STATE OF SOUTH DAKOTA
William J. Janklow, Governor

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

GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

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GROUND-WATER STUDY FOR THE CITY OF BISON, SOUTH DAKOTA

by

Fred V. Steece

Science Center
University of South Dakota
Vermillion, South Dakota
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GENERAL INFORMATION

At the request of the City of Bison and the West River Conservancy Sub-District, the South Dakota Geological Survey conducted a ground-water study intermittently during August and September, 1974, and May, 1975. This study included the following work: (1) a review was made of the geology as mapped by the South Dakota Geological Survey (Bolin, 1955; Curtiss, 1955a, 1955b; Hoppin and Curtiss, 1955); (2) a total of 32 test holes were drilled, 30 with an auger rig and 2 with a rotary rig; (3) a well inventory was made (app. A); (4) water samples were collected and analyzed from 28 wells in the Bison area.

The study was financed by the South Dakota Geological Survey, the West River Conservancy Sub-District, and the City of Bison. The cooperation of the residents and especially Joe Deibert, Ron Kopren, and Dennis Lewton, City officials; Dennis Knutson and Stanley Soderstrom, well drillers; and Joe Pogue, US Forest Service, Lemmon, South Dakota, is acknowledged.

Bison has had six wells drilled over the years. The wells range in depth from 565 to 867 feet and produce water from sands and sandy zones in the Fox Hills Formation. Well No. 4 was contaminated during drilling by the private well driller when oil products were added to free stuck drilling rod. This well was abandoned due to the presence of oil product in the water. Water production of individual city wells has not been measured, but the combined total is probably about 50 gallons per minute which is about one-half of the City's needs based on the Farmers Home Administration standard estimate of one-fourth gallon per min-

ute per person per day.

Since Bison has a population of approximately 400, the City needs about 100 gallons per minute to meet this standard. Water use at Bison has increased since 1968. Per capita consumption (it is assumed that per capita consumption is approximately equivalent to per meter consumption) has in creased from 1,488 gallons in 1968 to 2,166 gallons in 1974 (table 1). The per meter consumption rose from 4,121 to 5,505. The total water used in 1968 according to water meter record books in the possession of Mr. Leroy Penor, was approximately 8.1 million gallons as compared to approximately 11.2 million gallons in 1973. Because the data were available only through August, only a projected water use for 1974 could be given; the figure is approximately 11.9 million gallons.

It is obvious that because of increased demands for water by consumers, the overall water use at Bison is increasing rapidly and will continue to do so. The increased use is not so much a matter of increasing population as it is in the increase in the number of home appliances and other domestic water use. Several new homes have been built in Bison during the last 5 years, and each of these is more "modern" than the older homes. Also in the new housing addition is the need for lawn-watering. Because of the inflation spiral, many families are planting gardens to supplement their food supply and these require water also.

GEOLOGIC INFORMATION

The exposed rocks (table 2 and fig. 1) belong to the Lud-

TABLE 1. Water use at Bison, 1968, 1973, and 1974

	1968[1]	1973	1974
Total water use (gallons)	8,159,419	11,215,244	11,957,000
Average monthly water use (gallons)	679,952	934,603	996,377
Average number of meters	165	184	181[2]
Average monthly consumption per meter (gallons)	4,121	5,079	5,505[2]
Approximate population of Bison	457[3]	460[3]	460[3]
Approximate monthly per capita water consumption (gallons)	1,488	2,032	2,166

[1]There is no significant reason that 1968 records were chosen and are shown for comparison purposes only.

[2]Data complete only through August; figure is projected total

[3]Source: "Comprehensive Water and Sewer Plan," Perkins County, Table III-7, 1971

TABLE 2. Geologic Formations of the Bison Area

AGE	FORMATION	MAIN COMPOSITION	THICKNESS	WATER-BEARING CHARACTERISTICS
Tertiary	Ludlow	Sand, shale, coal	300	Low permeability, yields small amounts of water to wells
Cretaceous	Hell Creek	Shale, sand, coal	250	Low permeability, yields small amount of water
	Fox Hills	Sandstone, shale, sand	350	Low permeability, yields small amount of water
	Pierre	Shale	1350	Impermeable; not an aquifer
	Niobrara	Chalk, shale	365	Low permeability; poor aquifer
	Carlile	Shale	425	Impermeable, not an aquifer
	Greenhorn	Limestone, chalk, shale	200	Low permeability; poor aquifer
	Belle Fourche-Mowry	Shale	370	Impermeable; not an aquifer
	Dakota (Newcastle)	Sandstone, shale	70	Partly permeable; low yield
	Skull Creek	Shale	170	Impermeable; not an aquifer
	Fall River-Lakota	Sandstone, shale	200	Highly permeable; moderate yield (50 gpm); mineralized water
Jurassic-Triassic	Sundance-Spearfish	Red and gray shale, gypsum; some sand	530	Low permeability; low yield
Permian	Minnekahta	Limestone	50	Low permeability; low yield
Pennsylvanian-Permian	Opeche	Red shale	50	Impermeable; not an aquifer
	Minnelusa	Sandstone, shale, anhydrite, limestone	770	Mostly permeable; moderate yields (100-200 gpm), highly mineralized water
Mississippian	Madison	Limestone	1060	Highly permeable; high yield (200-400 gpm) highly mineralized water
Devonian-Silurian	Numerous formation names	Limestone, dolomite, anhydrite, sandstone, shale	630	Mostly permeable; yield unknown, water quality unknown, probably highly mineralized
Ordovician	Red River	Dolomite, limestone	530	Low to high permeability; yield low to high, highly mineralized water
	Winnipeg	Shale	130	Impermeable, not an aquifer
Cambrian	Deadwood	Sandstone, shale, sand, limestone	500	Highly permeable; yield unknown; quality of water unknown
Precambrian	(Unnamed)	Granite	Unknown	Impermeable; not an aquifer

