STATE OF SOUTH DAKOTA
William J. Janklow, Governor

DEPARTMENT OF WATER AND NATURAL RESOURCES
Warren R. Neufeld, Secretary

GEOLOGICAL SURVEY
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Open-File Report No. 32-UR

GROUND-WATER STUDY FOR THE CITY OF BELLE FOURCHE, SOUTH DAKOTA

by

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1980

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INTRODUCTION

At the request of the City of Belle Fourche, the South Dakota Geological Survey conducted a ground-water study in part of July and August, 1979, in the vicinity of Belle Fourche, South Dakota.

Included in the investigation of Belle Fourche area are:

(1) Study of geology

(2) Inventory of wells

(3) Drilling of 19 rotary test holes

(4) Installation of 2 wells to collect water samples

(5) Collection and analysis of 26 water samples in 1979 and 10 water samples in 1980.

Presently, the City obtains its water from an infiltration gallery located approximately 9 miles south of town, in the east one-half of section 28, Township 7 North, Range 2 East (fig. 1). The gallery is in alluvium deposits along Spearfish Creek.

In the past few years, coliform bacteria have been detected in water from the gallery, and a water shortage has occurred during the summer months in town. The purpose of this study was to identify other potential sources of water for the City's future use.

The project was financed by the City of Belle Fourche and the South Dakota Geological Survey. The cooperation of the residents of the area, especially Mayor Robert Helmer, City Engineer Earl McArthur, Deputy City Attorney Jaqueline Marousek, and the Director of Public Works Charles Mateer was greatly appreciated. Special thanks are due to local driller

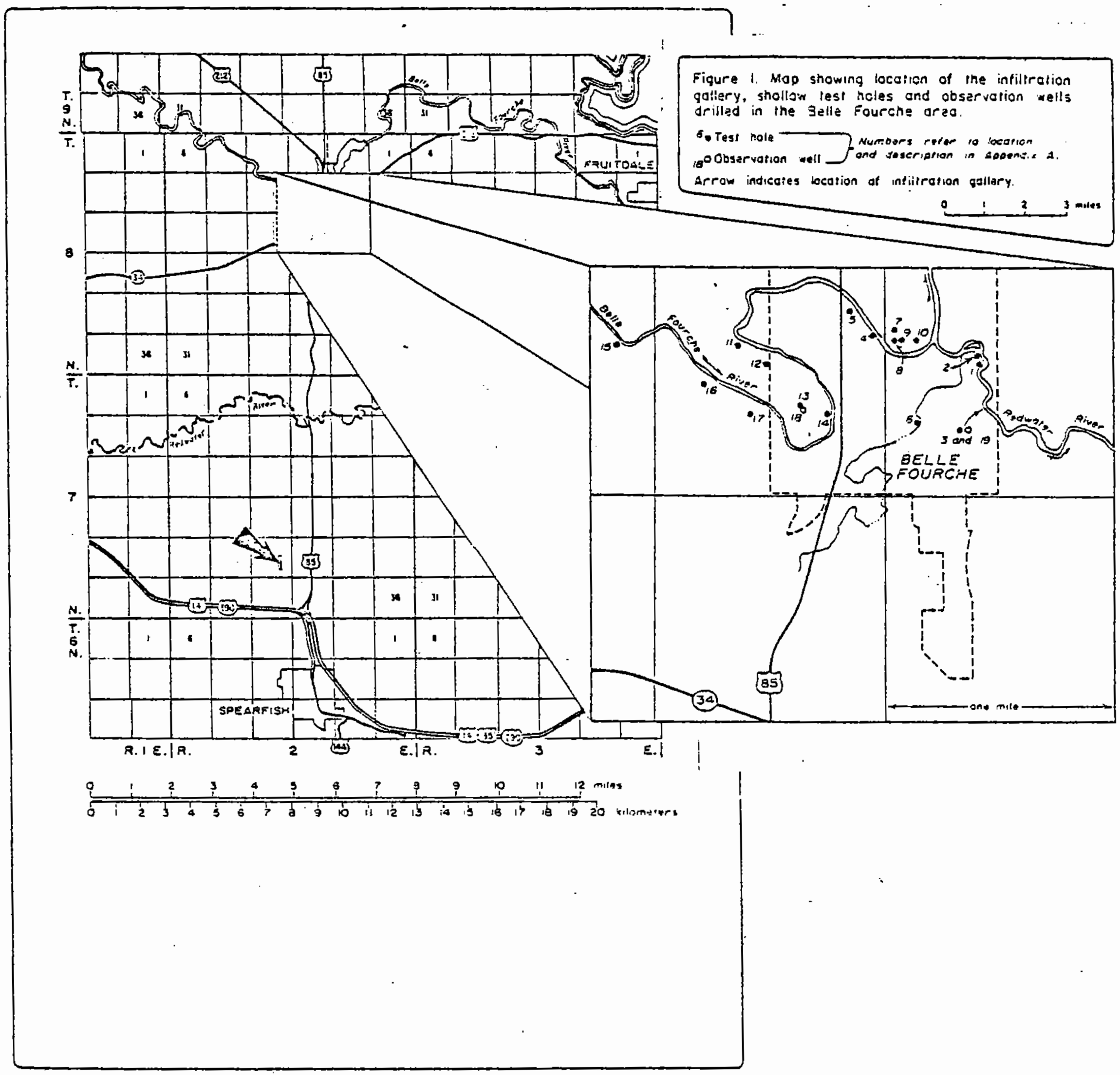


Figure 1. Map showing location of the infiltration gallery, shallow test holes and observation wells drilled in the Belle Fourche area.

6 ● Test hole; 18 ○ Observation well — Numbers refer to location and description in Appendix A.

Arrow indicates location of infiltration gallery.

Joe Graf and the late Merle Bandy for making their driller logs available. Brice and Taylor Drilling Company furnished the logs of the wells recently drilled in the area.

The following are the descriptions of the aquifers and quality of water.

