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OPEN-FILE REPORT 76-UR

**INVESTIGATION OF NITRATE-NITROGEN CONTAMINATION
IN GROUND WATER IN THE VICINITY OF
ALCESTER, SOUTH DAKOTA**

by

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INTRODUCTION

Purpose

This report contains the results of an investigation conducted by the South Dakota Geological Survey for the city of Alcester, South Dakota. The city of Alcester had excessive concentrations of nitrate-nitrogen in the municipal water supply. As a result, the Geological Survey was requested to examine nitrate-nitrogen concentrations in the Alcester area and to assess potential sources of water for the city. The study was financed by the city of Alcester, the East Dakota Water Development District, and the state of South Dakota.

Background Information

The city of Alcester is located in Union County in southeastern South Dakota. The U.S. Environmental Protection Agency (EPA) began requiring periodic testing of municipal water supplies in 1977. At least one of the three Alcester city wells had concentrations of nitrate as nitrogen plus nitrite as nitrogen, hereafter referred to in the text of this report as nitrate-nitrogen, greater than 10 milligrams per liter (mg/L) from July 1977 through 1984. Alcester had only two water supply wells in 1977 on the western edge of town. Located approximately 1½ blocks apart in a north-south direction, these two wells are referred to as city wells 1 and 2 (fig. 1). In 1981, the city installed another well, referred to as city well 3, between these two wells (fig. 1).

The three municipal water supply wells are completed in an aquifer consisting predominantly of quartz sand with some feldspars, pyriboles, and olivine, but lacking in carbonates. Because of the predominance of quartz in the sand, the aquifer will be referred to as the quartz sand aquifer in this report.

In July 1977, city wells 1 and 2 contained 13.5 and 6.2 mg/L nitrate-nitrogen, respectively (South Dakota Department of Environment and Natural Resources, unpublished data). The maximum allowable concentration for municipal water supplies is 10 mg/L nitrate-nitrogen. This maximum contaminant level has been set because of the potential toxic effect on infants. High concentrations of nitrate-nitrogen have been associated with methemoglobinemia in infants under 1 year of age (Driscoll, 1986).

METHODS

Drilling

The investigation included the drilling of 40 test holes (fig. 2) to determine the extent and thickness of the quartz sand aquifer in the vicinity of Alcester. Thirty-two test holes were drilled during the months of June and October 1985 using the mud-rotary method. Two test holes were drilled during January and September 1986 using the solid flight auger method. Another six test holes were drilled during October 1986 using the mud-rotary method. Logs of the test holes are provided in appendix A.

Monitoring Wells

Twenty-seven monitoring wells (fig. 2) were installed in test holes which encountered 7 feet or more of aquifer material (quartz sand). These wells were installed for the purpose of gathering water level and water chemistry data. The monitoring wells consist of 2-inch diameter polyvinyl chloride casing and screen. Information on screen length and well depth are provided in appendix A.

Water Samples

Water samples were collected from monitoring wells installed for this investigation. Samples were also collected from selected city and private wells. Sample locations are shown on figure 3. The samples were analyzed at the South Dakota Geological Survey's laboratory in Vermillion, the South Dakota Department of Health in Pierre, and at South Dakota State University in Brookings.

GEOLOGY

Bedrock

The bedrock units underlying the study area are, from oldest to the youngest, Precambrian Sioux Quartzite, Paleozoic dolomite, and four Cretaceous units – Dakota Formation, Graneros Shale, Greenhorn Limestone, and Carlile Shale. The bedrock stratigraphy was not investigated during drilling for this project. Therefore, a detailed discussion of the bedrock will not be presented.

The Dakota Formation occurs at a depth of approximately 375 feet in the study area, is approximately 250 feet thick, and consists of sand and sandstone with interbedded silt and clay layers. The Dakota Formation is specifically mentioned because it is used as an aquifer in the study area.

Three cross sections, whose locations are shown on figure 4, were drawn and illustrate that the Carlile Shale was the first bedrock unit encountered in drilling (figs. 5, 6, and 7). The configuration of the shale's surface in the study area is shown on figure 8.

Quartz Sand

A sand composed primarily of quartz and underlying much of the study area was the focus of this investigation. The mineralogy of the sand matrix is predominantly quartz and feldspar with no carbonates. Grain size ranges from a fine sand to a medium gravel. Silt and clay contents of the sand unit are very minimal and only a few clay layers within the unit were noted during drilling. The sand was found to range up to 51 feet thick (map location [ML] 26, fig. 6) and to lie directly on the Carlile Shale (figs. 5, 6, and 7).