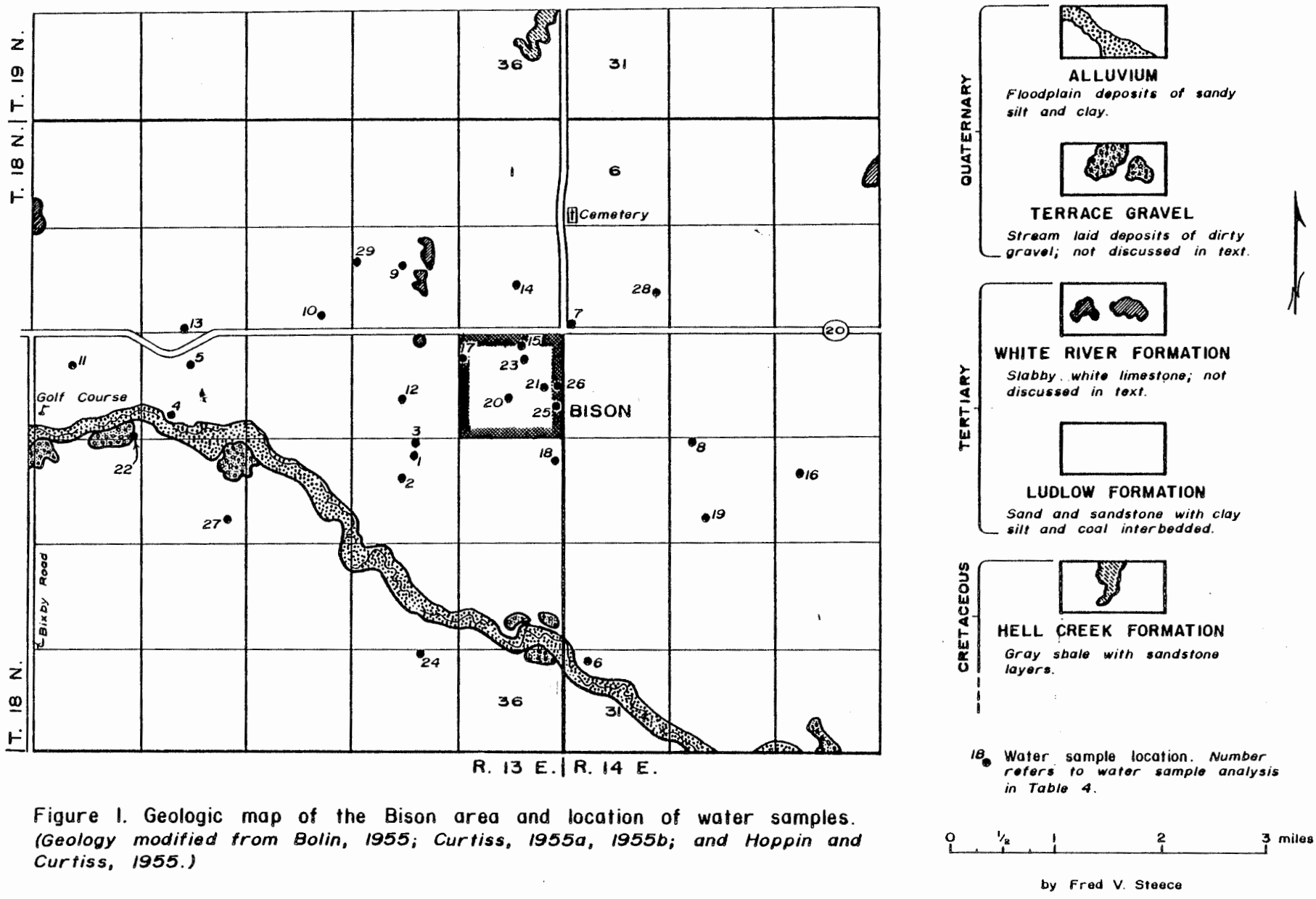
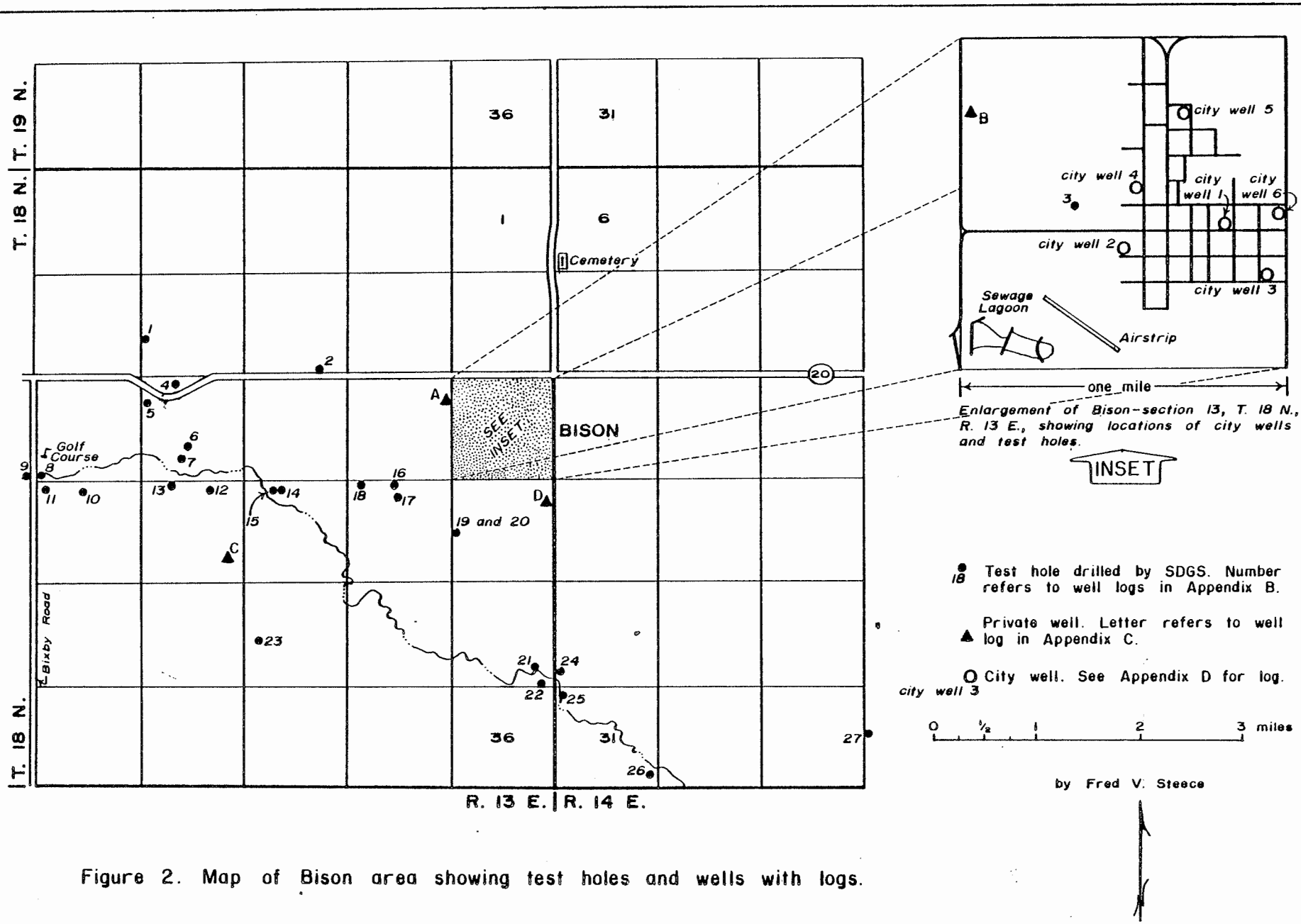


Figure 1. Geologic map of the Bison area and location of water samples. *(Geology modified from Bolin, 1955; Curtiss, 1955a, 1955b; and Hoppin and Curtiss, 1955.)*

low Formation consisting mainly of yellow to gray sand, silt and silty clay. There are some ledges of hard sandstone interbedded with these sediments. Also exposed in various parts of the area are brown to black soft lignite coals and peat-clay layers. The Ludlow sediments are normally too fine to yield much water to wells. These rocks are 220 feet thick in South Dakota Geological Survey rotary test hole 20 south of town (figs. 2 and 3; app. B). The same sequence is about 280 feet thick in South Dakota Geological Survey rotary test hole 3 (Pete Deutschle) on the west side of Bison (figs. 2 and 4; app. B). The rock sequence drilled by these two holes should be representative of the rocks underlying the entire town. Therefore, because the author saw the rock cuttings as they were brought out of the drill hole, and because good electric logs were made on the hole, descriptions of the Ludlow, Hell Creek and Fox Hills Formations are based on information obtained from these two test holes (test holes 3 and 20, app. B).

Alluvial sand and silt lies on top of the Ludlow Formation along the course of Thunder Butte Creek. The alluvium is generally too thin or too fine-grained to be a source of ground water.

Next below the Ludlow is a series of sands, clays, and coals known as the Hell Creek Formation. Because of their drab appearance, early geologists called these the "somber beds". The Hell Creek sand layers can yield water to wells, but usually the sand is mixed with clay and therefore water will not move through these layers and into the well fast enough to supply



Enlargement of Bison-section 13, T. 18 N., R. 13 E., showing locations of city wells and test holes.

Figure 2. Map of Bison area showing test holes and wells with logs.

Figure 3

SDGS Test Hole No. 20

SW SW SW NW–Sec. 24–T. 18 N.–R. 13 E.–Perkins Co.

Elev. 2717 feet–Depth 1010 feet

Date Drilled: May, 1975

by Fred V. Steece

Shale

Sand

Coal

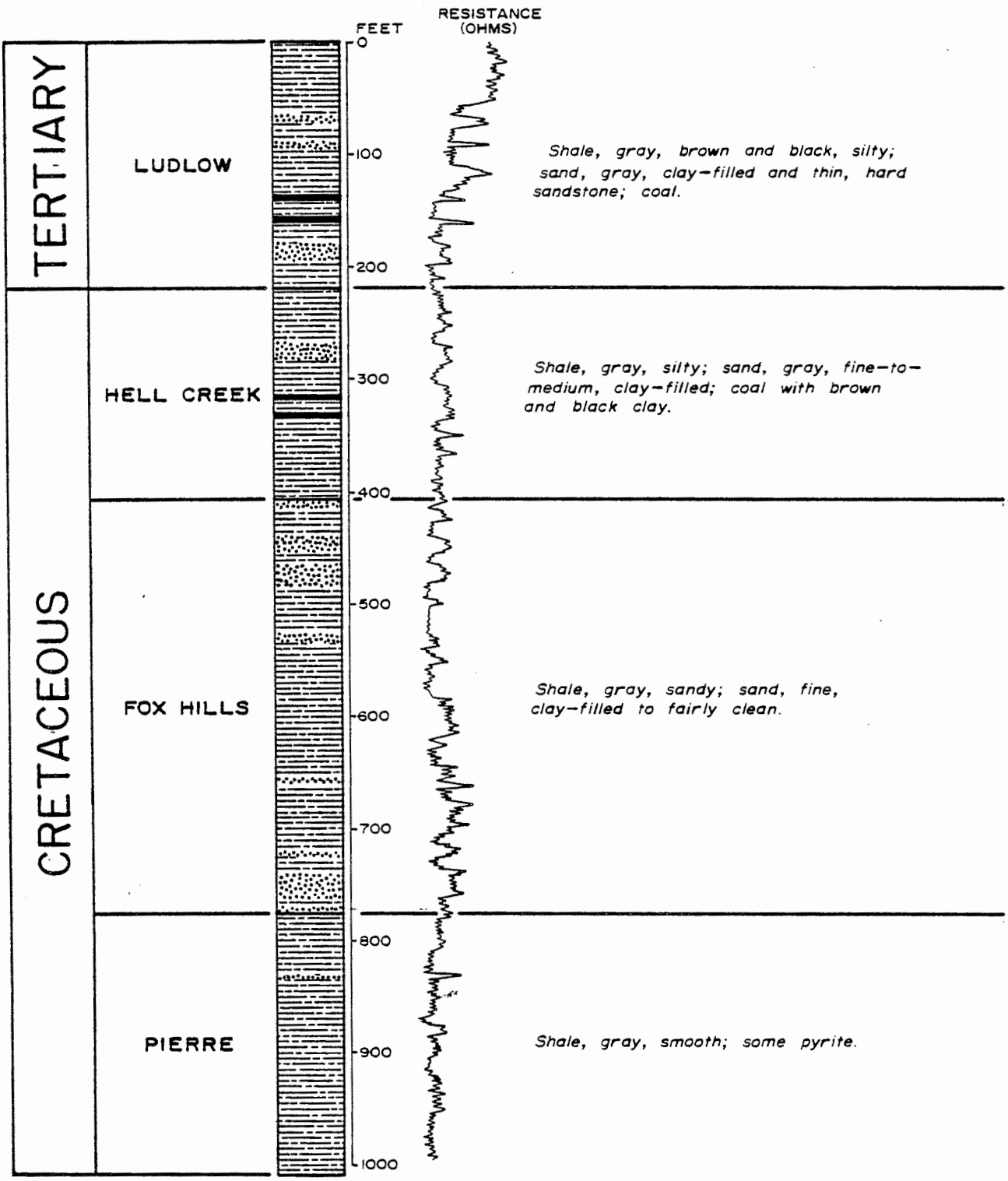


Figure 4

SDGS Test Hole No. 3 (Pete Deutschle's Land)

NE NW NE SW – Sec. 13 – T. 18 N. – R. 13 E. – Perkins Co.

