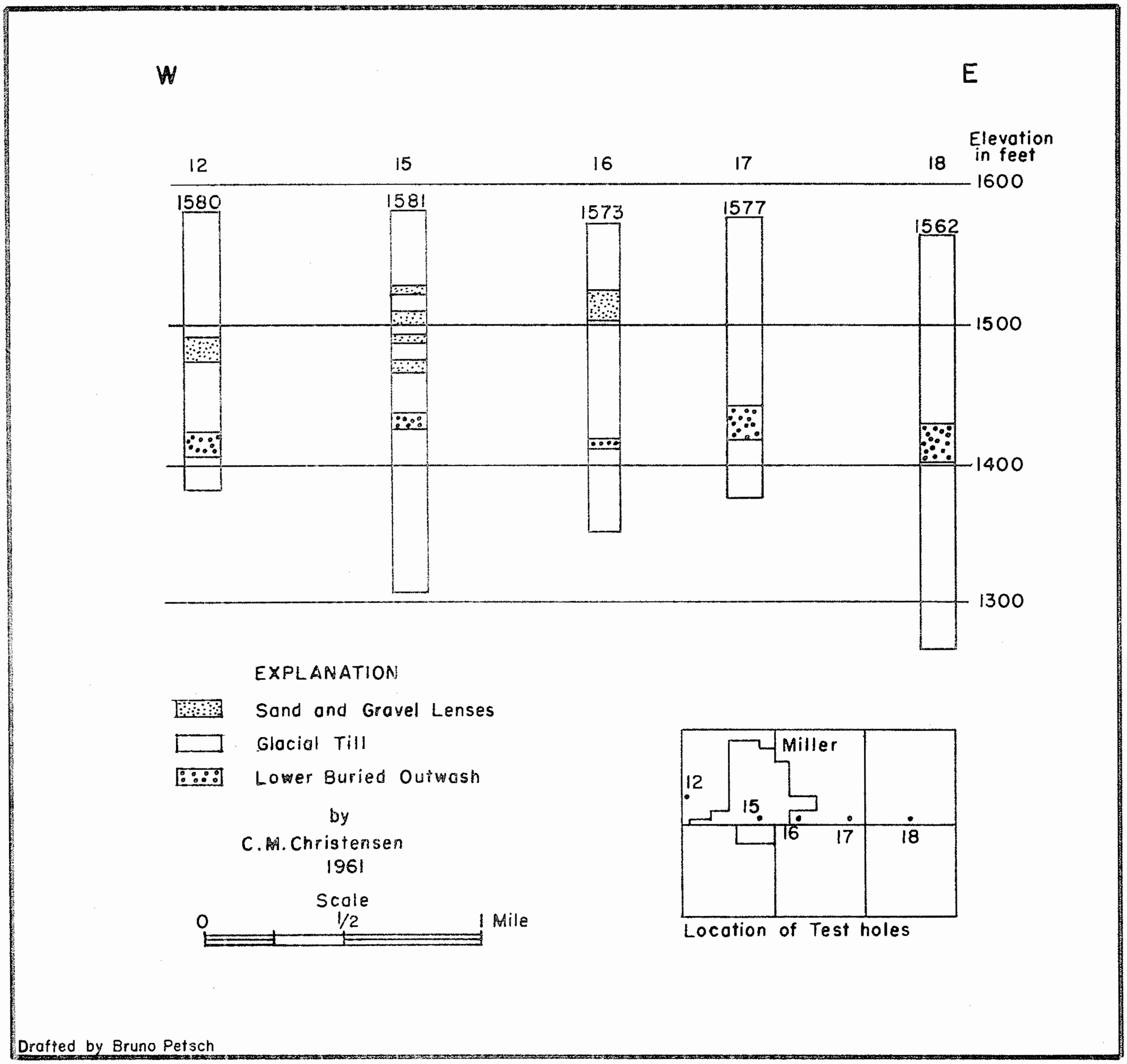

Figure 5. Geologic Cross-Section of Lower Buried Outwash Sediments, Miller Area.

culating. In general the more minerals a water contains, the poorer its quality. Water of the Dakota Sandstones is poorer in quality generally than water of the buried outwash deposits.

