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**OPEN-FILE REPORT 71-UR**

**INVESTIGATION OF THE DAKOTA FORMATION  
FOR THE  
LINCOLN COUNTY RURAL WATER SYSTEM**

by

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## INTRODUCTION

At the request of the Lincoln County Rural Water System, the South Dakota Geological Survey investigated a small part of the Dakota Formation in Lincoln County in 1988. Information generated from that investigation was presented orally and in printed form to the manager and board of directors of the rural water system on March 9, 1989, in Harrisburg, South Dakota, at the rural water office. The investigation was financed by the Department of Environment and Natural Resources through the South Dakota Geological Survey and by the Lincoln County Rural Water System.

## PURPOSE

The purpose of the investigation was to examine the thickness and water quality of the Dakota Formation in a part of Lincoln County, South Dakota. The rural water system wanted the information as part of their effort to examine options to augment their Big Sioux aquifer water sources

## STUDY AREA

The small area chosen for study was near where the Dakota Formation was reported to be in excess of 300 feet thick (NW $\frac{1}{4}$  NW $\frac{1}{4}$  NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec. 21, T. 99 N., R. 49 W.) and where the water quality was expected to be generally good.

## RESULTS

### Geology

Three test holes ranging in depth from 527 to 735 feet were drilled and two test holes were completed as monitoring wells. The locations of these test holes and wells are shown on figure 1 and the lithologic logs are presented in appendix A. The total thickness of the Dakota Formation in these three holes ranged from 97 to 234 feet. However, claystone (nonaquifer material) was found to be present throughout much of the formation thickness (fig. 2). The sandstone identified at the bottom of the cross section in figure 2 was found to be cemented and very hard. This sandstone is postulated to be Paleozoic in age. Available information indicates that if the sandstone is present, its areal extent is very limited in this locality.

### Ground Water

Seven water samples were collected from the Dakota Formation (fig. 3) and were analyzed for general inorganic content (table 1). One private well and six monitoring wells were sampled.

Water along the northern edge of the Dakota Formation in Lincoln County is known to be of generally poor quality. Samples LCR-88-004 and -005 represent water collected from the northernmost

extent of the Dakota Formation and results of analyses bear out the presumption of generally poor quality water along the northern edge of the formation.