Elev. 2777 feet – Depth 810 feet

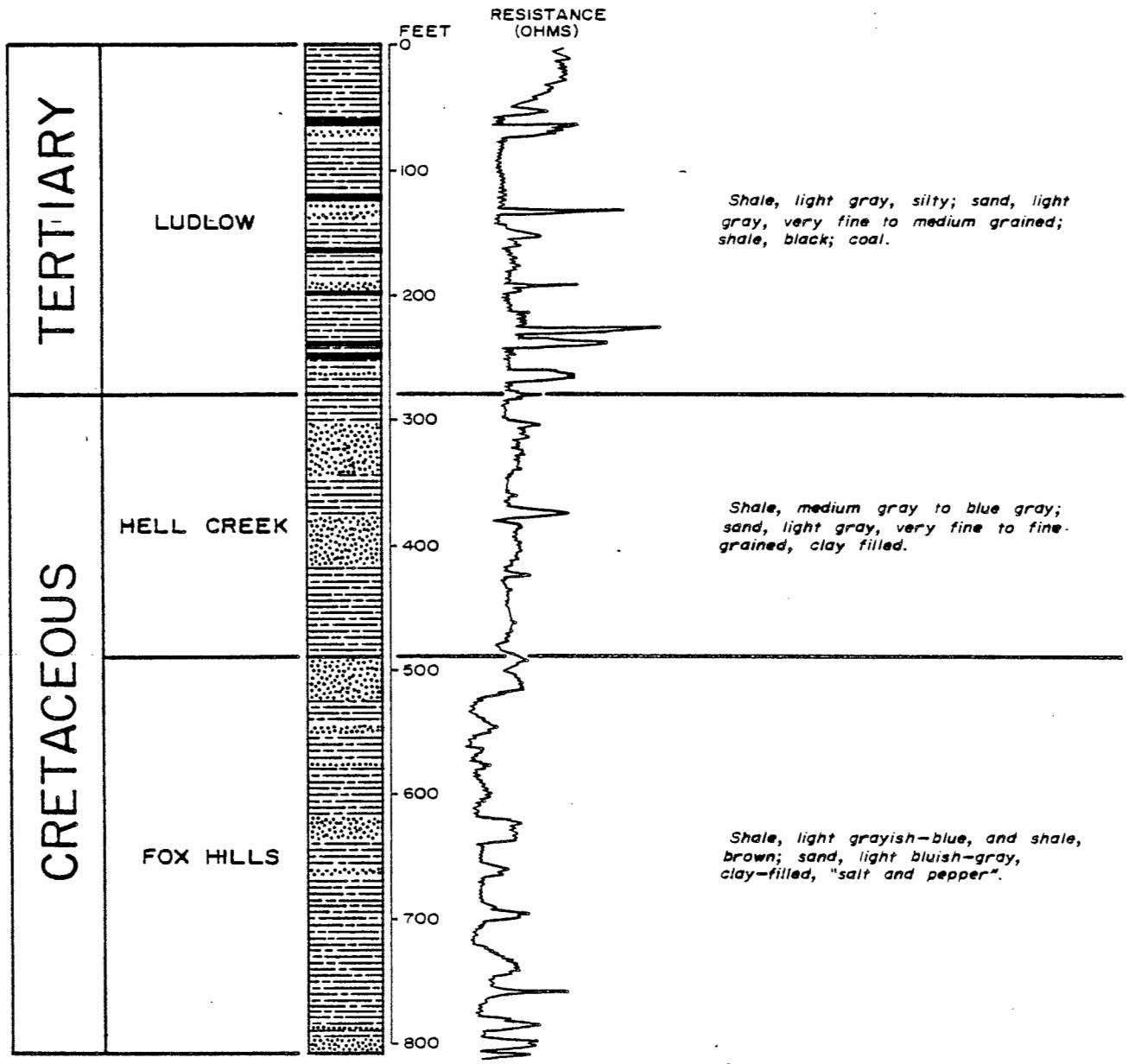
Date Drilled: May, 1975

by Fred V. Steece

Shale

Sand

Coal



sufficient water. This formation has a thickness of 210 feet in test hole 3 (app. b).

Below the Hell Creek is the Fox Hills Formation which consists of alternating sand, silt, and clay layers. The sand layers, resembling salt and pepper, provide only small amounts of water to wells because the sands are usually mixed with clay. Bison's water wells are completed in several of these sand layers in the Fox Hills Formation. The Fox Hills is at least 320 feet thick in test hole 3 (app. B). The character of these formations is also shown in well logs in Appendices C and D.

Beneath the three formations just described, is a series of rocks as much as 7,500 feet thick which are summarized in table 2. This table is based on information from the Shell No. 1 Veal oil test drilled 8 miles southeast of town in 1952.

GROUND-WATER INFORMATION

Many of the formations described in table 2 are aquifers but there is no definite information on the amount of water a well tapping them would produce (some estimates are shown on the last column of table 2). There is some information on the quality of water from these deeper formations shown in table 3. Quality of water from the shallower formations, namely the alluvium (Qal), the Ludlow (Tpl), Hell Creek (Kh), and Fox Hills (Kf) is generally good, although it is quite variable (table 4).

As a whole, water from the Ludlow Formation is the best in the area, although locally some of this water is highly mineralized. Water with less dissolved chemicals in the upper part of

TABLE 3. Analyses of water from deep formations in the Shell No. 1 Veal oil test (SE¼SE¼ sec. 7, T. 17 N., R. 15 E., Perkins County, Drilled in 1952)

		Dissolved Minerals (Parts Per Million)					
Formation	Depth	Total Solids	Sodium	Chloride	Calcium	Sulfate	Magnesium
Fall River-Lakota	3854-3855	3,857	1,230	804	6	5	2.1
Minnelusa	5368-5418	30,336	10,000	12,660	917	6,000	139
Madison	5479-5655	69,340	22,040	40,320	3,400	2,350	790
Madison	5752-5795	4,386	487	697	833	2,100	129
Madison	5949-5973	3,624	430	648	585	1,550	94
Devonian	6569-6633	150,000	46,400	91,400	9,180	1,550	1,650
Silurian	6851-6895	7,411	1,760	3,180	648	1,250	163
Red River	7131-7166	30,874	9,660	17,630	1,580	1,180	244
Deadwood	7901-7977	8,738	2,320	2,430	578	3,850	63