GROUND WATER IN ALLUVIAL AQUIFERS

Alluvial deposits are present along the Belle Fourche and Redwater Rivers. Nineteen shallow rotary test holes were drilled to identify the thicknesses of these deposits. For location of these test holes, see figure 1. The logs of these test holes are in appendix A.

The alluvial deposits consist of sand and gravel with some silt and clay content. The thickness of these deposits varies from a few feet to 20 feet (see test hole BF-18, app. A). Water levels were generally less than 10 feet from the land surface in the area.

Two temporary wells (observation wells) were constructed (BF-18 and BF-19) to collect water samples.

Table 1 shows the results of water samples collected from the area. The water sample from observation well BF-18 is designated by sample 4 in the table. This sample has a total solids content of 1740 parts per million (ppm), a hardness of 935 ppm, and a sulfate level of 975 ppm.

Water sample collected from observation well BF-19 is designated by water sample 5 in table 1. The total solids in this sample is 1265 ppm, hardness of 774 ppm with a sulfate content of 630 ppm. In both of these samples the water is

TABLE 1. Chemical analyses of water samples from the Belle Fourche area

(for location see fig. 2 and well records in appendix B)

Parts Per Million

Sample No.	Well No.	Source	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate Nitrogen	Fluoride	Hardness	Total Solids	Conductivity Micro mhos	Temperature Fahrenheit F°
A						250[2]	250[2]	0.3[2]	0.05[2]	10.0[1]	2.4[1]		500[2]		
1		Belle Fourche River	145	105	48	12	495	0.05*	0.12	0.5*	0.51	553	1130	1240	
2		Red Water River	200	10	47	5	485	0.05*	0.05*	0.5*	0.37	691	1000	1100	
3		Infil-tration gallery	75	4	29	7	70	0.2	0.02*	0.7	0.3	306	389		
4	W84	Al	260	142	70	8	975	0.10	0.63	0.1	0.75	935	1740	1650	
5	W85	Al	220	46	56	15	630	0.30	0.53	0.1*	0.58	774	1265	1240	
6	W9	Klk	5	120	1	4	80	0.35	0.05*	0.2*	0.47	17	310	510	
7	W10	Klk	11	191	4	16	250	0.30	0.05*	0.2	0.81	44	620	740	
8	W14	Klk	61	80	22	5*	165	0.38	0.07	0.5*	0.41	242	625	810	
9	W17	Klk	8	430	5	29	725	0.20	0.06	0.60	0.35	40	1360	1960	
10	W19	Klk	56	76	23	5*	160	0.51	0.05*	0.5*	0.37	234	540	770	
11	W22	Klk	47	36	23	4	100	0.05*	0.16	0.1*	0.42	212	385	450	
12	W82	Klk?	10	295	1.0*		77	0.1*	0.01*			29	1160		
13	W52	Js,Al?	202	9	50	3	450?	0.05*	0.05*	0.6	0.34	708	880	820	54°
14	W54	Js,Al?	290	12	65	2	750	0.09	0.05*	1.2	0.30	989	1330	1200	
15	W57	Js,Al?	98	19	100	2	200	0.06	0.05	2.7	0.48	655	800	970	
16	W48	Trs	535	18	90	2	1500?	0.05*	0.05*	0.1	1.25	1702	2500	1940	56°
17	W49	Pm	120	5	29	1*	160	0.05*	0.05*	0.1	0.59	418	500	550	61°
18	W23	Cml	582	58	92	61	1610	0.74			2.6	1830	2530	2305	101°
19	W37	Cml	105	2	23	5*	110	0.05*	0.05*	0.6	0.26	356	540	680	
20	W47	Cml	56	2	20	5*	25	0.05	0.05*	0.5*	0.20	322	260	435	
21	W50	Cml	74	4	22	1*	40	0.05*	0.05*	0.1	0.26	275	240	290	
22	W55	Cml	92	3	27	1*	55	0.20	0.05*	0.1	0.42	340	315	340	61°
23	W60	Cml	320	13	50	1*	750	0.05*	0.05*	0.2	0.34	1002	1270	1480	
24	W67	Cml	185	3	35	5*	340	0.05*	0.05*	0.6	0.33	605	870	1000	55°
25	W71	Cml	90	8	28	1*	90	0.11	0.05*	0.2	0.29	339	320	550	
26	W81	Cml	56	3	20	5*	25*	0.18	0.05	0.7	0.35	222	340	410	48°
27	W83	Cml?	55	2	25		25	0.1*	0.01*			240	480		
28	W58	Cmd	68	5.0*	32.1		100	0.05*	0.05*	0.25	1.18	301	320	600	
29	W61	Cmd	78	50	29.8		100	0.07	0.05*	0.2	0.38	316	340	810	68°

Sample No.	Well No.	Source	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate Nitrogen	Fluoride	Hardness	Total Solids	Conductivity Micro mhos	Temperature Fahrenheit F°
30	W80	Cmd	52	3	23	5*	25*	0.05*	0.05*	0.5*	0.29	224	330	400	54°
31	W4	Cmd	160	15	57	20	420	0.05*	0.05*	0.5*	1.6	633	940	1100	110°
32	W3	Cml,Cmd	395	35	90		1115	0.1*	0.02*		2.7	1354	2135		125.5°
33	W68	Cml,Cmd	175	5	34	5*	330	0.05*	0.05*	.5	0.44	576	840	980	
34a	Appendix C	Cml	593	3.6	97	0.5	1350	0.3	0.1			1880	2518		Estimated 100-109°
34b	Appendix C	Cmd,Cml?	137	6	34	5*	210	0.05*	0.05*	0.5*	0.39	481	640	840	75°
34c	Appendix C	Cmd,Cml?	177	6.0	40.2	2.5*	370	0.05*	0.05*	0.1*	0.37	601	730	970	76°
34d	Appendix C	Cmd,Cml?	163	7.0	39.0	2.5*	350	0.05*	0.05*	0.3	0.44	566	710	950	
35a	Appendix C	Cmd	54	5.0*	24.9	2.5*	30	0:05*	0.05*	0.1*	0.26	237	220	470	71°
35b	Appendix C	Cmd	55	2.0	24.5	2.5*	11	0.05*	0.05*	0.1*	0.27	238	190	423	

* Less Than

Sample A

[1]United States Environmental Protection Agencey "National Interim Primary Drinking Water Regulations" - December 24, 1975 (enforceable limits)

[2]United States Environmental Protection Agency "National Secondary Drinking Water Regulations" July 19, 1979 (recommended limits)

Source: Al, Alluvium; Klk, Cretaceous Lakota Sandstone; Js, Jurassic Sundance Formation, Trs, Triassic Spearfish Formation; Pm, Permian Minnekata Limestone; Cm, Pennsylvanian Minnelusa Sandstone; Cmd, Pennsylvanian, Madison Limestone

All samples were analyzed by the South Dakota Geological Survey, Vermillion, S.D. except for samples no. 3, 18, and 34a.