Figure 8 shows a bedrock high to exist just northeast of Alcester with a ridge above 1,300 feet in elevation extending generally to the east and a ridge above 1,290 feet extending to the north. The portion of the sand unit east and north of these bedrock high areas is lacking in pink feldspar that is common throughout the rest of the study area. The sand throughout the study area contains anorthite (sodium rich feldspar) which gives it a green hue.

Till

The majority of the study area is underlain by Illinoian till (Baird, 1957). The Illinoian till, which is older than 23,000 years before present, was deposited by continental glaciation during the Pleistocene Epoch of geologic time (Flint, 1955). Till is a heterogeneous sediment composed primarily of unstratified and unsorted sand, pebbles, and cobbles in a clay and silt matrix with pockets of stratified material. Since the deposition of the Illinoian till, a great deal of erosion has occurred creating relief in excess of 100 feet in the vicinity of Alcester. The till often directly overlies the quartz sand aquifer (figs. 5, 6, and 7) and can be greater than 140 feet thick.

Loess

A layer of pre-Wisconsin age wind blown silt and sand called the Loveland loess (Baird, 1957) covers most of the study area (figs. 5, 6, and 7). Test drilling in the study area showed the loess to range from 0 to 36 feet in thickness. On the west and south edges of Alcester, this loess layer ranges from 13 to 36 feet thick and lies directly over the quartz sand aquifer (ML numbers 23-32; fig. 2, app. A).

HYDROLOGY

Dakota Formation Water Quality

Four water samples from the Dakota aquifer were analyzed for chemical constituents (water samples 50-53, table 1). Two of the four samples (52 and 53) were taken from the same well but on different dates. Splits of water samples 51 and 53 were sent to the South Dakota State Health Laboratory and were analyzed for trace metals and radium 226 and radium 228 (table 2) in addition to the parameters indicated on table 1. The split of sample 51 (from the 630-foot deep well) had a concentration of radium 226 plus 228 that was above the drinking water standard of 5 picoCuries per liter. All three Dakota Formation wells had elevated concentrations of iron and all had concentrations of fluoride that were higher than water collected from other sources (table 1). However, all Dakota Formation wells had concentrations of nitrate-nitrogen far below the maximum contaminant level of 10 mg/L. The concentrations of iron observed in the Dakota Formation wells may be indicative of individual well problems rather than of the natural quality of water in the Dakota Formation. Some averages for concentrations of selected parameters are presented in table 3.

Quartz Sand Aquifer

Water Levels, Saturated Thickness, and Flow Directions

Water levels (figs. 5, 6, and 7) show that the quartz sand aquifer is under confined hydraulic conditions over most of the study area based on water levels measured on January 12, 1987. However, in the southwest corner of the study area at ML 38, 39, and 40 (fig. 2), it was under unconfined conditions even though the aquifer is buried in that locality. One other well (ML 25, fig. 2) within the city limits of Alcester also showed the aquifer to be unconfined where only about 15 feet of loess covers the top of the aquifer (water level was 1.4 feet below the top of the sand).

The saturated thickness of the aquifer is shown in figure 9. Where the aquifer was present, the saturated thickness was found to range from 2 to 55 feet.

Figure 10 shows the potentiometric surface of the quartz sand aquifer. The water levels listed for the individual data points on the figure indicate the elevation of water in wells at those locations on the January 12, 1987. The general directions of ground water movement in the immediate Alcester area are to the northwest, west, and southwest (fig. 10).

Water Quality

GENERAL CHEMISTRY

Water chemistry data was obtained from the analysis of water collected from monitoring wells installed for this project in addition to some private wells and two of the city wells. Results of the analyses are listed in table 1.

The average concentrations for selected parameters in water collected from the quartz sand aquifer are presented in table 3. For the area west and southwest of the bedrock high described earlier (water samples 1-42, table 1, and fig. 3), the averages show a water of relatively good quality. The exception to this is nitrate-nitrogen that will be discussed in the following section of this report. The average water chemistry in the aquifer in the northeast part of the study area (water samples 43-46) is slightly worse than the water quality elsewhere in the aquifer (table 3).

NITRATE-NITROGEN

Some very high nitrate-nitrogen concentrations were present in the southwest portion of Alcester, as high as 140 mg/L (fig. 11). Where more than one sample was available from a given well, only the highest concentrations are shown in figure 11. Some possible sources of elevated nitrate-nitrogen concentrations include the city's sewage system and two fertilizer distributors - Pete's Produce and Alcester Feed and Grain (fig. 1). The city's effluent line from its treatment facility had reportedly deteriorated to the point that significant amounts of fluid may have been allowed to escape into the ground. However, the maximum concentration of nitrate-nitrogen in the sewage was probably only about 35 mg/L.