TABLE 4. Chemical Analyses of Water Samples from the Bison Area

Map Number	Source	Parts per Million										Owner	Location	Depth of Well (feet)	Depth to Water (feet)
		Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Nitrate Nitrogen	pH	Hardness (CaCO3)	Total Solids				
A	---	---	---	---	250[2]	250[2]	0.30[2]	10.0[1]	---	---	500[2]				
1	Qal	150	15	15	40	80	.02	0.5	7.3	430	650	Don McKinstry	NESWNWNE Sec. 23,T.18 N.,R.13 E.	12	4
2	Qal	90	20	40	40	250	.20	0.0	7.3	380	820	Don McKinstry	SENESENW Sec. 23,T.18 N.,R.13 E.	Surface	Reservoir
3	Qal	65	20	29	10	320	.50	1.0	7.5	280	870	Don McKinstry	NENWNWNE Sec. 23,T.18 N.,R.14 E.	24	12
-	Qal	60	610	50	20	340	.08	1.0	7.3	370	1920	Morris Jensen	SESENWSE Sec. 13,T.19 N.,R.13 E.	14	2
4	TPL	50	10	90	10	30	.02	0.5	7.3	490	380	Alfred Heupel	NWNWSESW Sec. 16,T.18 N.,R.13 E.	60	Unknown
5	TPL	120	15	32	30	110	.00	0.0	7.4	432	450	Adolph Aker	NENESENW Sec. 16,T.18 N.,R.13 E.,	63	20
6	TPL	75	15	30	20	150	.00	0.0	7.2	300	460	Harry Penor	SENENWNW Sec. 31,T.18 N.,R.14 E.,	120	20
7	TPL	10	170	15	15	60	.00	0.0	7.6	100	480	Milford Cooper	SWSWSWSW Sec. 7,T.18 N.,R.14 E.,	120	60
8	TPL	70	90	25	20	90	.00	9.0	7.2	280	650	Adam Brockel	NENENWNW Sec. 20,T.18 N.,R.14 E.	40	30
9	TPL	15	210	20	15	190	.02	0.5	7.4	130	1010	Mick Almen	NESESENW Sec. 11,T.18 N.,R.13 E.	180	Unknown
10	TPL	50	90	135	20	680	.02	0.5	7.3	690	1420	Leland Hanson	SENESWSE Sec. 10,T.18 N.,R.13 E.	90	Unknown
11	TPL	190	35	120	10	720	1.00	2.0	7.3	950	1430	Adolph Aker	NENWSENW Sec. 17,T.18 N.,R.13 E.	225	Unknown
12	TPL	15	560	15	10	1625	.01	0.0	7.4	110	2790	Don McKinstry	NESENESW Sec. 14,T.18 N.,R.13 E.	123	80
13	KH	25	15	30	-	-	.08	-	7.2	190	720	Leland Hanson	SWSESESW Sec. 9,T.18 N.,R.13 E.	286	60
14	KH	15	220	15	10	200	.25	0.5	7.3	110	1100	LeRoy Penor	NWNWSE Sec. 12,T.18 N.,R.13 E.	350	Unknown
15	KH	10	380	15	40	370	.01	0.0	7.2	90	1120	Forest B. White	SENWNWNE Sec. 13,T.18 N.,R.13 E.	360	130
16	KH	25	380	15	20	380	.00	0.0	7.4	115	1400	Errol Wells	SENESWNW Sec. 21,T.19 N.,R.14 E.	390	90
17	KH	10	375	10	40	975	.00	1.0	7.6	35	1420	Irwin Tescher	SWSWNWNW Sec. 13,T.18 N.,R.13 E.	240	180
18	KH	10	600	20	40	1050	.80	1.0	7.3	110	2350	Ralph Veal	SESENENE Sec. 24,T.18 N.,R.13 E.	460	100
19	KF	10	390	35	20	290	.05	0.5	7.2	180	780	Ted Brockel	NESENWSW Sec. 20,T.18 N.,R.14 E.	520	250
20	KF	2	368	0	88	39	.00	0.0	8.4	8	819	Bison City No. 2	NESENESW Sec. 13,T.18 N.,R.13 E.	729	Unknown
21	KF	2	354	0	65	67	.00	0.3	8.4	6	881	Bison City No. 1	NENWNESE Sec. 13,T.18 N.,R.13 E.	565	Unknown
-	KF	10	425	15	200	50	.00	0.0	7.5	100	960	Rudolph Larson	NWNWNWSW Sec. 5,T.17 N.,R.14 E.	600	150
22	KF	10	290	25	50	320	.00	0.0	7.4	130	1000	Adolph Aker	SESESESE Sec. 17,T.18 N.,R.13 E.	435	30
23	KF	4	529	0	280	5	.10	0.0	8.4	10	1162	Bison City No. 5	SWSENWNE Sec. 13,T.18 N.,R.13 E.	835	Unknown
24	KF	30	320	10	60	25	.00	0.0	7.5	110	1180	D.L. Aker	NWNENWNE Sec. 35,T.18 N.,R.13 E.	495	Unknown
25	KF	4	501	0	270	18	.00	0.0	8.5	10	1204	Bison City No. 3	SESENESE Sec. 13,T.18 N.,R.13 E.	867	433
-	KF	20	430	10	25	420	.02	0.5	7.2	90	1220	Irving Abrahams	NWNWNWSW Sec. 3,T.17 N.,R.14 E.	200	150
26	KF	8	515	0	33	496	.10	0.0	8.4	22	1417	Bison City No. 6	NENENESE Sec. 13,T.18 N.,R.13 E.	794	245
27	KF	15	550	15	20	700	.00	0.0	7.3	100	1450	Alfred Heupel	SWSESESE Sec. 21,T.18 N.,R.13 E.	410	Unknown
-	KF	10	500	15	25	300	.00	0.0	7.4	90	1490	Morris Jensen	SENWNESE Sec. 13,T.19 N.,R.13 E.	340	Flows 2 GPM
28	KF	10	300	20	45	425	.00	0.0	7.6	95	1640	Marlo Johnson	NWSENESE Sec. 7,T.18 N.,R.14 E.	700	200
29	KF	40	570	10	20	710	.02	0.5	7.3	130	1680	Mick Almen	NWSWNW Sec. 11,T.18 N.,R.13 E.	500	70

Samples were analyzed by the S.D. Dept. of Health and by the South Dakota Geological Survey.
Source: Qal, aluvium; Tpl, Ludlow formation; Kh, Hell Creek formation, Kf, Fox Hills formation.
The wells with map numbers are shown on Figure 1; some of these wells are outside the area of the map.

Sample A

[1]United States Environmental Protection Agency "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)

the Ludlow is probably explained by direct percolation of rain and snowmelt into these sandy shales.

The next best quality of water is from the alluvium. Alluvium is found only under the bottomland along Thunder Butte Creek and South Fork of the Grand River. Deposits of alluvium are small and thin and would not yield large amounts of water to wells.

In contrast, water from the Hell Creek and Fox Hills Formations is slightly more mineralized as can be seen in table 4. Water from the various formations can be characterized as follows:

Alluvium (Qal) - hard; calcium sulfate; moderate total solids
Ludlow (Tpl) - hard; sodium sulfate; moderate to high total solids
Hell Creek (Kh) - soft; sodium sulfate; excessively high total solids
Fox Hills (Kf) - soft; sodium sulfate and sodium chloride; moderate to high total solids.

Test holes drilled by the South Dakota Geological Survey auger drilling rig in the alluvium along the South Grand River, about 6 miles north of Bison, indicated as much as 20 feet of saturated sand and gravel in the SW corner NW 1/4 sec. 7, T. 19 N., R. 14 E. The Survey recommended that the city drill a test well at this location, but no aquifer material was found and the location was abandoned.

ALTERNATIVES FOR CITY WATER SUPPLY

Recommendations to the City of Bison as to a solution to

their water problem are in the form of several alternatives. These alternatives are discussed below.

Alternative 1: Drill additional wells into Fox Hills

The City can continue to use their present water supply and drill additional wells as the need arises for additional water. This probably is the most practical alternative for the City. Because the Fox Hills aquifer is fine-grained, care should be taken to ensure that wells are properly completed and developed.

One consideration to be aware of is that prolonged pumping of water from the Fox Hills Formation throughout the City well field may be causing the static water level to be lowered in a general "cone-of-depression" surrounding the City. (See app. A, water levels in the City wells appear to be considerably lower than several nearby private wells completed in the same formation.) Because the Fox Hills allows the horizontal (and to a lesser extent, vertical) passage of water at a slow rate and because there are no "veins" or other highly permeable zones, sites for future wells can be selected on the basis of convenience to pipelines and surface irregularities. It might be a good idea to select future sites at convenient locations well outside the possible "cone-of-depression," even though the cost of building pipelines is fairly high. Continued sustained water withdrawals from the Fox Hills beneath Bison may continue to lower the static water level.

Alternative 2: Build surface reservoir

Many towns and cities around the State rely on surface reser-

voirs for part or all of their water supplies. Surface reservoirs have disadvantages such as the need for treatment and the risk of drying up during drought. A surface reservoir could provide water for fire protection, irrigation and other similar uses, at the same time saving the well water for drinking, cooking, and other uses. This would require separate water mains and would be an added expense to the town.

Alternative 3: Pipe water from Shadehill Reservoir

The City may wish to consider building a pipeline from Shadehill Reservoir approximately 14 miles cross country. Because this reservoir is maintained by the South Dakota Department of Game, Fish and Parks, an agreement would have to be negotiated with that agency.

Alternative 4: Drill North Grand River well

There may be a possibility of obtaining a large yield of shallow ground water from the alluvium along the North Grand River, about 20 miles north of town, upstream from the tailwaters of Shadehill Reservoir. The well or well field should be far enough above Shadehill to ensure exclusion of surface water at times of high water and flood water. Test drilling would have to be done in that area to determine the feasibility of this alternative.

Alternative 5: Drill 4,000-foot well

Another choice left to the City is to drill a well approximately 4,000 feet in depth, to tap the Fall River-Lakota aquifer (table 2). This aquifer probably would provide 50 gallons per

minute, or more, of highly mineralized ground water. The water should be under enough artesian pressure to raise the water to a static level of about 600 to 700 feet below land surface. The quality of water would be similar to the partial analysis below:

Shell No. 1 Veal, SE 1/4 SE 1/4, sec. 7, T. 17 N., R. 15 E.; drilled in 1952; water from Fall River-Lakota at a depth between 3854 to 3855 feet.

	Parts per Million
Total solids	3857
Sodium	1230
Chloride	804
Calcium	6.0
Sulfate	5
Magnesium	2.1

Other aquifers lie below the Fall River-Lakota that would supply adequate water, but the quality of the water would probably be even less desirable than that from the Fall River-Lakota.

CONCLUSION

The present study did not reveal any coarse-grained water-bearing material within the Ludlow, Hell Creek, or Fox Hills Formations that would yield large amounts of water to high capacity wells. Instead it was found that these formations are fine-grained with low permeability. Thus future wells completed in any of these formations will probably yield water at about the same rate as present wells produce in the immediate Bison area. The City of Bison, therefore, may select one or more of the several

alternatives that are open to them in order to ensure an adequate future water supply.

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APPENDIX A

Well records in the Bison area

Information was obtained from interviews with well owners and from City files.