Table 1 is a chemical comparison of water from several wells producing from the lower buried outwash in the Miller area, with the present Miller city wells which are producing from the Dakota Sandstones; the table also gives the U. S. Public Health Standards for drinking water.

Most samples in Table 1 are higher in sulfate content than the U. S. Public Health Standards, but, with the exception of Samples H, J, and N, all the lower buried outwash wells are lower in sulfate content than the two Miller city wells. The three samples mentioned above are high in sulfates and total solids and are not good quality water. In general, wells producing from glacial deposits in South Dakota are of a better quality than those producing from the Dakota Sandstones. For this reason it is believed that Samples H, J, and N may be from wells contaminated by artesian waters from the underlying bedrock or by surface waters.

Calcium and chloride content of the glacial wells averages about the same as in the two Miller city wells. The hardness and total solids of the lower buried outwash wells are in most cases much lower than those of the Miller city wells.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the city of Miller test for future water supplies in the lower buried outwash deposits. The city should contract with a commercial drilling company to drill more test holes in the area north, east and south of the city of St. Lawrence to determine the exact thickness of the lower buried outwash deposits in those areas. After the test drilling has been done a test well should be drilled in the most suitable location, and a pump test supervised by competent engineers should be run for a minimum of 72 hours to determine the yield, drawdown and recovery.

The city officials should consult the State Water Resources Commission with regard to obtaining a water right and a permit to drill the city well, and the State Department of 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 wells and water lines.

REFERENCES CITED

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

Table I. Chemical Analysis of Ground Water in the Miller Area.
(for location see Figure 2.)

Sample	Parts Per Million										Hardness $CaCO_3$	Total Solids
	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH		
A			50	250	500 †	0.3	0.05	10 †	0.9-1.7 ††			1000 †
B	197		54	90	1205	1.3	0.0	0.0	2.4	7.4	717	2124
C	140		37	117	1170	1.4	0.0	0.0	2.7	7.4	505	2125
D	6	370		112	432						228	1362
E	90	386	8	82	600	0.5	0.0	0.5	0.0		256	1490
F	183			56	437	0.0				7.9	210	1992
G	141			316	660	0.0				7.2	130	3126
H	564			220	1778	0.5				7.8	2990	4702
I	240			276	680	0.1				7.8	1350	2729
J	254			284	1555	0.0				7.6	1200	4410
K	30			72	445	0.0				7.9	171	1328
L	91	363	13	89	500	1.0	0.4	0.7	0.0		280	1400
M	85	415	19	125	588	1.9	Trace	0.6	0.0		288	1580
N	422	71	298	85	1848	0.3	0.0	0.0	0.4		2278	3656

† Modified for South Dakota by the State Dept. of Health (Written communication Feb. 5, 1962)

†† Optimum

Samples B and C were analyzed by the State Department of Health in Pierre; samples D, F, G, H, I, J, K, by the State Geological Survey's field chemical kit; and samples E, L, M, N, by the State Chemical Laboratory in Vermillion.

A - U.S. Dept. Public Health Drinking Water Standards (1961).

B - City of Miller No. 1

C - City of Miller No. 2

D - Millard Rediger S.W. 1/4 Sec. 2, T. 112 N., R. 68 W.

E - City of St. Lawrence

F - I.G. Crist S.E. 1/4 Sec. 22, T. 112 N., R. 68 W.

G - A. Wayne Haberling N.W. 1/4 Sec. 11, T. 112 N., R. 68 W.

H - Fred Bingham S.W. 1/4 Sec. 12, T. 112 N., R. 68 W.

I - Alex Kulm N.E. 1/4 Sec. 7, T. 112 N., R. 67 W.

J - Deuter N.W. 1/4 Sec. 31, T. 112 N., R. 67 W. (Map does not include this area.)

K - No Name

L - D. and V. Motor Co. S.E. 1/4 Sec. 3, T. 112 N., R. 68 W.

M - Fred Hicks S.E. 1/4 Sec. 33, T. 113 N., R. 68 W.

N - A. Olson S.E. 1/4 Sec. 32, T. 113 N., R. 67 W.