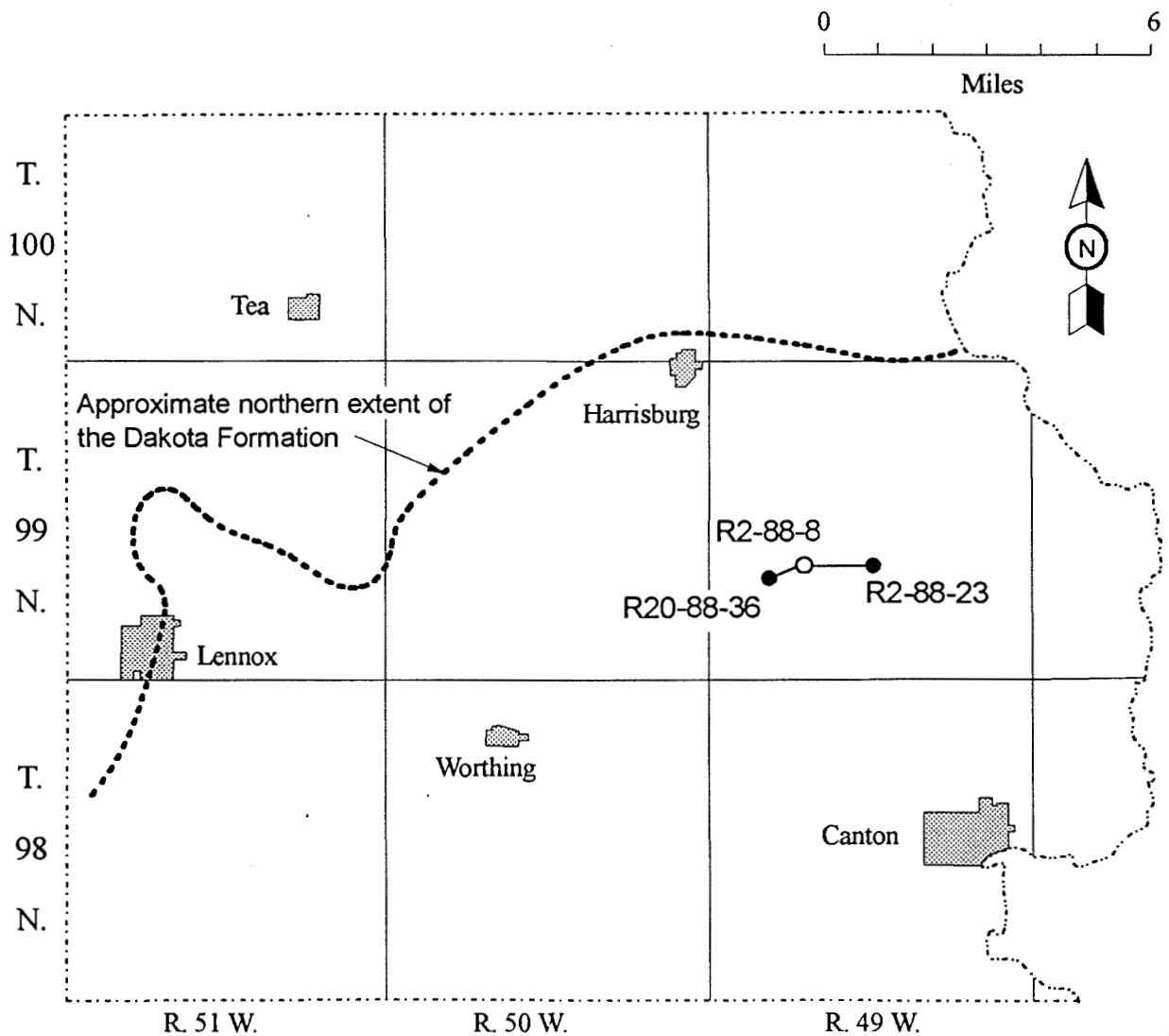
Samples LCR-88-001 and -002 were collected from the two monitoring wells installed for this project and sample LCR-88-003 was collected from a previously existing monitoring well. Sample LCR-88-006 was collected from a private well. Table 2 presents a comparison of the average water quality from these four wells (nearest to the rural water system's area of interest) with water distributed by the Lincoln County Rural Water System in 1986. The comparison shows that water from the Dakota Formation (excluding the two samples from the northern edge of the Dakota Formation and the farthest east sample) has slightly higher concentrations of chemicals than the water distributed by the rural water system in 1986. The elevated iron concentration in the private well (sample LCR-88-006) is probably indicative of a problem in that particular well rather than the natural iron concentration in the Dakota Formation.