Elevated concentrations of nitrate-nitrogen also occur south of Alcester but cannot be explained with the available data. Some possible sources for the contamination are septic systems at individual residences and the application of fertilizer to agricultural land. As is commonly the case, nitrate-nitrogen concentrations were found to fluctuate. In June 1985, wells at ML 34 and ML 35 had nitrate-nitrogen concentrations of 13 and 19.8 mg/L, respectively. However, in 1986, the concentrations were 9.5 and 29.1 mg/L, respectively (table 1). The monitoring well network and period of record are not adequate to assess nitrate-nitrogen in the ground water in this area.

Nitrate-nitrogen concentrations also were found to fluctuate in the city wells. Figure 12 shows a period of record from August 1982 through December 1986 for these wells. Of significance is that nitrate-nitrogen concentrations in all three wells were always above the drinking water standard of 10 mg/L. Also, a general trend of increasing concentrations with time is shown in the figure. The city ceased using well 1 in 1984 and ceased using well 3 in 1986.

PESTICIDES

On September 16, 1985, water samples were collected from the well at ML 27 (fig. 2) and from two city wells. The samples were taken to South Dakota State University in Brookings to be tested for pesticides. The city well samples did not contain any pesticides, but the water from the monitoring well was found to contain 1.7 micrograms per liter ($\mu\text{g/L}$) alachlor and 0.31 $\mu\text{g/L}$ atrazine.

The South Dakota Department of Agriculture took soil samples near the monitoring wells at ML 24 and ML 27 (fig. 2) on March 5, 1986. The results showed atrazine in the soil at both locations. At ML 24, the concentration was 33 $\mu\text{g/L}$ and at ML 27, the concentration was 54 $\mu\text{g/L}$.

Water samples were taken from the city water supply by the Office of Water Quality, South Dakota Department of Water and Natural Resources on September 2, 1986, and the results showed 3 $\mu\text{g/L}$ atrazine, 0.05 $\mu\text{g/L}$ alachlor, and 0.06 $\mu\text{g/L}$ metribuzin. Because of the low concentrations of the contaminants, another sample was taken on September 24, 1986, and the results showed 2.7 $\mu\text{g/L}$ atrazine, 0.17 $\mu\text{g/L}$ alachlor, and 0.06 $\mu\text{g/L}$ metribuzin. This confirmed the presence of these chemicals in the city water supply.

CONCLUSIONS AND RECOMMENDATIONS

Nitrate-Nitrogen

Although the quartz sand aquifer is buried and confined throughout most of the study area, there is an area on the west and south edges of Alcester where the aquifer is covered only by a layer of loess. Also, at one monitoring well in this area, the aquifer was found to be under unconfined conditions. This physical setting would allow for the movement of surface sources of nitrate-nitrogen into the quartz sand aquifer.

The pattern of elevated nitrate-nitrogen concentrations in the southwest part of Alcester shown in figure 11 is consistent with the release of nitrate contamination in the vicinity of the two fertilizer distributors and the sewage treatment facility. The general direction of ground water movement is to the northwest through this area according to figure 10. This provides for movement of contaminants in the ground water in that general direction. Also, the city wells that are present in the northwest part of town (fig. 1) would have induced some ground water flow in a northerly direction between the potential contamination sources and the wells when the wells were pumping. This interpretation of ground water flow direction and north-northwesterly contaminant movement in that area is supported by the trends of nitrate-nitrogen in the city wells (fig. 12).

When all three city wells were in operation, the closest well to the two fertilizer distributors and the sewage treatment facility (well 1, fig. 1) nearly always had the highest concentration of nitrate-nitrogen (fig. 12). After well 1 was shut down in April 1984, well 3 became the closest operating well to these potential contaminant sources and showed an increase in nitrate-nitrogen concentrations. This indicates that while well 1 was in operation, it acted to intercept some of the nitrate-nitrogen contamination as the contamination migrated toward the city wells. After well 1 was shut down, well 3 then acted in the same way by intercepting some of the nitrate-nitrogen contamination before the contamination could reach the northernmost city well, well 2. This is demonstrated by the consistently lower nitrate-nitrogen concentrations in well 2 versus well 3 (fig. 12).

The completion date for construction of a new sewage treatment plant was January 1, 1987. Close monitoring of the ground water may have allowed a qualitative assessment of the contribution, if any, of sewage to the nitrate-nitrogen concentrations in the ground water. However, monitoring of this sort did not occur.

Possible Sources for Municipal Water

There are three possible alternate sources of water for the city of Alcester. They are (1) the same quartz sand aquifer in which city wells 1, 2, and 3 were completed, but at some distance from the city where nitrate-nitrogen concentrations are acceptable, (2) the Dakota Formation, which is a deep bedrock aquifer, and (3) a rural water system.