Sample no. 3 was analyzed by the South Dakota Department of Environmental Protection. South Dakota Public Water Supply Data 1979 (the hardness value was corrected by the writers)

Source of data for sample no. 18, Earl J. Cox 1962 and U.S.G.S.

Source of data for sample 34a, J.P. Gries, 1979 considerably higher in chemical content than the present City water which has a total solids content of 389 ppm, hardness content of 306 ppm, and sulfates content of 70 ppm. (See water sample 3.)

The alluvium could yield water to small production wells but because of low water yield and poor quality this aquifer is not recommended for the City's future water source.

GROUND WATER IN FALL RIVER - LAKOTA AQUIFERS

The Fall River and Lakota sanstone aquifers are separated by a varicolored clay known as the Fuson Shale. The thickness and clay content of these sandstones vary in a short distance. Several wells have been drilled to both of these aquifers (see app. B).

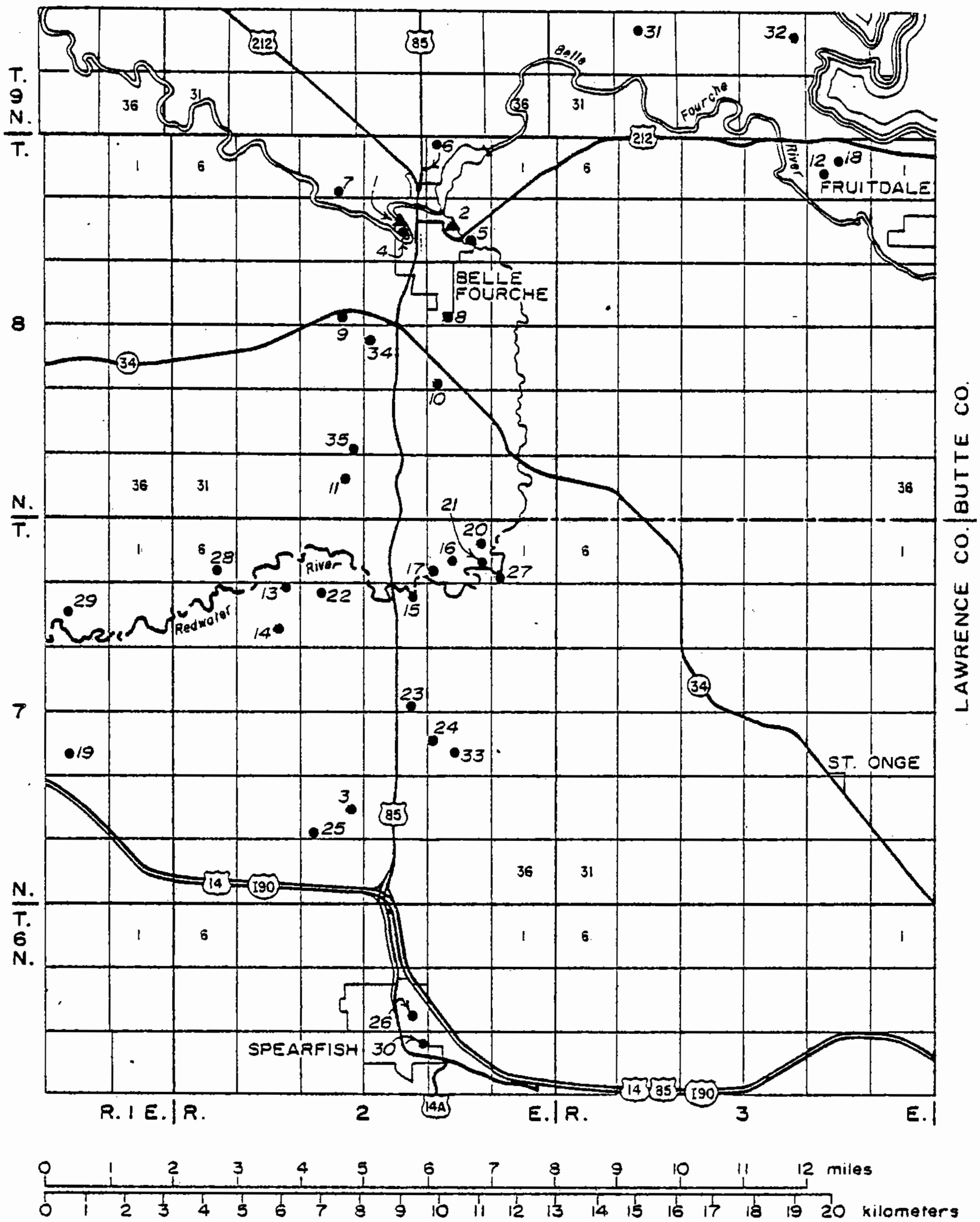
Samples 6 through 11 (table 1) were collected from wells yielding water from the Lakota Formation, except for water sample 9 these samples have less than 650 ppm total solids.

To reach the same aquifer, a well should be driller deeper north of town than south (compare depth of wells 9 and 14, app. B). For the locations of the water samples, see figure 2.

Yields from these aquifers are small in the area, therefore these aquifers are not recommended for the City use.