## RECOMMENDATIONS

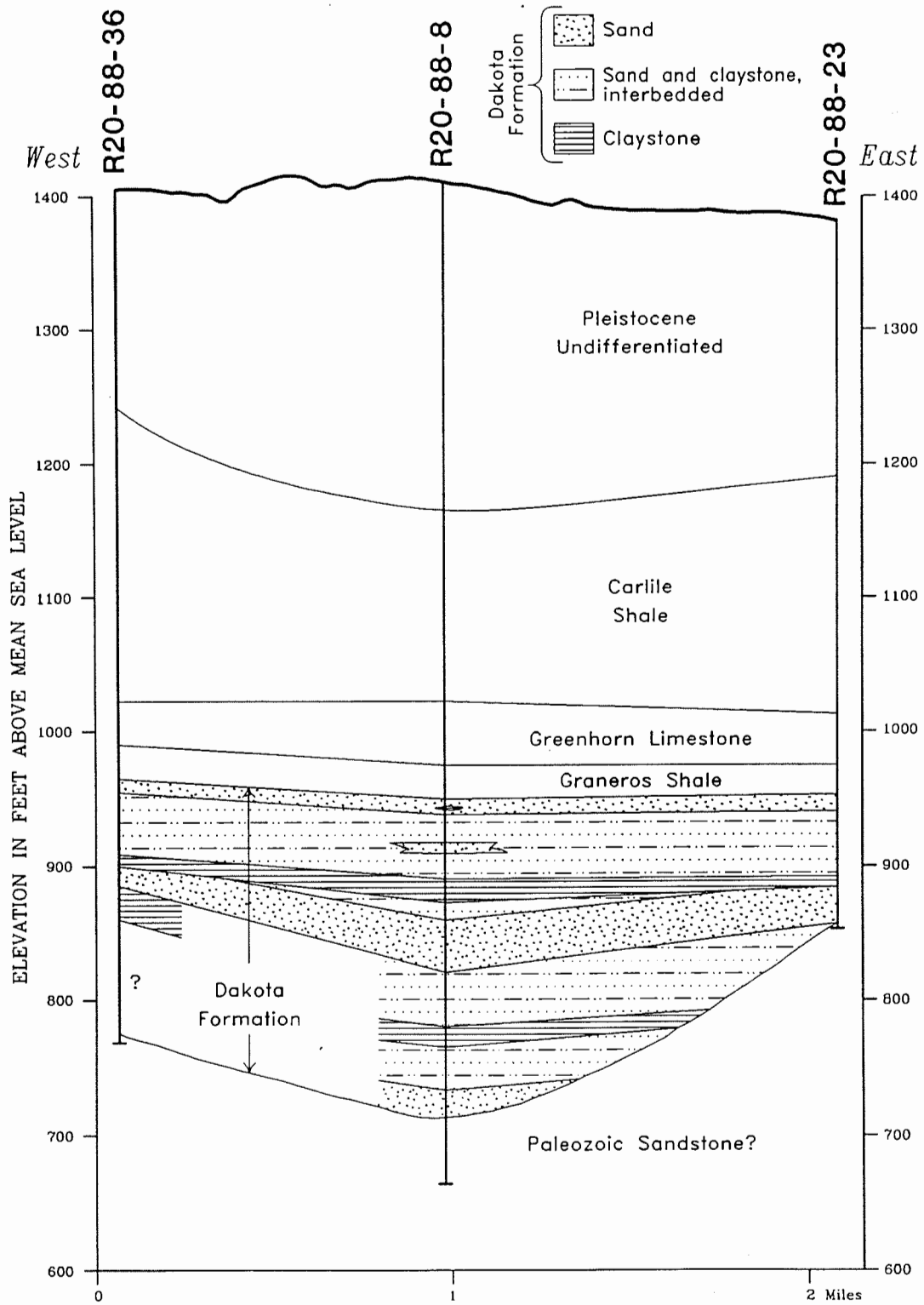
No examination of the water yielding potential of the Dakota Formation was made for this investigation. However, the cities of Canton and Worthing have production wells in the Dakota Formation capable of meeting their water supply needs. Also, the South Lincoln Rural Water System has large capacity production wells in the Dakota Formation in the area 2 to 6 miles south of Worthing. If the Lincoln County Rural Water System decides to develop a well field in the Dakota Formation, it is recommended that additional testing be conducted south of the test holes drilled for this investigation where the aquifer is likely thicker and the water quality may be better.

# Figure 1. Locations of test hole and monitoring wells.

- R2-88-8 ○ Test hole. Letter and numbers are the test hole identifier.
- R20-88-36 ● Monitoring well. Letter and numbers are the well identifier.
- Line of cross section shown on figure 2.



# Figure 2. Cross section.



# Figure 3. Locations of water samples.

LCR-88-003 ● Water sample collection point. Letters and numbers are the water sample number.