Use of water: S, stock; D, domestic; M, municipal.

Name of owner or tenant	Location	Reported depth (feet)	Reported depth to water (feet)	Use of water	Date drilled
Herb Kolb	SE¼SE¼NE¼SW¼ sec. 7, T. 17 N., R. 13 E.	220	---	S	1966
Irving Abrahams	NW¼NW¼NW¼SW¼ sec. 3, T. 17 N., R. 14 E.	200	90	D,S	1967
Rudolph Larson	SW¼SW¼SW¼NW¼ sec. 5, T. 17 N., R. 14 E.	600	150	D,S	1953
Errol Hall	NW¼ sec. 12, T. 17 N., R. 14 E.	420	---	D,S	----
David Storm	NW¼ sec. 17, T. 17 N., R. 16 E.	380	185	D,S	1975
Bob Hanson	NE¼NE¼NE¼SE¼ sec. 3, T. 18 N., R. 13 E.	180	144	D,S	1949
Bob Hanson	SE¼SE¼SE¼NW¼ sec. 3, T. 18 N., R. 13 E.	187	167	S	1940
Alex Krischen	NW¼NW¼NW¼SE¼ sec. 4, T. 18 N., R. 13 E.	200	110	S	1964
Leland Hanson	NE¼NE¼NE¼SE¼ sec. 9, T. 18 N., R. 13 E.	40	38	S	----

Leland Hanson	SW¼SE¼SE¼SW¼ sec. 9, T. 18 N., R. 13 E.	286	60	S	1959
Leland Hanson	SE¼NE¼SW¼SE¼ sec. 10, T. 18 N., R. 13 E.	120	40	S	1963
Mick Almen	NE¼SE¼SE¼NW¼ sec. 11, T. 18 N., R. 13 E.	180	---	S	1963
Mick Almen	NW¼NW¼SW¼NW¼ sec. 11, T. 18 N., R. 13 E.	500	80	D,S	1930
Leroy Penor	SE¼NW¼NW¼SE¼ sec. 12, T. 18 N., R. 13 E.	350	---	S	1959
Bison City No. 1	NE¼NW¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.	685	375	M	1950
SDGS (Deuschle) Test Hole 3	NE¼NW¼NE¼SW¼ sec. 13, T. 18 N., R. 13 E.	813	---	---	1975
Bison City No. 6	NE¼NE¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.	784	245	M	1969
Bison City No. 2	NE¼SE¼NE¼SW¼ sec. 13, T. 18 N., R. 13 E.	729	---	M	1952
Bison City Test Well	NE¼ sec. 13, T. 18 N., R. 13 E.	1,082	---	None	1950-52
Herb Kolb	NW¼NW¼NW¼SW¼ sec. 13, T. 18 N., R. 13 E.	135	135	None	1964
Bison City No. 3	SE¼SE¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.	867	433	M	1954
Bison City No. 5	SE¼SE¼NW¼NE¼ sec. 13, T. 18 N., R. 13 E.	835	337	M	1960

Name of owner or tenant	Location	Reported depth (feet)	Reported depth to water (feet)	Use of water	Date drilled
Forest White	SW¼NW¼NW¼NE¼ sec. 13, T. 18 N., R. 13 E.	360	180	D	1960
Irwin Tescher	SW¼SW¼NW¼NW¼ sec. 13, T. 18 N., R. 13 E.	240	180	D,S	1966
Bison City No. 4	SW¼SW¼SW¼NE¼ sec. 13, T. 18 N., R. 13 E.	1,400	---	None	1969
Don McKinstry	NE¼SE¼NE¼SW¼ sec. 14 T. 18 N., R. 13 E.	128	80	D,S	1934
Alex Krischer	SE¼SE¼NE¼NE¼ sec. 14, T. 18 N., R. 13 E.	329	200	D,S	1967
Adolph Aaker	NW¼NE¼SE¼NW¼ sec. 16, T. 18 N., R. 13 E.	63	20	S	----
Alfred Huepel	NW¼NW¼SE¼SW¼ sec. 16, T. 18 N., R. 13 E.	60	---	S	1962
Adolph Aaker	NE¼SE¼NW¼ sec. 17, T. 18 N., R. 13 E.	225	---	S	----
Alfred Huepel	SW¼SE¼SE¼SE¼ sec. 21, T. 18 N., R. 13 E.	410	---	D	1971
Don McKinstry	NE¼NW¼NW¼NE¼ sec. 23, T. 18 N., R. 13 E.	24	12	S	1930
Don McKinstry	NE¼SW¼NW¼NE¼ sec. 23, T. 18 N., R. 13 E.	12	4	S	1930
Don McKinstry	SE¼NE¼SE¼NW¼ sec. 23, T. 18 N., R. 13 E.	12	2	S	1961

Bison City Test Well	SW¼SW¼NE¼NE¼ sec. 23, T. 18 N., R. 13 E.	432	---	None	1966
Ralph Veal	NE¼SE¼SW¼ sec. 24, T. 18 N., R. 13 E.	375	100	S	1926
Ralph Veal	SE¼SE¼NE¼NE¼ sec. 24, T. 18 N., R. 13 E.	460	100	S	1973
Ralph Veal	SE¼SE¼NE¼NE¼ sec. 24, T. 18 N., R. 13 E.	240	---	None	1946
SDGS Test No. 20	SW¼SW¼SW¼NW¼ sec. 24, T. 18 N., R. 13 E.	1010	---	None	1975
Helen Brockel	NW¼NW¼NW¼NW¼ sec. 18, T. 18 N., R. 14 E.	120	60	D	1940
John Penor	SW¼SW¼SW¼SW¼ sec. 19, T. 18 N., R. 14 E.	205	---	D,S	1934
Adam Brockel	NE¼NE¼NW¼NW¼ sec. 20, T. 18 N., R. 14 E.	40	30	D,S	1930
Ted Brockel	NE¼SE¼NW¼SW¼ sec. 20, T. 18 N., R. 14 E.	520	250	D,S	1963
Errol Wells	SE¼NE¼SW¼NW¼ sec. 21, T. 18 N., R. 14 E.	390	90	D,S	1959
Ted Brockel	SE¼SE¼NW¼NW¼ sec. 29, T. 18 N., R. 14 E.	265	---	S	1963
Rudolph Larson	SE¼SE¼NW¼ sec. 32, T. 18 N., R. 14 E.	264	---	S	1960
Grazing Ass'n.	NE¼SE¼ sec. 8, T. 19 N., R. 13 E.	303	---	S	1975

Name of owner or tenant	Location	Reported depth (feet)	Reported depth to water (feet)	Use of water	Date drilled
Morris Jensen	SE¼NW¼NE¼SE¼ sec. 13, T. 19 N., R. 13 E.	340	Flowing 2 gpm	S	1953
Morris Jensen	SE¼SE¼NW¼SE¼ sec. 13, T. 19 N., R. 13 E.	14	---	S	1960
US Forest Service	NW¼NW¼ sec. 23, T. 19 N., R. 13 E.	173	161	S	1974
US Forest Service	SE¼SE¼NW¼ sec. 31, T. 19 N., R. 13 E.	450	120	S	1965
Alex Krischer	NW¼NW¼NW¼SE¼ sec. 33, T. 19 N., R. 13 E.	400	200	S	1966
US Forest Service	SW¼SW¼NE¼ sec. 13, T. 19 N., R. 14 E.	280	185	S	1966
Morris Jensen	SW¼ sec. 16, T. 19 N., R. 14 E.	370	190	S	1975
Morris Jensen	SW¼SE¼NE¼ sec. 19, T. 19 N., R. 14 E.	120	60	S	1951
Morris Jensen	NW¼SE¼SW¼ sec. 19, T. 19 N., R. 14 E.	340	185	S	1965
Morris Jensen	NW¼NW¼ sec. 22, T. 19 N., R. 14 E.	110	---	S	1974
George Williams	NW¼NW¼NW¼NW¼ sec. 35, T. 19 N., R. 14 E.	218	188	D,S	1925

APPENDIX B

Logs of test holes drilled by the South Dakota Geological Survey (for map location, see fig. 2)

SDGS Test Hole 1 (Auger hole)
Location: NW¼SW¼NW¼SW¼ sec. 9, T. 18 N., R. 13 E.

0- 4	Silt, brown, clayey, dry
4- 16	Sand, yellow-brown, dry; fine; some clay; moist
16- 18	Sand, yellow-brown, fine, little clay, saturated(?)

* * * *

SDGS Test Hole 2 (Auger hole)
Location: SE¼SE¼SW¼SE¼ sec. 10, T. 18 N., R. 13 E.

0- 4	Silt, light brown, some clay, dry
4- 31	Sand, light brown, fine, some clay
31- 36	Sand, gray-black, medium to fine, clayey, saturated
36- 44	Clay, gray, black, brown-black, silty, moist, peat and/or coal

* * * *

SDGS Test Hole 3 (Rotary hole 2, see enlarged map, fig. 2) (Deutschle)
Location: NE¼NW¼NE¼SW¼ sec. 13, T. 18 N., R. 13 E.