GROUND WATER IN MINNELUSA AQUIFER

The upper part of this formation is mostly pink sand and white sandstone, whereas the lower portion consists of shale, sand, and dolomite. The thickness of this formation is approximately 500 feet in the area.



3● Ground water sample

▲2 Surface water sample

Figure 2. Map showing the location of water samples collected from the Belle Fourche area.

A well 250 feet deep at the City of Spearfish (O'Neill well) yields water from this formation. This well is located 12 miles south of Belle Fourche. The original Belle Fourche Country Club well located southwest of town was drilled to a depth of 2150 feet and was yielding water from the Minnelusa Formation (Gries, 1979). More than 20 Minnelusa wells were located in the study area (app. B).

Water quality in this formation varies in different locations. Samples 20, 21, and 26 have less than 500 ppm total solids. Whereas samples 18 and 34a have more than 2000 ppm total solids. Sample 34a, collected from original Belle Fourche Country Club well, had a hardness of 1880 ppm and a sulfate level of 1350 ppm.

Sample 18 was collected from a Minnelusa well (2225 feet deep) located approximately 8 miles east of Belle Fourche. This water had a hardness of 1830 ppm and a total solids of 2530 ppm (Cox, 1962). A 4016 feet well (Olson well) located approximately 8 miles northeast of town yields water from Minnelusa and Madison Formations (Gries, 1979) with a total solids of 2135 ppm (sample 32).

Because of high chemical content and low production from the original Country Club well, this aquifer is not expected to produce satisfactory water for the City.

GROUND WATER IN THE MADISON AQUIFER

The Madison Formation consists of limestone and dolomite. This formation outcrops a few miles south of the City of Spearfish. A well in the City of Belle Fourche should be drilled to a depth of approximately 2700 feet to produce water from this formation.

The water moves through fractures and solution cavities in this formation. The yield of wells completed in this formation depends on the number and size of fractures encountered. The more fractures and larger the size of the fractures, the more will be the yield of the well.

Several wells have been drilled to this formation in the area. The aquifer is under artesian condition and flowing wells are very common in the area.

The quality of water from this formation varies in different locations. Generally the farther from the outcrop the more dissolved chemicals are present in the water.

The results of water analysis from the Spearfish City well (Dickey well) is designated by sample 30 in table 1. This water has 330 ppm total solids, with a hardness of 224 ppm. The temperature of water from this well is 54°F.

The Kenneth Bean well, located approximately 6 miles northeast of Belle Fourche, is drilled to a depth of 3511 feet. The total solids in this water is 940 ppm, with a hardness of 633 ppm, and the sulfate content of this water is 420 ppm. The temperature of this water is 110°F.

As discussed previously the Olson well located approximately 8 miles northeast of town yields water from the Minnelusa and the Madison Formations. The total solids in this water (sample 32) is 2135 ppm. This well flows at a rate of 1800 gpm and the temperature of water is 125.5°F.

Of special interest are the following two wells located south of the City of Belle Fourche.

The Country Club well is located in the NW¼ of section 22, Township 8 North, Range 2 East. This well was drilled in 1968 (see first part of Country Club well log, app. C). The electric log made in 1972 by the South Dakota Geological Survey shows that the depth of the well was 2290 feet. Sample 34 was collected when the well was completed in the Minnelusa Formation.

The files of Merle Bandy, a local driller, show that the well was redrilled to a depth of 2590 feet in 1973 (see second part of Country Club well, app. C) and the flow of the well was increased to 150 gpm.

Samples 34b, 34c, and 34d were collected during this study from the Country Club well. The average total solids content for these three samples was 693 ppm with an average hardness of 549 ppm with a temperature of 76°F. The quality of water indicates that some water still could be coming from the Minnelusa Formation.

A new well has been drilled in the SE¼ of section 28, Township 8 North, Range 2 East. This well is located approximately 1.5 miles south of the Country Club well. This well was drilled to a depth of 2220 feet (app. C, Nickelson well). Samples 35a and 35b were collected from this well. The average total solids in these two samples is 205 ppm with an average hardness of 237.5 ppm. The average sulfate content of these two samples is 20.5 ppm. Water from this well has lower chemical content than the present City water supply (sample 3, table 1). This well flows at a rate of 375 gpm.

With the available data, the most favorable source of water supply for the City of Belle Fourche is from the Madison Formation.

CONCLUSIONS AND RECOMMENDATIONS

There are a few aquifers in the Belle Fourche area that could yield enough water for small production wells. Considering the quantity and quality of water needed by the City, the Madison Formation appears to be the most favorable aquifer in the area. However, the Madison Formation is the deepest aquifer examined in this study and therefore, would result in the most expensive well construction.

Water in this formation moves through fractures and solution cavities. This means that the well should be drilled deep enough into the aquifer to penetrate these fractures. It is estimated that in the general vicinity of town this depth will be approximately 2700 feet and the temperature of the water expected to be approximately 80°F.

The average of three water samples collected from the Belle Fourche Country Club well shows a total solids content of 693 ppm, hardness of 549 ppm, and a sulfate level of 310 ppm.

Two samples were collected from a well recently drilled south of town (Nickelson well samples 35a and 35b, table 1). The average total solids of these two samples is 205 ppm with an average hardness of 237.5 ppm and an average sulfate content of 20.5 ppm. This water has less chemicals than the present City water (sample 3). The fluoride content in this water is 0.27 ppm. Fluoride would have to be added to meet the recommended level.

Recently a few water samples from the Madison Formation located several miles north and east of Belle Fourche exhibited high radiation levels. It is recommended that samples from the Belle Fourche County Club well and the Nickelson well be collcted and analyzed for radioactivity.

Before a permanent well is drilled the Division of Water Rights, Department of Water and Natural Resources should be consulted with regard to obtaining water rights and a permit to drill a city well. Also, the Division of Water Quality, Department of Water and Natural Resources should be contacted with regard to the biological and chemical suitability of the water.

Upon request the South Dakota Geological Survey will log the well and supervise the conduction of a pump test.

REFERENCES CITED

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Gries, J. P., 1979, Deep water well potential at Belle Fourche, unpublished, 9 p.