Quartz Sand Aquifer

The most promising area of the quartz sand aquifer in terms of saturated thickness was found to be south and southwest of Alcester (fig. 9). In this area, the saturated thickness appears that it may be satisfactory for the development of a municipal water supply. However, the unexplained presence of elevated nitrate-nitrogen concentrations in the ground water about half a mile south of Alcester combined with the southwesterly ground water flow direction gives rise to a concern. The concern is that even though nitrate-nitrogen concentrations were less than the drinking water standard of 10 mg/L along the western edge of section 33 south of town (fig. 11), concentrations may rise in the future especially with the development of a wellfield in that area which may accelerate the southwesterly movement of ground water from the area of high nitrate-nitrogen concentrations. Therefore, no long-term assurances can be given that nitrate-nitrogen concentrations in the ground water would remain at acceptable levels in this area.

The portion of the aquifer northeast of Alcester has a saturated thickness of up to 25 feet (fig. 9). The area with more than 20 feet of saturated thickness appears to be less extensive than the area of thick aquifer south and southwest of Alcester. Also, the general water quality in the aquifer northeast of town is not as good as elsewhere in the aquifer (table 3). Concentrations of nitrate-nitrogen are, however, acceptable in this part of the aquifer (fig. 11).

Before any decisions are made to establish a wellfield in the quartz sand aquifer, the city should conduct additional work. Additional testing should be conducted to verify the suitability of the aquifer in terms of thickness, water yield, and water quality.

Dakota Formation

Water from the Dakota Formation is different than water from the quartz sand aquifer in which the city wells are completed. Table 3 compares the averages of chemical constituents in water from the quartz sand aquifer with water collected from three wells in the Dakota Formation. The Dakota Formation wells are all within 3 miles of Alcester. Water from the Dakota Formation is softer (has less calcium and magnesium), may have more iron, has more sulfate, has less nitrate-nitrogen, and has more sodium, chloride and fluoride than the portion of the quartz sand aquifer south and west of Alcester. Additionally, one sample collected from the Dakota Formation exceeded the drinking water standard for radium 226 plus radium 228 combined.

The potential of the Dakota Formation in the Alcester area to sustain high yields to municipal production wells is unknown. Further investigation would be necessary by the city of Alcester to determine water quality and water-yielding potential of the Dakota Formation.

Rural Water System

Another possibility for the city of Alcester for a water source is the South Lincoln Rural Water System. Although this rural water system obtains its water from the Dakota Formation, its production wells are located in Lincoln County in an area where the quality of water in the Dakota Formation is very good. The water distributed by the rural water system to its customers is in compliance with all drinking water regulations.




ACTION TAKEN BY THE CITY SUBSEQUENT TO THIS INVESTIGATION

In November 1987, the city of Alcester began receiving its drinking water from the South Lincoln Rural Water System. No further investigation of the quartz sand aquifer or the Dakota Formation was undertaken.

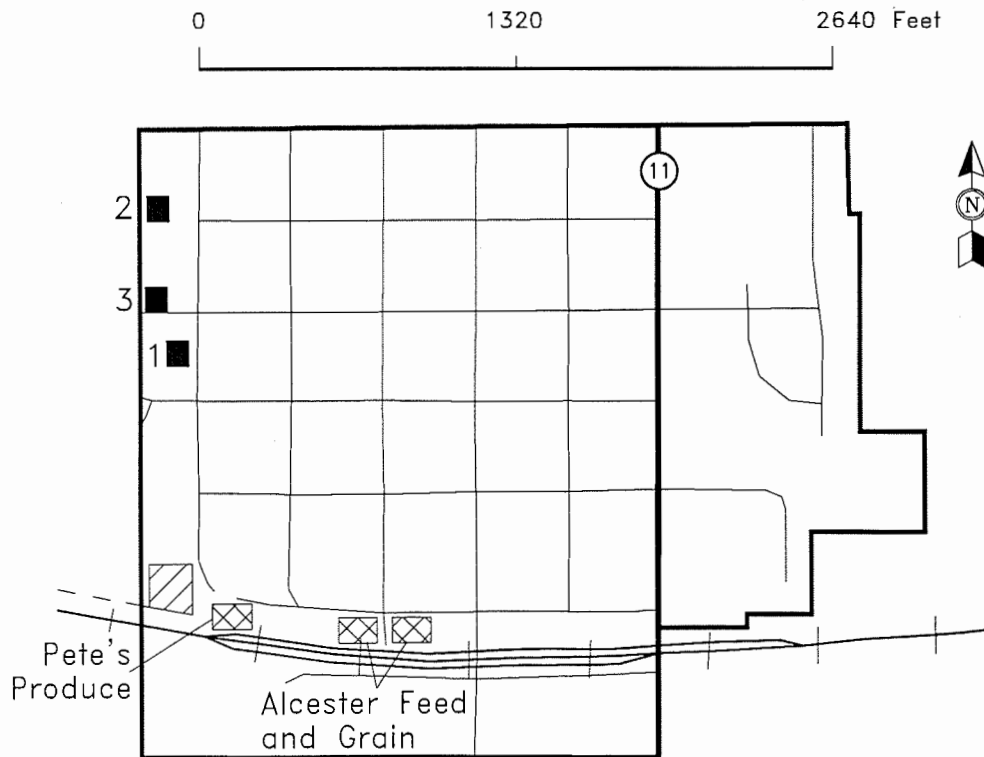
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- Driscoll, F.G., 1986, *Groundwater and wells*: St. Paul, Minnesota, Johnson Division, 2nd edition.
- Flint, R.F., 1955, *Pleistocene geology of eastern South Dakota*: U.S. Geological Survey Professional Paper 262, 173 p.
- U.S. Environmental Protection Agency, November 1994, *Drinking Water Regulations and Health Advisories*.