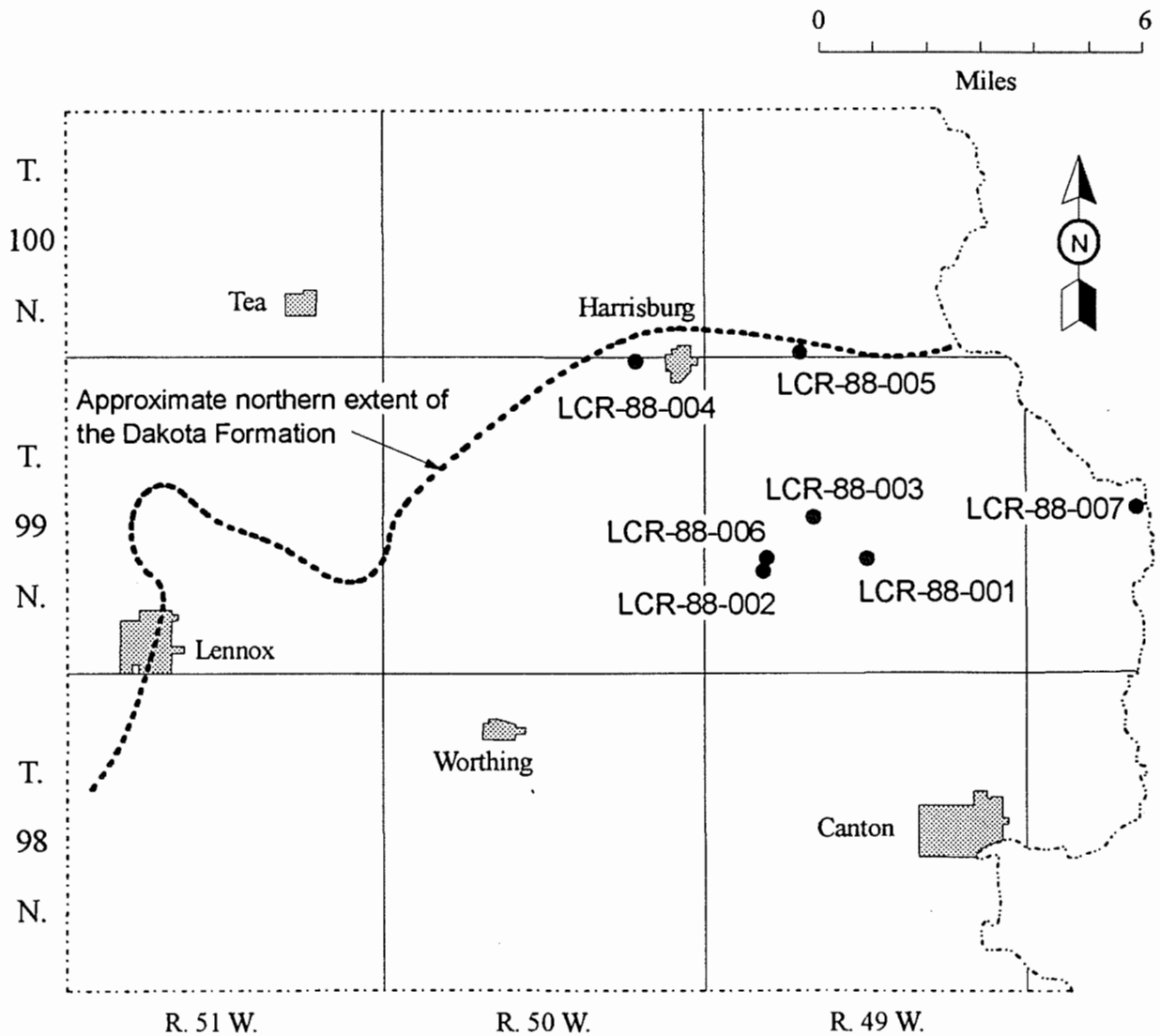


Table 1. Chemical analyses of water samples.