APPENDIX A

Logs of State Geological Survey Test Holes In The Miller Area

(for location see fig. 2)

Test Hole No. 1
Elevation: not measured
Depth to water: not measured

0- 23	clay, buff, sandy
23- 68	clay, gray, sandy
68- 71	gravel, pea size
71-129	clay, gray, sandy
129-140	Pierre Shale
140	total depth

* * * * * *

Test Hole No. 2
Elevation: 1475 feet
Depth to water: not measured

0- 21	clay, buff, sandy and silty
21- 58	clay, gray, very sandy
58- 60	sand, coarse 1/16-1/4-inch in diameter
60- 65	clay, gray, sandy
65- 75	sand, coarse to fine gravel
75- 84	clay, gray, sandy
84- 87	sand, coarse to fine gravel
87- 96	gravel, pea size
96- 99	clay, gray, sandy
99-115	gravel, find and coarse sand
115-120	clay, gray, sandy
	(plugged bit - losing mud - abandoned hole)

* * * * * *

Test Hole No. 3
Elevation: not measured
Depth to water: not measured

0- 21	clay, buff, sandy
21- 36	clay, gray, sandy
36- 44	sand, coarse and pea size gravel
44-135	clay, gray, sandy
135-140	Pierre Shale
140	total depth

* * * * * *

Test Hole No. 4
Elevation: 1491 feet
Depth to water: not measured

0- 15	silt, buff, clayey
15- 24	clay, buff, sandy
24- 70	clay, gray, sandy
70- 85	sand, coarse to pea gravel (black igneous pebbles)
85-107	gravel, pea size, few clay stringers 1-2 inches thick
107-120	clay, gray, sandy
120-140	Pierre Shale
140	total depth

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Test Hole No. 5
Elevation: 1529 feet
Depth to water: not measured

0- 25	clay, buff, very sandy
25- 65	clay, gray, sandy
65- 94	clay, gray, sandy, pebbly
94-113	sand, very coarse to pea-size gravel
113-123	clay, gray, with few sandy streaks
123-135	gravel, pea size interbedded with gray clay (75% gravel)
135-140	clay, gray, sandy, pebbly
140-158	gravel 1/2 - 3/4-inch in diameter
158-160	Pierre Shale
160	total depth

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Test Hole No. 6
Elevation: 1520 feet
Depth to water: not measured

0-21	clay, buff, sandy
21-35	sand, fine to fine gravel (losing circulation)
35-41	gravel (1/2 - 3/4-inch in diameter)
41-	plugged bit in sand 3 times, abandoned hole

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Test Hole No. 7
Elevation: 1486 feet
Depth to water: not measured

0- 24	clay, buff, sandy
24- 50	clay, gray, sandy
50- 52	sand, coarse, black igneous grains
52- 54	clay, gray, sandy
54- 60	sand, coarse, black igneous grains
60- 73	clay, gray, sandy
73- 92	sand, coarse and pea gravel
92-180	clay, gray, sandy with occasional thin gravel (2-4 inch lenses)
180	total depth

Test Hole No. 8
Elevation: 1524 feet
Depth to water: not measured

0- 19	clay, buff, sandy
19- 78	clay, gray, sandy
78-110	clay, gray, sandy, interbedded with thin coarse sand (2-4 inches thick)
110-120	sand, gray, fine to coarse
120-145	sand, gray, coarse to gravel
145-205	clay, gray, sandy with few gravelly streaks (1-2 inches thick)
205	total depth

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Test Hole No. 9
Elevation: 1563 feet
Depth to water: 4 feet

0- 8	sand, buff, coarse, loose
8- 15	clay, buff to light gray, sandy
15- 30	clay, light gray, sandy, interbedded with sand, gray, coarse, loose
30-155	clay, gray, sandy
155-160	sand, grit, much coal fragments
160-168	clay, gray, sandy
168-178	gravel, pea size (limestone, shale fragments and black igneous rocks)
178-302	clay, gray, sandy with occasional gravel streaks 1-2 inches thick
302-320	Pierre Shale
320	total depth

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Test Hole No. 10
Elevation: 1577 feet
Depth to water: 41 feet

0- 32	clay, buff, very sandy
32- 49	clay, gray, sandy
49- 51	sand, coarse, black igneous
51-107	clay, gray, sandy
107-110	sand, very coarse, black igneous
110-112	gravel, pea size
112-115	clay, gray, sandy
115-122	gravel, pea size
122-127	clay, gray, sandy
127-240	clay, gray, sandy with few gravel stringers
240	total depth