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APPENDIX A

Logs of test holes drilled in the Belle Fourche area
(for map location, see fig. 1)

Test Hole BF-1
Location: NW¼SE¼SE¼NW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 5 feet

0- 4	Clay, reddish-brown, silty, sandy, soft
4- 14	Sand, medium to coarse, and gravel, fine to coarse, angular
14- 17	Shale, gray, silty

* * * *

Test Hole BF-2
Location: SW¼NE¼SE¼NW¼ se. 11, T. 8 N., R. 2 E.
Depth to water: 6.5 feet

0- 3	Clay, reddish-brown, silty, sandy, soft
3- 10	Sand, fine to medium, silty, well-sorted
10- 13	Sand and fine gravel, silty
13- 17	Shale, gray, compact

* * * *

Test Hole BF-3
Location: SW¼NE¼NE¼SW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 4.5 feet

0- 1	Topsoil, brown
1- 16	Sand and gravel, angular
16- 17	Shale, gray, silty

* * * *

Test Hole BF-4
Location: NE¼NE¼SE¼NE¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: 4.5 feet

0- 1	Topsoil, brown, sandy
1- 16	Sand and fine gravel
16- 20	Shale, gray, soft

* * * *

Test Hole BF-5
Location: NE¼SW¼NE¼NE¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: 6.5 feet

0- 6	Clay, dark brown, sandy, silty

Test Hole BF-5 -- continued.

6- 12	Sand, fine, silty, clayey
12- 18	Sand and fine gravel, angular
18- 20	Clay, gray, sandy, silty

* * * *

Test Hole BF-6
Location: NW¼SE¼NW¼SW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 8 feet

0- 12	Sand and fine gravel, silty, contains rubbish (landfill)
12- 18	Sand and fine gravel
18- 22	Shale, gray, soft

* * * *

Test Hole BF-7
Location: NW¼NW¼SW¼NW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 8 feet

0- 1	Topsoil, black
1- 4	Clay, reddish-brown, silty, soft
4- 11	Clay, brown, very sandy, very silty, soft
11- 14	Sand and fine gravel, angualr
14- 17	Shale, gray, compact

* * * *

Test Hole BF-8
Location: SW¼NW¼SW¼NW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 9 feet

0- 5	Topsoil, brown, sandy
5- 14	Sand, fine to medium, subrounded
14- 16	Sand and fine gravel, silty
16- 18	Clay, gray, silty
18- 20	Shale, brown, silty, compact
20- 32	Shale, gray, with lenses of green sandstone
32- 37	Shale, gray, compact

* * * *

Test Hole BF-9
Location: SE¼NW¼SW¼NW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: 8 feet

0- 15	Clay, brown, soft, with interbedded silts
15- 17	Shale, gray, compact

* * * *

Test Hole BF-10
Location: NW¼NE¼SW¼NW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: unknown

0- 5	Clay, brown, very sandy, silty, soft
5- 15	Sand, fine to medium, silty
15- 17	Sand and fine gravel, silty
17- 23	Shale, gray, compact

* * * *

Test Hole BF-11
Location: SE¼NW¼SE¼NW¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: unknown

0- 1	Clay, brown, very sandy, silty
1- 16	Sand, fine, silty with clay lenses
16- 18	Shale, dark gray, hard, bentonitic

* * * *

Test Hole BF-12
Location: NE¼SE¼SE¼NW¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: 11 feet

0- 1	Topsoil, brown, sandy
1- 12	Sand, medium to very fine
12- 18	Sand and fine gravel
18- 22	Shale, dark gray, compact

* * * *

Test Hole BF-13
Location: NW¼NE¼NW¼SE¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: Greater than 10 feet

0- 18	Sand, fine to very coarse, subangular
18- 20	Shale, gray

* * * *

Test Hole BF-14
Location: NW¼SW¼NE¼SE¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: 10 feet

0- 5	Clay, brown, very sandy, silty
5- 15	Sand, fine to medium, silty, clayey
15- 17	Sand and fine gravel
17- 20	Shale, gray, compact

* * * *

Test Hole BF-15
Location: SE¼NW¼SE¼NE¼ sec. 9, T. 8 N., R. 2 E.
Depth to water:

0- 12	Sand, medium to fine, silty, clayey
12- 17	Sand and fine gravel, silty, clayey
17- 20	Shale, dark gray, hard

* * * *

Test Hole BF-16
Location: NE¼NE¼NW¼SW¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: unknown

0- 1	Topsoil, brown, sandy
1- 14	Sand, medium to fine, silty, clayey
14- 15	Sand and fine gravel, silty
15- 17	Shale, dark gray, hard

* * * *

Test Hole BF-17
Location: NW¼SE¼NE¼SW¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: unknown

0- 1	Topsoil, brown, sandy
1- 14	Sand, medium to fine, slightly silty, slightly clayey
14- 15	Sand and fine gravel
15- 17	Shale, dark gray, hard

* * * *

Test Hole BF-18
Location: SW¼NE¼NW¼SE¼ sec. 10, T. 8 N., R. 2 E.
Depth to water: unknown

0- 7	Sand, fine to medium, silty
7- 18	Sand, coarse to fine
18- 20	Sand and fine gravel
20- 26	Shale, gray

Observation well installed to a depth of 16 feet and pumped at approximately 6 gal/min.

* * * *

Test Hole BF-19
Location: SW¼NE¼NE¼SW¼ sec. 11, T. 8 N., R. 2 E.
Depth to water: unknown

0- 4	Sand, fine, silty
4- 14	Sand and gravel

Test Hole BF-19 -- continued.

14- 22	Shale, gray
	Observation well installed to a depth of 11.5 feet and pumped at approximately 18 gal/min.