Water sample number	Well identifier	Date of collection	Well depth (feet)	Conductivity <sup>2</sup>	Parameters <sup>1</sup> and concentrations in milligrams per liter														
					TDS	Hardness	Alk T	HCO <sub>3</sub>	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO <sub>3</sub> -N	SO <sub>4</sub>	
Standards	--	--	--	--	500 <sup>3</sup>	--	--	250 <sup>3</sup>	4.0 <sup>4</sup>	0.30 <sup>3</sup>	--	--	--	--	--	0.05 <sup>3</sup>	--	10.0 <sup>4</sup>	250 <sup>3</sup>
LCR-88-001	R2-88-23	10/27/88	506	847	510	271	298	363	69	7	0.81	19.9	24	<0.05	<0.05	<0.05	79	<0.04	152
LCR-88-002	R20-88-36	11/08/88	627	987	640	284	247	301	76	31	1.34	20.7	23	<0.05	<0.05	0.1	98	<0.04	226
LCR-88-003	LN-80F	11/09/88	707	1273	930	599	345	421	159	12	0.73	9.5	49	0.21	0.26	0.26	61	<0.04	353
LCR-88-004	LN-79I	11/09/88	349	3302	2884	1873	627	764	473	7	0.22	12.1	168	0.08	0.27	0.27	170	<0.04	1540
LCR-88-005	LN-81K	11/10/88	543	2176	1803	1125	380	463	274	22	0.49	14.3	107	0.55	0.55	0.55	117	<0.04	972
LCR-88-006	O. Larson	11/10/88	465	793	530	236	233	284	60	5	1.07	19.9	21	1.89	1.89	<0.05	79	<0.04	182
LCR-88-007	LN-80H	11/10/88	387	960	634	437	322	393	104	31	0.35	10.2	43	<0.05	<0.05	0.05	44	0.05	169

<sup>1</sup>TDS - total dissolved solids; **Hardness** - hardness as CaCO<sub>3</sub>; **Alk T** - total alkalinity; **HCO<sub>3</sub>** - bicarbonate; **Ca** - calcium; **Cl** - chloride; **F** - fluoride; **Fe** - iron; **K** - potassium; **Mg** - magnesium; **Mn** - manganese; **Na** - sodium; **NO<sub>3</sub>-N** - nitrate as nitrogen; **SO<sub>4</sub>** - sulfate

<sup>2</sup>Conductivity is presented in micromhos per centimeter

<sup>3</sup>U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories"; November 1994 (Secondary maximum contaminant level. Recommended limit.)

<sup>4</sup>U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories"; November 1994 (Maximum contaminant level. Enforceable limit.)



Table 2. Comparison of water quality between selected Dakota Formation wells and the Lincoln County Rural Water System.

Water sample number	Well identifier	Date of collection	Well depth (feet)	Conductivity <sup>2</sup>	Parameters <sup>1</sup> and concentrations in milligrams per liter													
					TDS	Hardness	Alk T	HCO <sub>3</sub>	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO <sub>3</sub> -N	SO <sub>4</sub>
Standards	--	--	--	--	500 <sup>3</sup>	--	--	250 <sup>3</sup>	4.0 <sup>4</sup>	0.30 <sup>3</sup>	--	--	--	0.05 <sup>3</sup>	--	10.0 <sup>4</sup>	250 <sup>3</sup>	
LCR-88-001	R2-88-23	10/27/88	506	847	510	271	298	363	69	7	0.81	<0.05	19.9	<0.05	24	79	<0.04	152
LCR-88-002	R20-88-36	11/08/88	627	987	640	284	247	301	76	31	1.34	<0.05	20.7	<0.05	23	98	<0.04	226
LCR-88-003	LN-80F	11/09/88	707	1273	930	599	345	421	159	12	0.73	0.21	9.5	0.26	49	61	<0.04	353
LCR-88-006	O. Larson	11/10/88	465	793	530	236	233	284	60	5	1.07	1.89	19.9	<0.05	21	79	<0.04	182
Average of Dakota Formation wells					975	348	281	342	91	14	0.99	--	17.5	29	79	--	228	
Lincoln County Rural Water System <sup>5</sup>					673	274	72	87.8	57.2	27.8	0.74	0.33	4.9	31.9	0.01	19.9	0.6	226