0- 10	Clay, yellow-brown, sandy
10- 60	Shale, medium gray, silty, smooth
60- 65	Coal, black, soft
65- 75	Shale, medium to dark gray, smooth
75- 85	Sand, fine to medium, gray, some clay filling
85-120	Shale, medium to dark gray, some sandy
120-125	Coal, black, hard, sharp
125-130	Shale, sandy, black
130-145	Sand, light gray, clay filled
145-165	Shale, gray, smooth, firm
165-170	Coal, black and brown lignite
170-190	Shale, black
190-195	Sandstone, light gray, hard; sandy clay
195-200	Coal, hard, blocky
200-300	Shale, gray, silty, smooth, some coal
300-350	Sand, firm, bluish-gray, clay-filled
350-370	Shale, medium olive-gray, smooth
370-420	Sand, medium gray, very fine to medium
420-425	Shale, medium gray, silty, smooth, firm
425-430	Sand, light gray, very fine, clay-filled
430-510	Shale, gray, green, smooth

SDGS Test Hole 3 -- continued.

510-525	Sand, light bluish-gray, fine to very fine, clay-filled
525-700	Shale, grayish-green, smooth, silty to sandy
700-780	Shale, gray, some shows pyrite, hard, some clay-filled sand
780-785	Sand, medium gray, fine, clay-filled, salt and pepper
785-810	Shale, medium gray, smooth, some sand, some soft brown clay

* * * *

SDGS Test Hole 4 (Auger hole)
Location: SE¼NW¼NE¼NW¼ sec. 16, T. 18 N., R. 13 E.

0- 17	Silt, light brown, clayey, dry, calcareous
17- 44	Sand, medium brown, little clay; saturated
44- 69	Silt to very fine sand, medium and dark gray, some black clay

* * * *

SDGS Test Hole 5 (Auger hole)
Location: SW¼SW¼NW¼NW¼ sec. 16, T. 18 N., R. 13 E.

0- 4	Silt and fine sand, light brown, clayey, dry
4- 5	Rocks, crystallines
5- 25	Sand, brownish-yellow, fine, clayey; saturated
25- 34	Clay, medium to dark gray, little silt; moist
34- 35	Silt, dark gray, clayey; moist, wouldn't penetrate

* * * *

SDGS Test Hole 6 (Auger hole)
Location: SE¼SE¼NE¼SW¼ sec. 16, T. 18 N., R. 13 E.

0- 8	Silt, light brown, clayey, dry, plant fragments
8- 10	Clay, black, silty; saturated, plant fragments
10- 15	Silt, light brown and light gray, saturated, clayey
15- 23	Clay, medium gray, silty, moist, fairly hard
23- 26	Clay, gray, brown; saturated
26- 37	Sand, medium gray, fine; moist
37- 49	Clay, gray-brown, silty, moist, hard

* * * *

SDGS Test Hole 7 (Auger hole)
Location: SW¼NE¼SE¼SW¼ sec. 16, T. 18 N., R. 13 E.

0- 5	Silt, brown, very clayey, moist

SDGS Test Hole 7 -- continued.

5- 8	Clay, brown, very silty, moist, some sand and gravel
8- 13	Clay, yellow-brown and red-brown, silty, saturated
13- 18	Silt, brown, clayey, saturated, water started coming up
18- 20	Clay, gray and black, silty, moist, peat(?)
20- 31	Sand, gray, very fine, clayey, moist, some very clayey sand
31- 35	Silt, gray, very clayey, moist
35- 44	Clay, gray, silty, some bentonite

* * * *

SDGS Test Hole 8 (Auger hole)
Location: NW¼SW¼SW¼SW¼ sec. 17, T. 18 N., R. 13 E.

0- 3	Sand, light brown, clayey; dry
3- 4	Clay, brown, silty; moist
4- 7	Sand, brown, medium, slightly clayey; saturated
7- 8	Silt, yellow-brown and light gray; saturated
8- 10	Clay, medium gray, silty; moist to saturated, plant fragments
10- 19	Silt, medium and dark gray, clayey, moist

* * * *

SDGS Test Hole 9 (Auger hole)
Location: SE¼SE¼SE¼SE¼ sec. 18, T. 18 N., R. 13 E.

0- 4	Sand, brown, coarse, clayey, saturated at 4 feet
4- 8	Clay, yellow-brown, silty, saturated
8- 13	Silt, yellow-brown, clayey, moist
13- 19	Silt, light gray, clayey (upper part may be saturated)

* * * *

SDGS Test Hole 10 (Auger hole)
Location: NE¼NE¼NE¼NW¼ sec. 20, T. 18 N., R. 13 E.

0- 4	Sand, brown, very coarse, clayey, dry, some gravel
4- 7	Sand, brown, coarse to very coarse, clayey, moist
7- 8	Clay, brown, sandy, moist
8- 12	Sand, brown, coarse, clayey, very moist
12- 16	Clay, brown and some gray, sandy, moist
16- 24	Silt, gray, clayey, moist, some coal and/or peat fragments

* * * *

SDGS Test Hole 11 (Auger hole)
Location: NE¼NW¼NW¼NW¼ sec. 20, T. 18 N., R. 13 E.

0- 2	Sand, light brown, fine, clayey; dry
2- 3	Gravel, brown, fine; moist
3- 8	Silt, tan, clayey; moist, calcareous
8- 10	Clay, medium gray, silty; moist, noncalcareous
10- 12	Silt, medium gray, clayey; moist, some black layers
12- 19	Clay, medium gray, slightly silty; moist, noncalcareous bentonite

* * * *

SDGS Test Hole 12 (Auger hole)
Location: SE¼NE¼NW¼NE¼ sec. 21, T. 18 N., R. 13 E.

0- 5	Silt, brown, some very fine sand, clayey, slightly moist
5- 8	Sand, brown, very fine, saturated
8- 13	Silt, brown and dark brown, clayey, saturated
13- 19	Clay, gray, very silty, saturated

* * * *

SDGS Test Hole 13 (Auger hole)
Location: NW¼NW¼NE¼NW¼ sec. 21, T. 18 N., R. 13 E.

0- 2	Clay, light tan, sandy; dry
2- 4	Silt to fine sand, brown; moist, some coarse sand
4- 7	Sand, brown, fine, moist
7- 11	Sand, brown, medium, very clayey, saturated
11- 13	Sand, brown, very fine, clayey, saturated
13- 14	Silt, light gray, clayey, moist
14- 20	Gravel, brown, coarse, very clayey, saturated
20- 27	Clay, gray, very silty; saturated, hard, could not penetrate

* * * *

SDGS Test Hole 14 (Auger hole)
Location: SE¼NW¼NE¼NW¼ sec. 22, T. 18 N., R. 13 E.

0- 2	Sand, brown, fine; dry, some clay layers
2- 3	Clay, brown, sandy, dry
3- 4	Sand, tan, coarse, dry
4- 5	Gravel, brown, fine; dry, medium to coarse sand, some 15mm pebbles
5- 10	Gravel, brown, fine, dry, rock at 7 feet
10- 15	Sand, brownish, medium to fine, moist
15- 16	Rock
16- 22	Sand, brownish-red, medium, moist, some clay
22- 25	Clay, medium gray to black, silty, saturated

SDGS Test Hole 14 -- continued.

25- 28	Clay, black, sandy, saturated
28- 28.5	Hard zone, no sample, did not penetrate

* * * *

SDGS Test Hole 15 (Auger hole)
Location: SW¼NW¼NE¼NW¼ sec. 22, T. 18 N., R. 13 E.

0- 2	Clay, light brown, dry
2- 11	Silt, brown, clayey, saturated
11- 15	Gravel, brown, very clayey, coarse, saturated
15- 21	Silt, brown to yellow-brown, clayey, moist
21- 29	Clay, brown, silty, saturated, some plant fragments

* * * *

SDGS Test Hole 16 (Auger hole)
Location: NE¼NE¼NE¼NW¼ sec. 23, T. 18 N., R. 13 E.

0- 2	Clay, light tan; dry
2- 5	Clay, brown, silty; moist, calcareous
5- 7	Silt, yellow-brown, clayey; saturated
7- 11	Clay, black, silty; saturated, some peat at 8 feet, plant fragments
11- 22	Silt, light gray, clayey; moist, streaks of light gray (bentonite?)
22- 28	Clay, tan, dry, hard, silty, moist at 27 to 28 feet

* * * *

SDGS Test Hole 17 (Auger hole)
Location: NE¼SE¼NE¼NW¼ sec. 23, T. 18 N., R. 13 E.

0- 8	Silt, brown, clayey, dry, some very fine sand
8- 10	Clay, brown, silty, moist
10- 15	Silt, brown and some gray, very clayey, moist, saturated 14 feet
15- 17	Clay, gray and brown, very silty, moist
17- 18	Silt, black, clayey, moist
18- 24	Silt, gray, clayey, dry

* * * *

SDGS Test Hole 18 (Auger hole)
Location: NE¼NW¼NW¼NW¼ sec. 23, T. 18 N., R. 13 E.

0- 4	Soil, brown, very clayey, silty
4- 15	Silt, yellow-brown, some light gray, clayey, moist

SDGS Test Hole 18 -- continued.