* * * *

APPENDIX 8

Well Records in the Belle Fourche Area

Source: Kfr, Cretaceous Fall River Sandstone; Klk, Cretaceous Lakota Sandstone; Jm, Jurassic Morrison Formation; Js, Jurassic Sundance Formation; Trs, Triassic Spearfish Formation; Pm, Permian Minnekahta Limestone; Po, Permian Opeche Shale; Cml, Pennsylvanian Minnelusa Sandstone; Cmd, Pennsylvanian Madison Limestone; Al, Alluvium

Use: D, domestic; S, stock; I, irragation

Well No.	Owner	Location	Elev. (feet)	Depth of Well (feet)	Depth to Water (feet)	Bottom Hole Formation	Source of Water	Use
W1	Bob Maranville	NE¼NW¼sec.33,T.9N.,R.2E.	3120	945	138	Kfr	Kfr	D
W2	Rob Gilbert	SE¼SE¼sec.35,T.9N.,R.2E.	3020	1320		Trs	Klk	D
W3	Olson	SE¼NE¼sec.27,T.9N.,R.3E.	3000	4016	Flow 1800 gpm	Cmd	Cml&Cmd	I
W4	Kenneth Bean	SE¼NE¼NE¼NW¼sec.29,T.9N.,R.3E.	3120	3511	Flow 1000 gpm	Cmd	Cmd	I
W5	Harold Riley	SW¼SW¼sec.20,T.8N.,R.1E.		200	35	Trs	Js	D
W6	Harold D. Hudson	SW¼SW¼sec.24,T.8N.,R.1E.	3290	220	100	Klk	Klk	D
W7	Enrico Bonato	SW¼NE¼sec.34,T.8N.,R.1E.	3480	360	15	Trs	Klk,Js, Trs	S
W8	Enrico Bonato	NE¼NW¼sec.36,T.8N.,R.1E.	3320	200	33	Klk	Klk	S
W9	Wheeler Welding	SE¼NE¼NE¼SE¼sec.3,T.8N.,R.2E.	3080	705	100	Klk	Klk	D
W10	A.H. Jarvi	NW¼SE¼SW¼SE¼sec.4,T.8N.,R.2E.	3040	820		Klk	Klk	S
W11	Henry Hespe	SE¼SE¼sec.11,T.8N.,R.2E.	3030	435	10	Kfr	Kfr	D
W12	V. Norman	SW¼SW¼sec.13,T.8N.,R.2E.	3085	360	33	Kfr	Kfr	D
W13	O.G. Able	SE¼NE¼sec.14,T.8N.,R.2E.	3070	520	20	Klk	Klk	D
W14	Marvin Stettler	NW¼SW¼SE¼SW¼sec.14,T.8N.,R.2E.	3170	310	100	Klk	Klk	D
W15	John Ducar	SW¼SE¼sec.14,T.8N.,R.2E.	3100	430	27	Klk	Klk	D
W16	Jonas Wood	NE¼sec.16,T.8N.,R.2E.	3140	520	49	Jm?	Klk	D
W17	Lyold Norstrom	NW¼SW¼SE¼sec.16,T.8N.,R.2E.	3120	340	Flow 30 gpm	Klk	Klk	D
W18	B.F. Country Club	SE¼SW¼NW¼NW¼sec.22,T.8N.,R.2E.	3220	2590	Flow 125 gpm	Cmd	Cml,Cmd	I
W19	Joe Graf	SW¼NE¼SW¼SW¼sec.23,T.8N.,R.2E.	3180	240	70	Klk	Klk	D
W20	Cadwallader	NW¼SE¼SE¼sec.28,T.8N.,R.2E.	3280	760	Flow	Js	Js?	D
W21	Alfred Wislicen	NE¼NE¼sec.29,T.8N.,R.2E.	3250	40	15	Kfr	Kfr	D
W22	Darrell J. Nickelson	NW¼SW¼SE¼NE¼sec.33,T.8N.,R.2E.	3300	340	20	Jm	Klk	D
W23	John Dusing	SE¼NW¼sec.2,T.8N.,R.3E.	2990	2225	Flow	Cml	Cml	S,I
W24	Fruitdale City Well	NW¼SE¼sec.12,T.8N.,R.3E.	2945	715		Klk?	Klk	D
W25	Robert M. Williams	SE¼SE¼sec.14,T.8N.,R.3E.	2975	560	Flow 60 gpm	Jm	Klk	D
W26	T.J. Broadhurst	SW¼NE¼sec.31,T.8N.,R.3E.	3200	1853	Flow	Cml	Cml	
W27	McElroy	SE¼SW¼SW¼sec.33,T.8N.,R.3E.	3260	2340	Flow	Cml	Cml	
W28	John Troyer	NE¼NE¼sec.5,T.7N.,R.1E.		80	10	Trs	Js	D
W29	W.W. Thompson	SW¼sec.10,T.7N.,R.1E.	3360	700	Flow	Po?	Trs? Pm?	S,I
W30	W.W. Thompson	NW¼SE¼sec.10,T.7N.,R.1E.	3350	1100	Flow	Cml	Cml	S
W31	Oliver Swanson	SW¼NE¼sec.11,T.7N.,R.1E.	3380	1004	Flow	Cml	Cml	S,I