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Test Hole No. 11
Elevation: 1562 feet
Depth to water: 29 feet

0- 35	clay, buff, sandy
35-125	clay, gray, sandy
125-130	sand, coarse and pea-size gravel
130-180	clay, gray, sandy
180	total depth

* * * * * *

Test Hole No. 12
Elevation: not measured
Depth to water: not measured

0- 25	clay, buff, sandy
25- 90	clay, gray, sandy
90-105	sand, coarse, gray
105-157	clay, gray, sandy
157-170	gravel, pea size
170-200	clay, gray, sandy
200	total depth

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Test Hole No. 13
Elevation: not measured
Depth to water: not measured

0- 20	clay, buff, sandy
20- 70	clay, gray, sandy
70- 80	sample as above with occasional fine gravelly streaks 1-2 inches in thickness
80-305	clay, gray, sandy, very few 2-inch gravel lenses
305-310	Pierre Shale
310	total depth

* * * * * *

Test Hole No. 14
Elevation: 1581 feet
Depth to water: not measured

0-29	clay, buff, sandy and very silty
29-40	clay, gray, sandy and very sandy
40	abandoned hole because of lost circulation

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Test Hole No. 15
Elevation: 1581 feet
Depth to water: not measured

0- 33	clay, buff, sandy
33- 53	clay, gray, sandy
53- 59	sand, coarse and nut-size gravel, some lignite coal
59- 76	clay, gray, sandy
76- 80	gravel, nut size
80- 90	clay, gray, sandy
90- 97	gravel, pea size
97-109	clay, gray, sandy
109-113	gravel, pea size and coarse sand
113-126	clay, gray, sandy
126-136	clay, gray, sandy, thinly interbedded with nut-size gravels or pebbles
136-145	clay, gray, pebbly
145-155	gravel, pea size, some nut-size
155-300	clay, gray, sandy. Mud thickened to such a degree that hole was abandoned. If shale was reached it was below 274 feet.

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Test Hole No. 16
Elevation: 1573 feet
Depth to water: 12 feet

0- 35	clay, buff, sandy
35- 50	clay, gray, sandy
50- 70	sand, coarse, dark gray, becoming gravelly at 60 feet
70-157	clay, gray, sandy
157-163	gravel, pea size
163-220	clay, gray, sandy, in places very sandy
220	total depth

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Test Hole No. 17
Elevation: 1577 feet
Depth to water: 9 feet

0- 25	clay, buff, sandy and pebbly
25-134	clay, gray, sandy
134-159	sand, coarse and pea-size gravel
159-200	clay, gray, sandy
200	total depth

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Test Hole No. 18
Elevation: 1562 feet
Depth to water: 10 feet

0- 30	clay, buff, sandy, pebbly
30-138	clay, gray, sandy, pebbly

(continued on next page)

Test Hole No. 18--continued

138-162	sand, gray, fine to coarse (nearly pea-size gravel 155-162)
162-296	clay, gray, sandy with few thin sandy streaks
296	total depth

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Test Hole No. 19
Elevation: not measured
Depth to water: not measured

0- 25	clay, buff, sandy
25- 60	clay, gray, sandy
60- 61	sand, coarse
61-167	clay, gray, sandy
167-169	gravel, pea size
169-260	clay, gray, sandy
260	total depth

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Test Hole No. 20
Elevation: not measured
Depth to water: not measured

0 - 25	clay, buff, sandy and pebbly
25 - 76.1	clay, gray, sandy and pebbly
76.1- 76.2	gravel, pea size, contains many coal fragments
76.2- 79	clay, gray, sandy
79 - 80	coal fragments (lignite)
80 -148	clay, gray, sandy and pebbly
148 -149	gravel, pea size, limestone pebbles
149 -160	clay, gray, sandy and pebbly
160 -161	gravel, pea size
161 -190	clay, gray, sandy and pebbly
190 -191	gravel, pea size, limestone pebbles
191 -192	clay, gray, sandy
192 -193	gravel, pea size, limestone pebbles
193 -220	Pierre Shale
220	total depth

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Test Hole No. 21
Elevation: 1637 feet
Depth to water: not measured