15- 29	Clay, light gray, some silt stringers, dry, some gypsum

* * * *

SDGS Test Hole 19 (Rotary hole)
Location: SW¼SW¼SW¼NW¼ sec. 24, T. 18 N., R. 13 E. (Hole abandoned; see log 20)

0- 25	Clay, fine to coarse, sandy, yellow-brown
25- 30	Silt, clay-rich, sandy, yellowish-brown, limonite
30- 35	Coal, black, blocky to blade-like, some gray shale
35- 50	Shale, medium dark-gray, silty, some slightly sandy
50- 55	Sandstone, light gray, medium gray, silty shale
55- 85	Shale, medium dark-gray, firm silty
85- 95	Sandstone, very fine, clay-filled
95-115	Shale, medium gray, smooth
115-120	Clay, yellow-brown, hard
120-125	Shale, light gray, silty, taking water
125-135	Clay, light gray, soft
135-145	Coal, black, hard, blocky; some brown clay
145-155	Shale, gray; some brownish-black

* * * *

SDGS Test Hole 20 (Rotary Hole 1)
Location: SW¼SW¼SW¼NW¼ sec. 24, T. 18 N., R. 13 E.

0- 20	Clay, black to yellow-brown, silty, sandy (road fill?)
20- 25	Sand, light gray, fine, clay-filled; some coal
25- 35	Shale, medium gray, silty, salt and pepper
35- 40	Sandstone, light greenish-gray, hard, gray clay, coal
40- 55	Shale, medium gray, silty, smooth
55- 60	Coal, small flakes and blocks
60- 65	Shale, dark brown to dark gray; coal
65- 70	Sand, light gray, silty, clay-filled, salt and pepper
70- 85	Sand, fines: quartz, pyrite, coal, clay, iron-stained pyrite
85- 90	Sandstone, light gray, fine, hard, small sharp chips
90- 95	Sand, light gray, silty, salt and pepper
95- 140	Shale, medium gray, clay-rich, smooth
140- 145	Coal, black, blocky, choppy drilling at 143
145- 155	Shale, black, smooth; and shale, brown-gray, smooth
155- 160	Coal, light gray, silty, soft
160- 185	Shale, light gray, silty, some coal

SDGS Test Hole 20 -- continued.

185- 205	Sand, tan, silty, clay-filled; fines: quartz, mica, gypsum, coal
205- 280	Shale, dark brownish-gray, smooth; some coal
280- 285	Sand, coarse
285- 325	Shale, grayish-green, sandy, some clay and coal
325- 330	Sand, grayish-green, silty, clay-filled, salt and pepper
330- 410	Shale, black, hard, abundant coal, some brown, smooth
410- 430	Sand, medium blue-gray, clay-rich, salt and pepper
430- 435	Shale, medium gray, smooth, some brown compact shale, sand
435- 465	Sand, medium green-gray, fine to medium, clay-filled, some shale
465- 470	Shale, medium gray, smooth, some sand
470- 475	Sand, blue-gray, very fine, clay-filled
475- 500	Sand, greenish and blue-gray, clay-filled
500- 610	Shale, bluish-gray, smooth, silty, some clay
610- 615	Clay, light gray, fine, sandy, soft
615- 655	Shale, light medium-gray, silty to sandy
655- 660	Siltstone, tan, hard, and smooth firm shale, light gray
660- 665	Sand, fine; some dark shale
665- 740	Sand, fine, light bluish-gray, clay-filled; some shale
740- 780	Shale, medium gray to dark gray, firm drilling from 768 to 770 feet, choppy at 771 feet
780- 785	Sand, very light gray, very fine shale
785- 830	Shale, medium gray, smooth, firm, somewhat silty
830- 845	Clay, light gray to very light gray, some sand and shale
845-1010	Shale, gray, firm; tan siltstone, soft clay (bentonitic?)

* * * *

SDGS Test Hole 21 (Auger hole)
Location: SE¼NW¼SE¼SE¼ sec. 25, T. 18 N., R. 13 E.

0- 4	Sand, brown, very fine, clayey, dry
4- 15	Silt, dark brown, clayey, moist, some fine sand
15- 18	Coal, and/or peat fragments
18- 24	Silt, black, very clayey, moist, calcareous, some coal

* * * *

SDGS Test Hole 22 (Auger hole)
Location: SW¼SE¼SE¼SE¼ sec. 25, T. 18 N., R. 13 E.

0- 4	Gravel, brown, clayey, dry

SDGS Test Hole 22 -- continued.

4- 8	Sand, brown, very coarse, clayey, moist
8- 17	Clay, yellow-brown, sandy, moist
17- 19	Clay, black, very silty, moist
19- 24	Silt, light gray, clayey, not very moist

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SDGS Test Hole 23 (Auger hole)
Location: SW¼NE¼NW¼SW¼ sec. 27, T. 18 N., R. 13 E.

0- 9	Clay, yellow-brown, very silty, dry
9- 13	Silt, brown, very clayey, saturated, calcareous
13- 29	Clay, gray, very silty, saturated, peat or coal fragments

* * * *

SDGS Test Hole 24 (Auger hole)
Location: SW¼NW¼SW¼SW¼ sec. 30, T. 18 N., R. 14 E.

0- 1	Clay, tan, silty, dry
1- 5	Clay, brown, silty, moist
5- 14	Silt, brown, clayey, saturated
14- 24	Clay, brown, silty, moist, hard

* * * *

SDGS Test Hole 25 (Auger hole)
Location: NE¼NW¼NW¼NW¼ sec. 31, T. 18 N., R. 14 E.

0- 4	Sand, tan, medium, clayey; dry, some 8-10 mm pebbles
4- 12	Sand, light red-brown, medium, clayey, dry to moist
12- 15	Sand, tan to brown, very fine, little clay, moist
15- 20	Sand, medium, little clay, moist
20- 30	Clay, brown, silty, moist
30- 39	Silt, medium gray, clayey, moist, hard

* * * *

SDGS Test Hole 26 (Auger hole)
Location: NE¼SE¼SE¼SE¼ sec. 31, T. 18 N., R. 14 E.

0- 9	Sand, brown, very coarse, clayey, dry, some gravel
9- 11	Clay, yellow-brown, very silty, moist, calcareous
11- 12	Clay, red-brown, very silty, dry, noncalcareous
12- 14	Silt, brown, clayey, moist, slightly calcareous
14- 18	Silt, brown and black, very clayey, moist to dry, noncalcareous

SDGS Test Hole 26 -- continued.

18- 29	Silt, brown and gray, clayey, dry

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SDGS Test Hole 27 (Auger hole)
Location: SW¼SW¼SW¼NW¼ sec. 34, T. 18 N., R. 14 E.

0- 4	Silt, yellow-brown, dry, noncalcareous
4- 5	Rock, limey deposits, calcareous, very light gray
5- 6	Silt, gray-brown, clayey, moist, noncalcareous
6- 14	Silt, brown, clayey, moist, calcaerous
14- 20	Silt, gray-brown, clayey, moist, noncalcareous
20- 23	Sand, dark gray, medium, clayey, saturated
23- 28	Silt, dark gray and black, clayey, moist

* * * *

SDGS Test Hole 28 (Auger hole)
Location: SW¼SW¼SW¼NW¼ sec. 7, T. 19 N., R. 14 E. (not shown on fig. 2)

0- 5	Silt, light brown to tan, clayey, dry, calcareous
5- 7	Clay, brown, silty, moist, slightly calcareous
7- 23	Silt, brown, clayey, moist, calcareous
23- 24	Sand, brown, medium to fine, clayey, moist
24- 30	Silt, dark brown, clayey, saturated
30- 32	Sand, brown, medium, clayey, moist
32- 43	Gravel, brown, fine, clayey, saturated
43- 50	Sand, medium gray, coarse to fine, saturated
50- 64	Clay, gray, saturated, lumpy

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SDGS Test Hole 29 (Auger hole)
Location: SW¼SW¼NW¼SW¼ sec. 7, T. 19 N., R. 14 E. (not shown on fig. 2)

0- 3	Sand, brown, fine to medium, some clay, dry
3- 11	Sand, brown, some clay, saturated at 5 feet
11- 13	Silt, dark gray, very clayey, moist
13- 18	Silt, dark brown, very clayey, moist, some green zones
18- 24	Silt, gray-brown, clayey, moist
24- 34	Sand, gray, very fine to fine, some clay, moist
34- 44	Sand, gray, very fine, very clayey, moist

* * * *

SDGS Test Hole 30 (Auger hole)
Location: NW¼NW¼SW¼NW¼ sec. 18, T. 19 N., R. 14 E. (not shown on fig. 2)

SDGS Test Hole 30 -- continued.

0- 2	Sand, light brown, medium, dry
2- 11	Gravel, brown, fine, dry, mostly coarse sand
11- 13	Sand, bluish-green, very fine, clayey, saturated
13- 18	Clay, medium gray, very silty, moist, hard
18- 20	Silt, medium gray, clayey, moist
20- 22	Clay, medium gray, silty, moist
22- 38	Silt, medium gray, clayey, moist, hard
38- 44	Clay, dark gray, slightly silty, moist, hard, lumpy

* * * *

SDGS Test Hole 31 (Auger hole)
Location: NW¼SW¼NW¼SW¼ sec. 3, T. 17 N., R. 14 E. (not shown on fig. 2)

0- 1	Silt, brown-black, sandy, clayey, dry
1- 4	Sand, brown, very fine, some clay, moist
4- 12	Sand, brown, very fine, very clayey, saturated at 6 feet(?)
12- 24	Silt, gray, very clayey, moist

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SDGS Test Hole 32 (Auger hole)
Location: NE¼NE¼SE¼NE¼ sec. 4, T. 17 N., R. 14 E. (not shown on fig. 2)

0- 3	Silt, brown
3- 6	Gravel, brown, clayey; moist, rocky, some 10 to 20 mm pebbles
6- 8	Gravel, red-brown, little clay, moist; fewer rocks
8- 9	Silt, gray-green, clayey; moist, noncalcareous
9- 11	Clay, grayish-tan, silty; moist, noncalcareous
11- 14	Silt, grayish-tan, little clay; saturated, some limonite, hard
14- 27	Clay, medium gray, silty, moist
27- 34	Silt, medium gray, sandy (very fine), clayey; moist

* * * *

APPENDIX C

Logs of private wells drilled in the area. These logs were obtained from Dennis Knutson, Hettinger, North Dakota, and Stanley Soderstrom, Bowman, North Dakota.