<sup>1</sup> TDS - total dissolved solids; Hardness - hardness as CaCO<sub>3</sub>; Alk T - total alkalinity; HCO<sub>3</sub> - bicarbonate; Ca - calcium; Cl - chloride; F - fluoride; Fe - iron; K - potassium; Mg - magnesium; Mn - manganese; Na - sodium; NO<sub>3</sub>-N - nitrate as nitrogen; SO<sub>4</sub> - sulfate

<sup>2</sup> Conductivity is presented in micromhos per centimeter

<sup>3</sup> U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Secondary maximum contaminant level. Recommended limit.)

<sup>4</sup> U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Maximum contaminant level. Enforceable limit.)

<sup>5</sup> The data for the Lincoln County Rural Water System are from a sample collected on 4/17/86. The rural water system's water source at this time was the Big Sioux aquifer

## APPENDIX A

### Logs of test holes and monitoring wells

#### LEGAL LOCATION and LOCATION

The logs are listed by smallest township number, then the smallest range number, the smallest section number, and then by quarter section: NE = A; NW = B; SW = C; SE = D. A comparison of a **LEGAL LOCATION** and a **LOCATION** is as follows. A **LEGAL LOCATION** of NW SE NE SW sec. 08, T. 106 N., R. 52 W. is the same as a **LOCATION** of 106N-52W-08CADB.

#### LATITUDE and LONGITUDE

The format is **DD.MMSS** where **D** is degrees, **M** is minutes, and **S** is seconds.

#### DRILLING COMPANY

**SDGS** is an abbreviation for South Dakota Geological Survey.

#### TOTAL DRILL HOLE DEPTH, SCREEN LENGTH, and TOTAL CASING AND SCREEN

The numbers are presented in feet.

#### CASING STICK-UP

The number is presented in feet above ground surface.

#### SCREEN TYPE and CASING TYPE

**PVC** is an abbreviation for polyvinyl chloride. **MFG.** is an abbreviation for manufactured and indicates a product that is commercially available. **SCH.** is an abbreviation for schedule which refers to the thickness of the casing wall. **SLOT** is the size, in inches, of the openings on the screen.

#### GROUND SURFACE ELEVATION

The number is presented in feet above mean sea level. **T** - the elevation was estimated using a 7.5 minute series topographic map.

#### CASING DIAMETER

The number is presented in inches.

County: LINCOLN  
 Drill Site: 1  
 Legal Location: SW SE SE SE sec. 20, T. 099 N., R. 49 W.  
 Latitude: 43.2225  
 Land Owner:  
 Project: LINCOLN COUNTY RWS  
 Drilling Company: SDGS  
 Driller: T. MCCUE  
 Geologist: D. ILES  
 Date Drilled: 05-31-1988  
 Ground Surface Elevation: 1413.00 T  
 Total Drill Hole Depth: 735.0  
 USGS Hydrological Unit Code: 10170203  
 Electric Log Information:  
 Spontaneous Potential:  
 Natural Gamma: X  
 Samples:

Location: 099N-49W-20DDDC

Longitude: 96.3858

Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY

Test Hole Number: R2-88-8

Single Point Resistivity: X  
 Extra:

0	-	10	Clay, light-yellowish-brown, very silty and sandy; calcareous specks
10	-	13	Sand, light-brown, fine to medium, silty; calcareous
13	-	22	Silt, light-brown, very sandy; calcareous
22	-	28	Clay, gray to dark-gray, pebbly, sandy, silty; some selenite crystals; several chalk and shale pebbles; calcareous (till)
28	-	64	Clay, gray, pebbly, sandy, silty; calcareous (till)
64	-	67	Silt, light-yellowish-brown, very sandy; calcareous
67	-	69	Sand, yellowish-brown, fine; calcareous
69	-	82	Clay, yellowish-brown to gray, sandy, silty, pebbly; calcareous (till)
82	-	99	Sand, light-brown, medium to coarse, moderately well-rounded, primarily quartz; some fine pebble gravel; some shale and chalk clasts
99	-	108	Clay, dark-gray grading to light-gray, sandy; slightly calcareous
108	-	154	Silt, light-gray to light-olive, sandy; slightly calcareous; clayey lenses from 108 to 121 feet
154	-	167	Silt, light-gray-brown, very sandy, clayey; noncalcareous
167	-	246	Clay, gray, sandy, pebbly, silty, shaley from 185 to 246 feet (till)
246	-	322	Claystone, gray; slightly fissile; noncalcareous (Carlile Shale)
322	-	388	Claystone, gray, silty(?); more fissile than interval from 246 to 322 feet; noncalcareous (Carlile Shale)
388	-	435	Claystone, light-gray, slightly silty; slightly fissile; abundant small white calcareous specks (Greenhorn Limestone)
435	-	461	Shale, gray; slightly calcareous (Graneros Shale)
461	-	466	Sand, fine (Dakota Formation)
466	-	468	Claystone, gray (Dakota Formation)
468	-	472	Sand, fine (Dakota Formation)
472	-	493	Sand, fine; with some interbedded gray claystone (Dakota Formation)
493	-	502	Sand, fine (Dakota Formation)
502	-	520	Sand, fine; with some interbedded gray claystone (Dakota Formation)
520	-	537	Claystone, gray (Dakota Formation)
537	-	552	Claystone, gray; with interbedded fine sand (Dakota Formation)
552	-	590	Sand, fine; with some gray claystone (Dakota Formation)
590	-	630	Sand, fine; with some gray claystone; grading downward to a gray claystone with some sand (Dakota Formation)
630	-	645	Claystone, gray (Dakota Formation)
645	-	676	Sand, fine; interbedded with gray claystone (Dakota Formation)
676	-	695	Sand, fine(?) (Dakota Formation)

695 - 735 Sandstone, fine to medium; cemented; noncalcareous

Lithologic interpretations below 461 feet are based primarily on the electric log.

County: LINCOLN	Location: 099N-49W-22CCCC
Drill Site: 2	
Legal Location: SW SW SW SW sec. 22, T. 099 N., R. 49 W.	
Latitude: 43.2226	Longitude: 96.3741
Land Owner:	
Project: LINCOLN COUNTY RWS	
Drilling Company: SDGS	
Driller: T. MCCUE	Driller's Log:
Geologist: D. ILES	Geologist's Log: X
Date Drilled: 08-16-1988	Drilling Method: ROTARY
Ground Surface Elevation: 1386.00 T	
Total Drill Hole Depth: 527.0	Test Hole Number: R2-88-23
Water Rights Well:	SDGS Well Name: R2-88-23
Other Well Name:	
Basin: BIG SIOUX	Aquifer: DAKOTA
Management Unit:	
Screen Type: PVC, SCH. 80, MFG., 0.020 SLOT	Screen Length: 10.0
Casing Type: PVC, SCH. 80	Casing Diameter: 2.0
Casing Top Elevation:	
Casing Stick-up: 4.00	Total Casing and Screen: 525.0
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity: X
Natural Gamma: X	Extra:
Samples:	

Total casing and screen includes 15 feet of blank casing below the screen. the screen is from 496 to 506 feet and is not open to the blank casing below it. filter pack from approximately 465 to 520 feet.