Figure 1. Locations of city wells, city sewage treatment plant, and fertilizer distributors.

-  City sewage treatment plant and effluent line.
- 2  City well. Number indicates sequence well was drilled.
-  Fertilizer distributors

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.



R. 49 W.

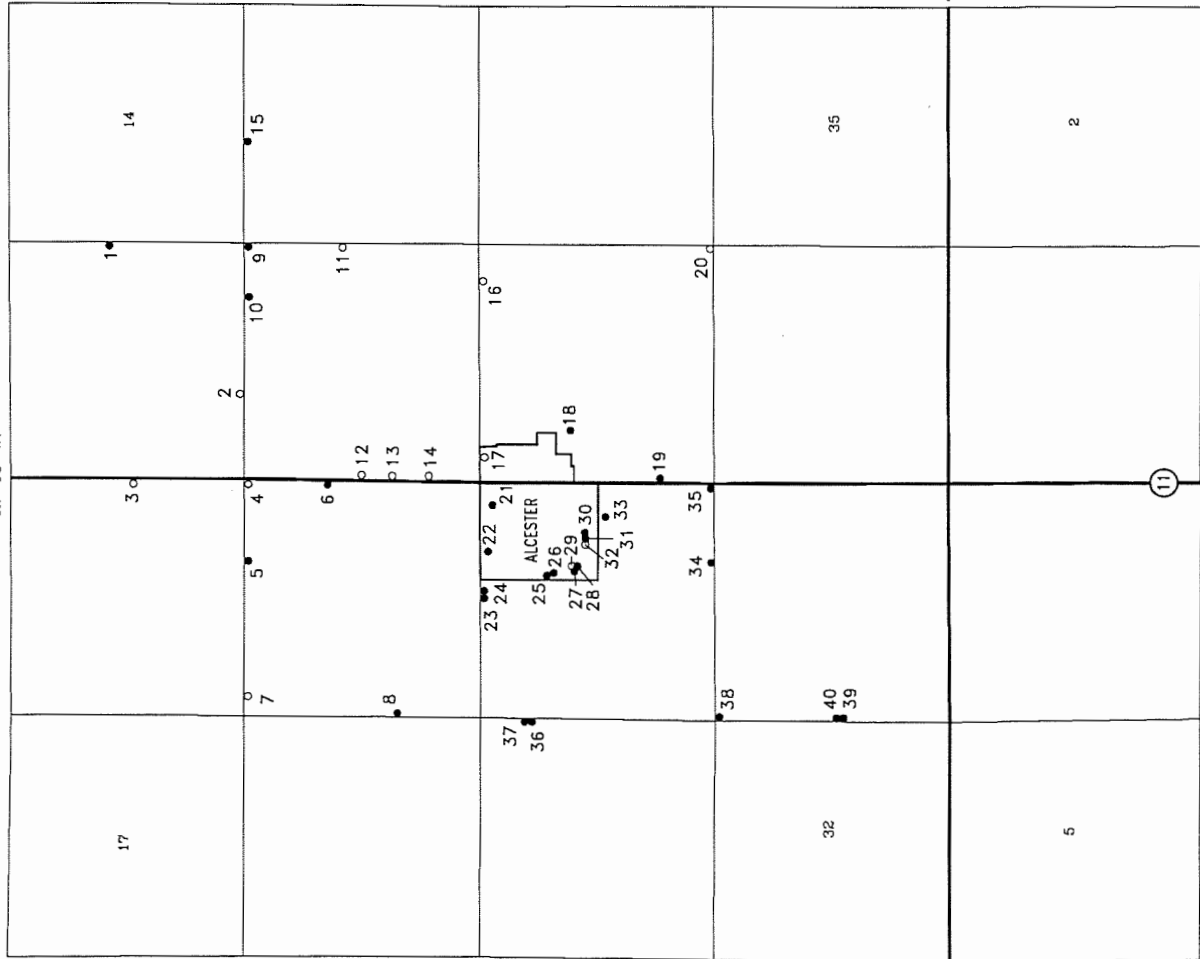
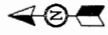


Figure 2. Locations of test holes and monitoring wells drilled for this investigation.