Well No.	Owner	Location	Elev. (feet)	Depth of Well (feet)	Depth to Water (feet)	Bottom Hole Formation	Source of Water	Use
W32	Oliver Swanson	NE¼NE¼sec.12,T.7N.,R.1E.	3350	1121	Flow	Cml	Cml	S,I
W33	Rollin Bryan	NE¼sec.13,T.7N.,R.1E.	3315	576	Flow	Po?	Pm?	D,S,I
W34	Joe Schenk	SW¼sec.13,T.7N.,R.1E.	3350	80	Flow 8 gpm	Trs	Js? Trs?	D
W35	Anderson Bros.	SW¼SW¼sec.14,T.7N.,R.1E.	3464	625	Flow	Cml	Pm,Cml	D,S,I
W36	Papousek	SW¼SW¼SW¼NW¼sec.19,T.7N.,R.1E.	3525	825	Flow	Cml	Pm?Cml	D
W37	Richard Sleep	NE¼SW¼sec.23,T.7N.,R.1E.	3450	500	Flow	Cml	Cml	D,S,I
W38	Edwin Johnson	NE¼SE¼sec.23,T.7N.,R.1E.	3410	340	Flow 30 gpm	Pm	Pm	D
W39	Maurice Hickenbothan	NE¼SE¼sec.23,T.7N.,R.1E.	3410	45		Trs	Trs?Al?	D
W40	Ken Englehardt	NE¼SE¼sec.23,T.7N.,R.1E.	3410	43		Trs	Trs	D
W41	Eugene Sleep	NW¼SE¼sec.25,T.7N.,R.1E.	3570	500	10	Cml	Cml	D
W42	Harry Edwards	SW¼NE¼sec.26,T.7N.,R.1E.	3524	270	29	Cml	Cml	S
W43	Walt Crofutt	SE¼NE¼sec.26,T.7N.,R.1E.	3550	174	22	Trs	Trs	D,I
W44	S.D. Dept. Transportation	NE¼sec.30,T.7N.,R.1E.	3476	600	Flow 70 gpm	Cml	Cml	D
W45	Tullock Sisters	SE¼SE¼sec.30,T.7N.,R.1E.	3510	985	Flow	Cml	Cml	D
W46	Estes Edwards	SW¼NW¼sec.34,T.7N.,R.1E.	3652	400	15	Cml	Cml	D
W47	Lon Widdoss	NW¼SE¼SE¼NE¼sec.2,T.7N.,R.2E.	3180	1350		Cml	Cml	D
W48	Don Helmer	NE¼SW¼NE¼SW¼sec.2,T.7N.,R.2E.	3350	989	Flow 50 gpm	Trs	Trs	S
W49	Larry Helmer	NW¼NW¼SW¼SW¼sec.2,T.7N.,R.2E.	3200	943	Flow 100 gpm	Po	Pm	D
W50	Don Helmer	NW¼SE¼NE¼SE¼sec.2,T.7N.,R.2E.	3165	1290	Flow 150 gpm	Cml	Cml	D,S
W51	A. Jarvi	SW¼SE¼NW¼sec.6,T.7N.,R.2E.	3640	700	270	Trs	Js	S
W52	A. Jeffery	NW¼NW¼NE¼NE¼sec.8,T.7N.,R.2E.	3260	40		Js	Js?Al?	D
W53	Vincent Crago	SE¼NE¼SE¼SW¼sec.8,T.7N.,R.2E.	3320	40	10	Js	Js?Al?	D
W54	Jim Jennings	NE¼NE¼SW¼SE¼sec.8,T.7N.,R.2E.	3315	30		Js	Js.Al?	D
W55	Don Helmer	NW¼NW¼NE¼NW¼sec.9,T.7N.,R.2E.	3320	1425	Flow 300 gpm	Cml	Cml	S
W56	Grago Bros.	NE¼SE¼sec.9,T.7N.,R.2E.	3350	1285	Flow	Cml	Cml	
W57	Jahner	SE¼SE¼NW¼NE¼sec.10,T.7N.,R.2E.	3210	30		Js	Js?Al?	D
W58	Bruce Carlson	NE¼SE¼sec.6,T.7N.,R.2E.	3400	2400?	Flow 350 gpm	Cmd?	Cmd?	D
W59	Howard Perkins	SE¼SW¼ SW¼sec.15,T.7N.,R.2E.	3437	1218	Flow	Cml	Cml.Pm?	S
W60	Marvin Sankey	SW¼SW¼SE¼SE¼sec.15,T.7N.,R.2E.	3410	1250	Flow	Cml	Cml	D,S
W61	Fred Brady	NW¼sec.11,T.7N.,R.1E.	3380	1440	Flow 450 gpm	Cml	Cml	I
W62	Bob Humphrey	SE¼sec.17,T.7N.,R.2E.	3340	30	8	Js	Js?Al?	D,S
W63	Grago Bros.	NE¼SW¼sec.18,T.7N.,R.2E.	3405	845	Flow 600 gpm	Cml	CmlPm?	I

Well No.	Owner	Location	Elev. (feet)	Depth of Well (feet)	Depth to Water (feet)	Bottom Hole Formation	Source of Water	Use
W64	Redwater Irr. Co.	SW¼NE¼sec.19,T.7N.,R.2E.	3405	700	Flow	Cml	Cml	I
W65	John Nyberg	SW¼NW¼sec.20,T.7N.,R.2E.	3340	1150	Flow	Cml	Cml	S
W66	Racick & Nyberg	NE¼SE¼sec.20,T.7N.,R.2E.	3390	1115	Flow	Cml	Cml	S
W67	Warren Johnson	SW¼SW¼SW¼NW¼sec.23,T.7N.,R.2E.	3360	1088	Flow 60 gpm	Cml	Cml	O
W68	Warren Johnson	NE¼SW¼sec.23,T.7N.,R.2E.	3378	1498	Flow	Cmd	Cmd,Cml	I
W69	Randy Christensen	NE¼NE¼sec.29,T.7N.,R.2E.	3405	40		Trs	Trs?Al?	D
W70	John Ward	SW¼SW¼sec.28,T.7N.,R.2E.	3442	60	18	Trs	Trs?Al?	D
W71	Jim Eddy	NW¼SE¼SW¼SW¼sec.28,T.7N.,R.2E.	3440	640	Flow	Cml	Cml	D,S
W72	Bill Evans	NE¼NE¼sec.29,T.7N.,R.2E.	3427	475	Flow	Po,Cml?	Pm?Cml?	D,I
W73	Bill Evans	NW¼NW¼sec.29,T.7N.,R.2E.	3480	660	Flow	Cml	Cml	I
W74	Leo McGuigan	SE¼sec.29,T.7N.,R.2E.	3480	640	Flow	Cml	Cml	D,S
W75	Leo McGuigan	SE¼NE¼sec.30,T.7N.,R.2E.	3475	381	Flow	Pm	Pm	D,S
W76	Vern Backens	NE¼SE¼sec.32,T.7N.,R.2E.	3575	500	40	Cml	Cml	D,I
W77	C.H. Carlson	NW¼sec.33,T.7N.,R.2E.	3480	90	20	Trs	Trs?Al?	D,I
W78	Highway Dept.	SE¼sec.34,T.7N.,R.2E.	3525	825		Cml	Cml	D
W79	Felix Ryther	NE¼NE¼sec.3,T.7N.,R.3E.	3320	1635		Cml	Cml	
W80	Spearfish (Dickey)	NE¼sec.15,T.6N.,R.2E.	3673	560	8	Cmd	Cmd	D
W81	Spearfish (O'Neill)	SE¼sec.10,T.6N.,R.2E.	3650	250	8	Cml	Cml	D
W82	Robert Helmer	SW¼NW¼sec.2,T.8N.,R.3E.	2980	290?	Flow			S
W83	Ralph Crago	SW¼SW¼sec.1,T.7N.,R.2E.	3200	?	Flow			D,I?
W84	SDGS well #18	SW¼NE¼NW¼SE¼sec.10,T.8N.,R.2E.	3010	18		Al	Al	
W85	SDGS well #R19	SW¼NE¼NE¼SW¼sec.11,T.8N.,R.2E.	3010	11.5		Al	Al	
W86	Darrell Nickelson	SE¼SE¼sec.28,T.8N.,R.2E.	3250	2220	Flow 375 gpm	Cml	Cml	D