0- 41	clay, buff, sandy
41-135	clay, gray, sandy and pebbly
135-141	gravel, pea size and coarse sand
141-146	clay, gray, sandy
146-155	gravel, pea size and coarse sand
155-169	clay, gray, sandy
169-179	sand, coarse and fine gravel

(continued on next page)

Test Hole No. 21--continued

179-255	returns were 90% sand and gravel but it is probable that the sample was clay which mixed with upper gravels as the pump pressure did not rise
255-260	clay, gray, sandy
260	total depth

* * * * * *

Test Hole No. 22
Elevation: 1628 feet
Depth to water: 31 feet

0- 19	clay, buff, sandy
19- 50	clay, gray, sandy
50- 55	sand, coarse, gray
55- 65	clay, gray, sandy
65-153	clay, gray, very sandy
153-156	sand, coarse and pea-size gravel
156-162	clay, gray, sandy
162-170	sand, coarse
170-240	clay, gray, interbedded with sand and gravel stringers
240	total depth

* * * * * *

Test Hole No. 23
Elevation: 1627 feet
Depth to water: not measured

0-39	clay, buff, sandy
39-141	clay, gray, sandy
141-143	sand, coarse and fine gravel
143-173	clay, gray, very sandy
173-176	sand, coarse, black
176-206	clay, gray, very sandy
206-216	sand, black, coarse
216-226	clay, gray, very sandy
226-235	gravel, pea size
235-241	clay, gray, sandy
241-254	sand, coarse with some pea-size gravel
254-260	Pierre Shale
260	total depth

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Test Hole No. 24
Elevation: not measured
Depth to water: not measured

0- 39	clay, buff, sandy
39-155	clay, gray, sandy, pebbly with few sandy streaks
155-162	gravel, pea size

(continued on next page)

Test Hole No. 24--continued

162-172	sand, fine to coarse
172-195	could not catch sample in screen - probable clayey silt
195-208	gravel, pea size
208-235	clay, very sandy (old alluvium?)
235-240	Pierre Shale
240	total depth

* * * * * *

APPENDIX B

Records of Wells

Well Location: Letters stand for quarter section, first numbers for section, second for township north, third for range west
Type of Well: Du, dug; D, drilled; B, bored
Character of Material: o, outwash; sl, sand lense; ss, sandstone, s, silt
Use of Water: D, domestic; S, stock

Well Location	Owner or Tenant	Type of Well	Depth of well below land surface (feet)	Geologic Source	Character of Material	Use of Water
SE-7-111-67	C. R. Cravens	--	115±	glacial	sl	S,D
NW-3-111-68	Albert Jones	--	33	--	--	D
NW-3-111-68	Albert Jones	--	160	glacial	o	S
NW-10-111-68	Robert Pugh	--	1400±	Dakota	ss	S,D
NW-11-111-68	A. Wayne Haberling	D	--	--	--	S
NE-11-111-68	John Gerdus	--	1100-1400	Dakota	ss	--
NW-4-116-67		D	1100-1400	Dakota	ss	S,D
SW-4-112-67	C. Sissions	D	1100-1400	Dakota	ss	S,D
NE-5-112-67	Abandoned	--	50±	--	--	--
SE-5-112-67		D	1100-1400	Dakota	ss	S,D
NW-6-112-67		D	1100-1400	Dakota	ss	S
SE-7-112-67	Vitten	--	120±	glacial	o	S,D
NE-7-112-67	Alex Kulm	--	120±	glacial	o	D
SE-8-112-67	Fremark	D	1100-1400	Dakota	ss	S,D
SE-9-112-67	Fremark	D	1100-1400	Dakota	ss	S,D
SW-9-112-67		D	1100-1400	Dakota	ss	S,D
NW-17-112-67	H. W. Cotton	B	100	glacial	sl	S,D
NW-20-112-67		D	240±	glacial	o	S,D