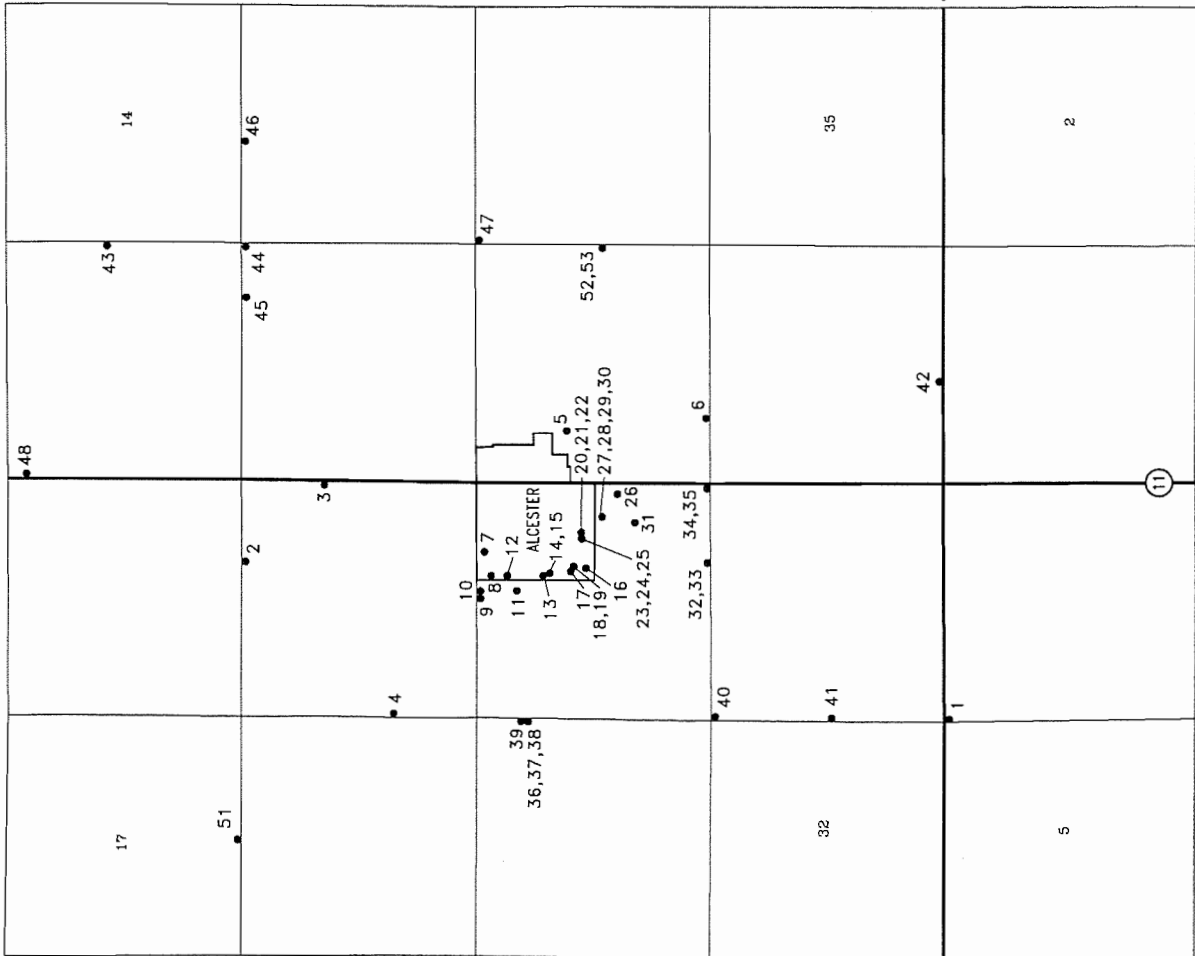
- 15. Monitoring well. } Number indicates map location
- 11o Test hole. } number as listed on lithologic logs in appendix A.

T. 95 N.
T. 94 N.

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.