Alex Krischen Well - A
Location: SE¼NE¼NE¼ sec. 14, T. 18 N., R. 13 E.

0- 9	Clay, buff
9- 10	Sandstone, soft
10- 12	Clay, buff
12- 13	Sandstone, soft
13-167	Clay, buff to gray; some sand and coal
167-168	Coal
168-181	Clay
181-241	Sandstone ledge
241-269	Clay
269-300	Sand, gray, medium
300-303	Sandstone
303-306	Sand, gray, medium
306-309	Coal
309-329	Clay; coal streak

* * * *

Irwin Tescher Well - B
Location: SW¼NW¼NW¼ sec. 13, T. 18 N., R. 13 E.
(See enlarged map, fig. 2)

0- 5	Surface
5- 39	Clay, buff and brown, with trace of rock and gravel
39- 45	Sand, gray/blue, with mica
45- 78	Clay, gray, some sand
78- 79	Rock
79- 93	Clay, gray, with sandstone
93-106	Sand, gray
106-109	Rock
109-117	Clay, sandy, gray
117-118	Rock
118-188	Clay, gray, some sandy
188-188	Rock ledge
188-215	Clay, gray
215-218	Rock
218-224	Clay, gray, sandy
224-247	Sand, some blue sandy, clay

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Alfred Heupel Well - C
Location: SE¼SE¼ sec. 21, T. 18 N., R. 13 E.

Alfred Heupel Well - C -- continued.

0- 15	Clay
15- 16	Coal, soft
16- 67	Clay and shale, rock
67- 68	Coal, hard
68- 69	Clay
69- 72	Rock
72- 93	Clay, sandy, some rock
93-120	Clay, some rock
120-123	Clay, green
123-127	Coal
127-128	Clay, green
128-145	Clay, sandy
145-151	Sand
151-154	Rock
154-156	Sand, coarse
156-171	Clay
171-173	Coal
173-245	Clay, coarse, sandy and green shale
245-272	Clay
272-273	Rock
273-324	Clay, sandy, coarse
324-325	Rock
325-382	Clay, sandy and shale
382-385	Rock
385-386	Clay, sandy
386-392	Sand, coarse, and sandstone
392-405	Clay

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Ralph Veal Well - D
Location: NE¼NE¼ sec. 24, T. 18 N., R. 13 E.

0- 31	Clay, yellow
31- 47	Sand, blue
47- 48	Rock
48- 60	Clay, dark
60- 64	Coal
64- 85	Clay
85- 98	Clay, gray
98-120	Clay
120-123	Coal
123-176	Clay, coarse, sandy
176-177	Rock
177-264	Rock
264-265	Rock
265-400	Clay, sandy, some shale, water at 400 feet
400-428	Clay, sandy, 3-inch rock
428-440	Clay
440-441	Rock
441-460	Clay, sandy

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US Forest Service - E
Location: SE¼NW¼ sec. 31, T. 19 N., R. 13 E.
(not shown on fig. 2)

0- 3	Topsoil
3- 26	Shale, sandy
26- 34	Clay
34- 45	Clay
45- 46	Rock
46-130	Clay, sandy
130-132	Coal
132-162	Clay, soft, sandy
162-163	Rock
163-205	Clay, sandy
205-207	Rock, hard
207-235	Clay
235-237	Coal
237-250	Clay, green, sandy
250-252	Coal
252-275	Clay, sandy
275-360	Clay
360-361	Rock, hard
361-384	Clay
384-385	Rock, hard
385-430	Clay, green
430-450	Sand, coarse (clay?)

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Errol Hall Well - F
Location: NW¼ sec. 12, T. 17 N., R. 14 E.
(not shown on fig. 2)

0- 94	Clay, buff, sandy, some gray, brown, and blue
94- 95	Rock
95- 96	Clay, gray
96- 99	Rock
99-119	Clay, with coal streaks, gray
119-123	Sand, gray, medium
123-135	Clay, gray, with coal
135-175	Clay, with coal streaks
175-176	Rock ledge
176-205	Clay, with coal and rock
205-216	Sand, gray, with clay streak
216-254	Clay, with coal streak
254-265	Sand, fine, blue
265-265	Rock
265-270	Sand, fine, blue
270-271	Rock
271-274	Clay, sandy
274-275	Rock
275-300	Clay, with blue sandstone

Errol Hall Well - F -- continued.

300-347	Clay, sandy, gray
347-420	Clay, fine blue sand, good hard

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Herb Kolb Well - G
Location: Center S½ sec. 17, T. 17 N., R. 13 E.
(not shown on fig. 2)

0- 10	Clay, yellow
10- 28	Shale, gray
28- 33	Coal
33- 41	Shale, gray
41- 45	Rock
45-142	Shale, gray, with hard streaks
142-152	Sand
152-162	Shale, sandy
162-182	Sand
182-242	Shale, sandy

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APPENDIX D

Logs of city wells and test holes drilled for the City of Bison by private drillers. These logs were obtained from the City files.

City of Bison Well 1
Location: NE¼NW¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.
(see enlarged map, fig. 2)

0- 10	Clay, sandy
10- 25	Sandstone
25- 40	Clay
40- 50	Shale, blue
50- 87	Shale, sandy
87- 93	Coal
93- 95	Shale
95-145	Sand and shale
145-145	Rock
145-200	Shale, blue, sandstone
200-202	Rock (hard)
202-250	Shale, sand; water
250-292	Shale, and sandstone shells
292-350	Shale, sand and rock
350-350	Rock
350-372	Sand; water
372-483	Shale, some sand and water
483-525	Sand; water
525-540	Shale, blue
540-555	Sand; water
555-565	Shale
565-580	Sand; water
580-585	Shale
585-600	Sand; water
600-602	Rock
602-638	Shale
638-655	Sand
655-675	Shale
675-685	Sand

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City of Bison Well 3
Location: SW¼SE¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.
(see enlarged map, fig. 2)

0- 36	Clay and siltstone, buff to gray; some gray sandstone
36- 44	Sand, well sorted, slightly cemented
44- 52	Clay, very sandy, buff
52- 56	Sandstone, buff

City of Bison Well 3 -- continued.

56-422	Clay, gray, silty, trace sandstone, some free sand
422-434	Shale, gray to greenish-gray, some sandy
434-750	Clay, medium gray to greenish, some free sand

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City of Bison Well 5
Location: SW¼SE¼NW¼NE¼ sec. 13, T. 18 N., R. 13 E.
(see enlarged map, fig. 2)

0- 2	Dirt, black
2- 4	Clay, yellow
4- 10	Shale, broken
10- 16	Clay, sandy, gray
16- 26	Shale, sand and dark
26- 40	Clay, sandy
40- 60	Sand, coarse; shale
60- 68	Shale, gray
68-110	Coal; shale
110-150	Clay, sandy, gray
150-151	Rock
151-230	Shale; sticky, black, clay
230-232	Rock
232-634	Shale, hard gray, some sticky clay, some coal
634-680	Sand, fast drilling
680-700	Shale, sandy; fair shale
700-760	Sand, fair to good
760-780	Sand; rock
780-835	Sand; hard shell

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City of Bison Well 6
Location: NE¼NE¼NE¼SE¼ sec. 13, T. 18 N., R. 13 E.
(see enlarged map, fig. 2)

0- 8	Sand, yellow sand
8- 15	Shale
15- 20	Sand
20- 33	Shale
33- 37	Clay
37- 38	Coal, hard
38- 77	Clay, sand, dark
77- 79	Coal, hard
79-132	Clay, sandy
132-137	Coal, hard
137-158	Clay, sandy
158-160	Rock
160-186	Clay, light, sandy
186-260	Shale

City of Bison Well 6 -- continued.

260-262	Coal, hard
262-293	Clay, sandy
293-295	Coal, hard
295-325	Sand, coarse
325-432	Shale
432-433	Rock, hard
433-784	Sand, coarse, dark, hard, some sandy clay

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City of Bison (test well drilled by Caywood)
Location: NE¼ sec. 13, T. 18 N., R. 13 E.
(not shown on fig. 2)

0- 170	Clay, silty, gray, lignitic; light to greenish-gray
170- 185	Silt, light gray
185- 338	Clay, light gray, silty
338- 399	Siltstone, light greenish-gray
399- 685	Clay, some sandy, gray, specks of organic material
685- 687	Shale, dark gray, lignitic
687- 691	Clay, light gray
691- 882	Sandstone, fine, some clay
882-1082	Clay, dark gray, non-silty

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