Well Location	Owner or Tenant	Type of Well	Depth of well below land surface (feet)	Geologic Source	Character of Material	Use of Water
NW-20-112-67		D	240±	glacial	o	S,D
NW-20-112-67	Mrs. C. E. Hall	D	200±	glacial	o	S,D
NW-29-112-67	Frank McGinus	D	1350±	Dakota	ss	S,D
NW-30-112-67	Delvin Mattke	--	165	glacial	o	S,D
NW-31-112-67	Deuter	Du	40	alluvium	s	S,D
NW-31-112-67		D	1100-1400	Dakota	ss	S,D
NE-32-112-67	Jones	D	1100-1400	Dakota	ss	S,D
NW-2-112-68	Abandoned		--	alluvium	--	--
SW-2-42-68	Millard Rediger	D	200±	glacial	s	S,D
SE-3-42-68	D & V Motor Co.	D	120±	glacial	o	D
SE-3-112-68	Zeigler	D	1300±	Dakota	ss	--
NE-6-112-68	Wilbur Jones	D	1200?	Dakota	ss	S,D
SE-7-112-68		D	1100-1400	Dakota	ss	--
SE-9-112-68		D	--	--	--	S,D
SW-10-112-68	William Rediger	--	180-200?	glacial	o	D
SE-12-112-68	Burrell Collins	D	1150	Dakota	ss	S,D
NW-12-112-68	Fred and Della Bingham	--	170	glacial	o	S
NW-12-112-68	Fred Roth	B	150?	glacial	o	S,D
SE-13-112-68	Russell Roth	D	140	glacial	o	S,D
NW-15-112-68	Clarence Thiel	D	150±	glacial	o	S,D
SE-15-112-68	Fred Siversten	D	160	glacial	o	--
NE-16-112-68	Taylor	B	130±	glacial	o	D
NW-18-112-68	City of Lawrence	D	170	glacial	o	D
NW-18-112-68	City of Lawrence	D	140	glacial	o	D

Appendix B--Records of Wells--continued

Well Location	Owner or Tenant	Type of Well	Depth of well below land surface (feet)	Geologic Source	Character of Material	Use of Water
SE-19-112-68	H. A. Poindexter	D	1370	Dakota	ss	S,D
SW-19-112-68	Poindexter	D	1400+	Dakota	ss	--
SE-20-112-68	Alvie Haberling	D	1320±	Dakota	ss	S,D
SW-21-112-68	Harley Fulton	D	1328-	Dakota	ss	S,D
SW-22-112-68	J. G. Crist	D	150	glacial	o	S,D
SE-22-112-68	Dean Robinson	D	200	glacial	o	S,D
NE-23-112-68	Dean Robinson	--	150	glacial	o	S,D
NE-31-112-68	Max Hargen	--	--	alluvium?	s	--
NE-31-112-68	Ben Hodgestraat	--	--	alluvium?	s	--
SE-33-112-68	Lewis Olson	D	1400±	Dakota	ss	S,D
NW-34-112-68	Warren Skinner	--	--	glacial?	--	S,D
SW-35-112-68	Abandoned	--	--	--	--	S
NE-13-112-69	Abandoned	--	--	alluvium?	s	--
SW-29-113-67	George Melber	D	80-90	glacial	sl	S,D
SE-31-113-67	Lanz	D	1100-1400	Dakota	ss	S,D
SW-32-43-67	Lanz	D	1100±	Dakota	ss	S,D
NW-32-113-67		D	1100-1400	Dakota	ss	S,D
SE-32-113-67	A. Olsen	Du	42	alluvium	--	S,D
NW-34-113-67		D	1050±	Dakota	ss	S,D
NW-13-113-68		D	1100-1400	Dakota	ss	S,D
NE-20-113-68	Emil Wagner	D	1165±	Dakota	ss	S,D
NW-21-113-68		D	1100-1400	Dakota	ss	--
SE-21-113-68		D	1100-1400	Dakota	ss	S,D
NE-22-113-68	Robert Wagner	D	1058	Dakota	ss	S,D

Appendix B--Records of Wells--continued

Well Location	Owner or Tenant	Type of Well	Depth of well below land surface (feet)	Geologic Source	Character of Material	Use of Water
NW-24-113-68		D	1047	Dakota	ss	S,D
SE-26-113-68	A. W. Olson	D	1125	Dakota	ss	S,D
SW-29-113-68	V. Spry	D	1145?	Dakota	ss	S,D
SE-31-113-68		D	1100-1400?	Dakota	ss	S,D
SE-33-113-68	Fred Hicks	D	162	glacial	o	S,D