R. 49 W.



T. 95 N.
T. 94 N.

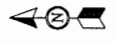


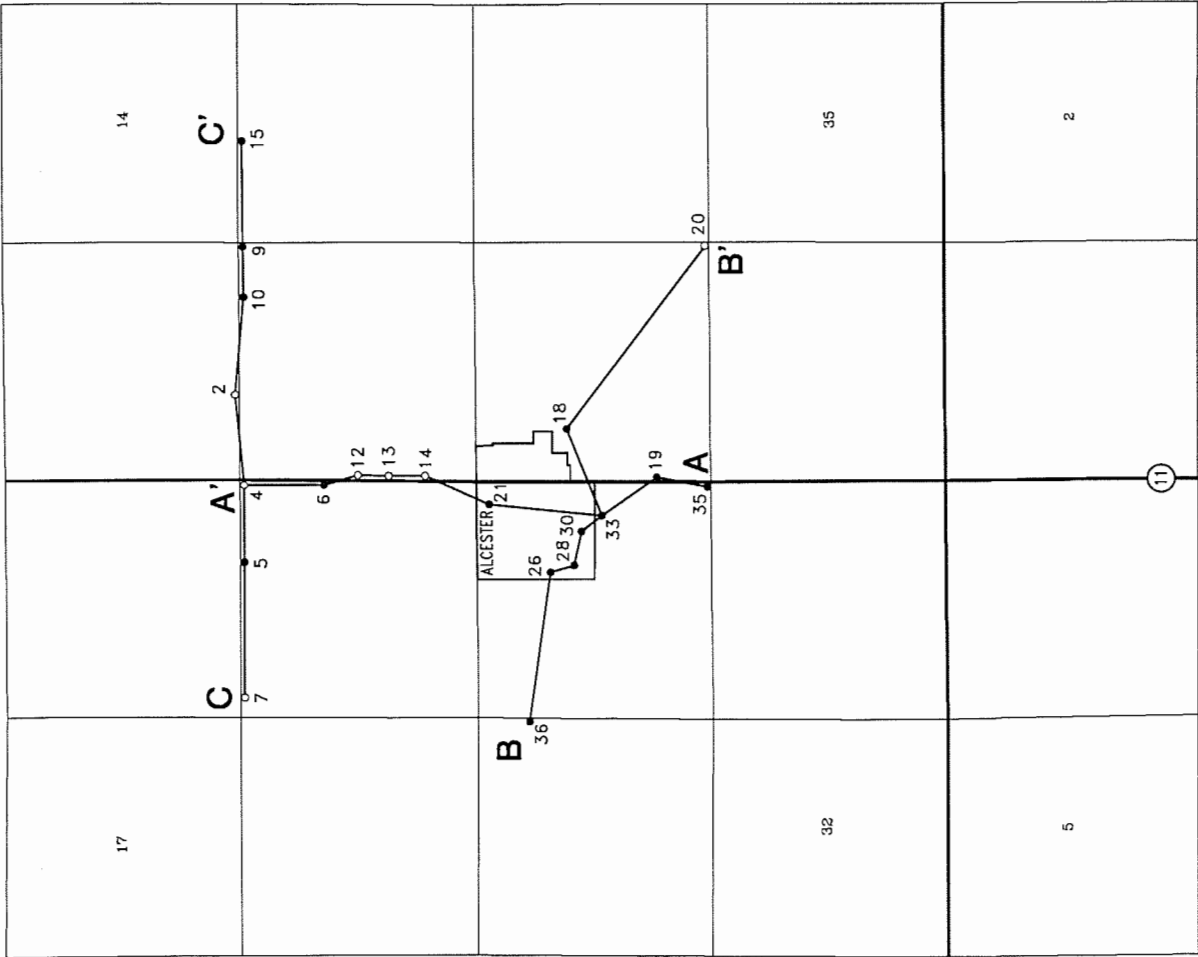
Figure 3. Locations of water samples.

•
46
Water sample location. Number indicates sample number as listed in table 1.

Water samples 49 and 50 not shown. See table 1 for locations.

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.

R. 49 W.



T. 96 N.
T. 94 N.



0 1/2 1 Mile

Figure 4. Locations of cross sections.

- 15. Monitoring well. } Number indicates map location
- 12. Test hole. } number as listed on lithologic logs in appendix A.

C C' Line of cross section. See figures 5, 6, and 7 for cross sections.

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.

Figure 5. Cross section A-A'

See figure 4 for cross section location.

- Qloesi..... Loess - silt
- Qalsi..... Alluvium - silt
- Qals..... Alluvium - sand
- Qalg..... Alluvium - gravel or sand and gravel
- Qit(ox)..... Till - Illinoian, oxidized
- Qit(unox)..... Till - Illinoian, unoxidized
- Qpit(ox)..... Till - pre-Illinoian, oxidized
- Qqs..... Quartz sand
- Qcs..... Clay/silt
- Kc..... Carlisle Shale

--x-- Potentiometric surface of the quartz sand aquifer on 1/12/87.