APPENDIX C

Logs of Belle Fourche Country Club and Nickelson wells

Belle Fourche Country Club, Water Well 1
Drilled 1968 by James Baker, Osage, Wyoming

Microscopic description of ditch samples of cuttings below the top of the Minnekahta limestone by J. P. Gries

Minnekahta Formation 1800 - 1930

1880-1890	Limestone, pink, finely crystalline, dense
-1900	Limestone, same
-1910	Limestone, pink to lavender, finely crystalline, dense
-1930	Limestone, dolomitic, glassy, pink to brown and gray, dense

Opeche Formation 1930 - 1980

1930-1980	Shale, maroon to red, some sandy, with streaks anydrite

Minnelusa Formation 1980 to total depth

1980-1990	Sandstone, medium, pink to maroon, porous to well cemented
-2000	Sandstone, same
-2010	Sandstone, poorly sorted, red-orange to white, mostly tight
-2020	Sandstone, fine to medium, white, tight
-2030	Anhydrite, medium crystalline, white
-2040	Anhydrite as above, and sandstone, white, friable
-2050	Sandstone, white to pink, friable to well cemented
-2060	Anydrite, white, with sandy streaks
-2070	Same
-2080	Sandstone, fine, white, porous
-2088	Sandstone, pink to white, porous to slightly cemented casing set at this point and cemented back up hole for 600 feet
-2100	Neat cement from casing job
-2110	Cement and sandstone, fine to medium, white, more or less calcareous
-2115	Sandstone, same
-2030	Sandstone, fine to coarse, white, porous to slightly cemented
-2140	Sandstone, same, but tighter, with dolomite cement
-2150	Sandstone, same, mostly well cemented
-2160	Sandstone, fine, friable to very porous
-2165	Sandstone, fine to medium, dolomitic, tight to slightly porous

Belle Fourche Country Club, Water Well 1 -- continued.

	-2170	Sandstone, fine to medium, friable
	-2175	Sandstone, fine to medium, dolomitic to friable
	-2180	Sandstone, same; 80 percent; dolomite, finely crystalline, white to pink, some sandy, and with pinpoint porosity, 20 percent
	-2185	Sandstone, same, 70 percent; dolomite, same, 30 percent
	-2190	Sandstone, same, 30 percent; dolomite, same 70 percent
	-2195	Sandstone, same, 60 percent; dolomite, same 40 percent
	-2205	Sandstone, fine to coarse, white and pink, porous to well cemented; trace of dolomite in upper part
*	-2215	Sandstone, fine to coarse, pink and white, porous to well cemented
*	-2220	Sandstone, same, 50 percent; dolomite, finely crystalline, gray, earthy, 50 percent
*	-2225	Sandstone, same 80 percent; dolomite, same 20 percent
*	-2230	Sandstone, same
*	-2235	Sandstone, same, with streaks pink dolomite
*	-2240	Dolomite, finely crystalline, pink; trace sand as above
*	-2245	Dolomite, same, 50 percent; grading back to sandstone, dolomitic, pink
*	-2250	Dolomite, pink, probably fractured

* Correction

FROM THE FILE OF MERLE BANDY

2178-2251	Pink and white sand
2251-2279	Hard pink sand and white limestone
2279-2335	Hard pink limestone and dolomite
2335-2388	Pink sand - 60 gallon
2338-2429	Pink sand and limestone
2429-2465	Hard pink limestone, dolomite and chert
2465-2590	White, pink, cream limestone

Cased from 2060 to 2231 - 2½ inch black pipe perforated 2172 to 2210

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Well Log: Darrell Nickelson
Belle Fourche, SD

Drilled and logged by Brice and Taylor Drilling Company, Rapid City, South Dakota

Legal Description: 1100 FEL 500 FSL Section 28, T. 8 North, Range 2 East
Completed 3-11-80
Total depth - 2220 feet
GPM flow - 375

0- 100	Black shale
100- 110	Brown sandstone
110- 140	Gray shale
140- 160	Green and maroon shale
160- 640	Green and black shale and sandstone
640- 655	Brown and red shale
655-1470	Spearfish
1470-1510	Minnekahta
1510-1600	Opeche
1600-1665	Limestone
1665-1715	Gray sandstone (last 5 feet loose)
1715-1745	Limestone
1745-1753	Gray sandstone
1753-1830	Limestone, hard
1830-1837	Red sandstone
1837-1883	Limestone
1883-1919	Red sandstone
1910-1920	Limestone
1920-1975	Mostly sandstone red and gray
1975-1985	Hard probably lime or hard sandstone
1985-2070	Softer limestone some fractures fairly soft at 2070
2070-2110	Gray sandstone
2110-2130	Limestone not very hard 2130 soft spot possible sandstone
2130-2145	Hard limestone
2145-2150	Softer limestone
2150-2175	Fractured limestone (water)
2175-2220	Harder some small fractures

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