0 - 10	Clay, light-yellowish-brown, silty, sandy, pebbly; calcareous (till)
10 - 14	Clay, gray, silty, sandy, pebbly; calcareous (till)
14 - 25	Clay, light-yellowish-brown to light-olive-brown, silty, sandy, pebbly; calcareous (till)
25 - 40	Clay, light-gray, silty, sandy, pebbly; calcareous (till)
40 - 56	Clay, light-gray, silty, sandy, pebbly; interbedded with sand and gravel; calcareous (till)
56 - 61	Clay, yellowish-brown, silty, sandy, pebbly; calcareous (till)
61 - 72	Sand and gravel, medium sand to medium pebble gravel
72 - 96	Clay, light-gray, silty, sandy, pebbly; calcareous (till)
96 - 122	Silt, pinkish-brown, clayey(?); slightly calcareous
122 - 140	Gravel and sand, fine sand to medium pebble gravel; oxidized
140 - 159	Silt, light-gray-green; calcareous
159 - 166	Clay, dark-gray, silty; noncalcareous to slightly calcareous
166 - 189	Clay, gray, silty; with chunks of brown to reddish-brown sandstone(?)
189 - 290	Claystone, gray; noncalcareous (Carlile Shale)
290 - 368	Claystone, gray; slightly calcareous (Carlile Shale)
368 - 406	Claystone, gray, silty; calcareous (Greenhorn Limestone)
406 - 428	Shale, gray; calcareous (Graneros Shale)
428 - 432	Sand and claystone, gray claystone, fine sand (Dakota Formation)
432 - 440	Sand, fine (Dakota Formation)
440 - 488	Sand, fine; with some interbedded gray claystone (Dakota Formation)

488 - 496 Claystone, gray (Dakota Formation)  
 496 - 525 Sand, fine; with some gray claystone (Dakota Formation)  
 525 - 527 Sandstone, white, fine; cemented, hard

Lithologic interpretations below 428 feet are based primarily on the electric log.

County: LINCOLN	Location: 099N-49W-29BBBB
Drill Site: 3	
Legal Location: NW NW NW NW sec. 29, T. 099 N., R. 49 W.	
Latitude: 43.2224	Longitude: 96.4005
Land Owner:	
Project: LINCOLN COUNTY RWS	
Drilling Company: SDGS	
Driller: G. JENSEN	Driller's Log:
Geologist: D. ILES	Geologist's Log: X
Date Drilled: 08-08-1988	Drilling Method: ROTARY
Ground Surface Elevation: 1407.00 T	
Total Drill Hole Depth: 638.0	Test Hole Number: R20-88-36
Water Rights Well:	SDGS Well Name: R20-88-36
Other Well Name:	
Basin: BIG SIOUX	Aquifer: DAKOTA
Management Unit:	
Screen Type: PVC, SCH. 80, MFG., 0.025 SLOT	Screen Length: 10.0
Casing Type: PVC, SCH. 80	Casing Diameter: 2.0
Casing Top Elevation:	
Casing Stick-up: 2.00	Total Casing and Screen: 629.0
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma: X	Extra:
Samples:	

Filter pack from approximately 560 to 627 feet.

0 - 2	Topsoil
2 - 16	Clay, brown, silty, sandy, pebbly (till)
16 - 39	Clay, gray, silty, sandy, pebbly (till)
39 - 41	Sand, medium
41 - 63	Clay, gray, silty, sandy, pebbly (till)
63 - 78	Clay, brown, silty, sandy, pebbly (till)
78 - 83	Sand, fine
83 - 92	Clay, tan, silty, sandy, pebbly (till)
92 - 108	Clay, light-gray
108 - 145	Silt, light-gray
145 - 162	Silt, tan
162 - 170	Clay, gray, silty, sandy, pebbly (till)
170 - 348	Claystone, gray, some brown (Carlile Shale)
348 - 386	Claystone, gray, some brown; slightly calcareous (Carlile Shale)
386 - 417	Claystone, gray; calcareous (Greenhorn Limestone)
417 - 442	Shale, gray (Graneros Shale)
442 - 452	Sand, very fine to fine (Dakota Formation)
452 - 498	Sand, very fine to fine; with interbedded claystone (Dakota Formation)

- 498 - 507 Claystone, gray (Dakota Formation)
- 507 - 522 Sand, very fine to fine; increasing clay content toward bottom (Dakota Formation)
- 522 - 547 Claystone, gray (Dakota Formation)
- 547 - 632 Dakota Formation; specific lithology is unknown because of drilling difficulties and a malfunction in the geophysical logger
- 632 - 638 Sandstone, white; cemented, hard

Lithologic interpretations below 417 feet are based primarily on the electric log.