Map location (ML) numbers are as shown on figure 2 and as listed on lithologic logs in appendix A.

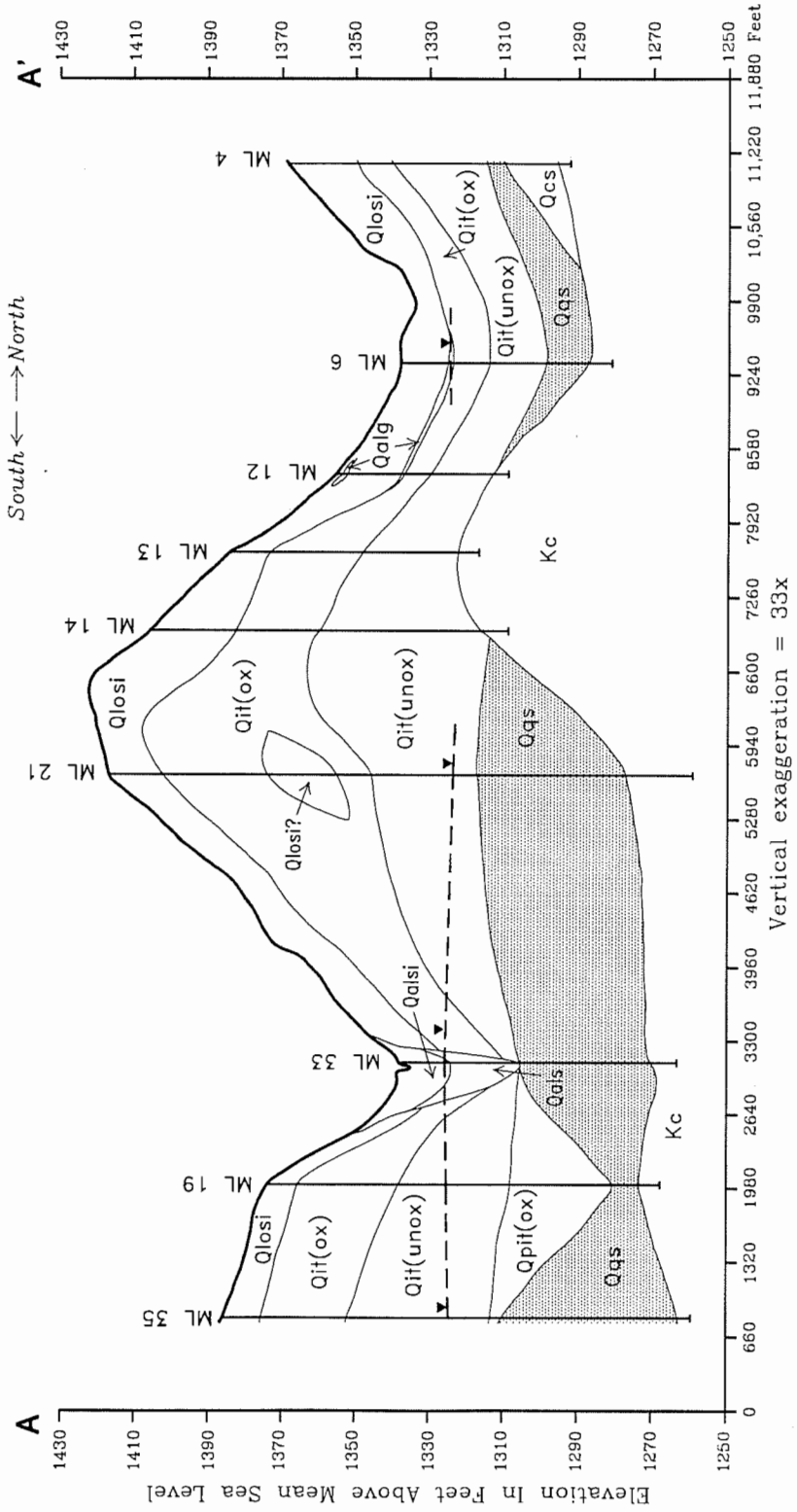


Figure 6. Cross section B-B'.

See figure 4 for cross section location.

- Qlosi..... Loess - silt
 - Qlos..... Loess - sand
 - Qalc..... Alluvium - clay
 - Qalsi..... Alluvium - silt
 - Qals..... Alluvium - sand
 - Qalg..... Alluvium - gravel or sand and gravel
 - Qit(ox)..... Till - illinoian, oxidized
 - Qit(unox)..... Till - illinoian, unoxidized
 - Qqs..... Quartz sand
 - Kc..... Carlile Shale
- ▲-- Potentiometric surface of the quartz sand aquifer on 1/12/87.
- Map location (ML) numbers are as shown on figure 2 and as listed on lithologic logs in appendix A.

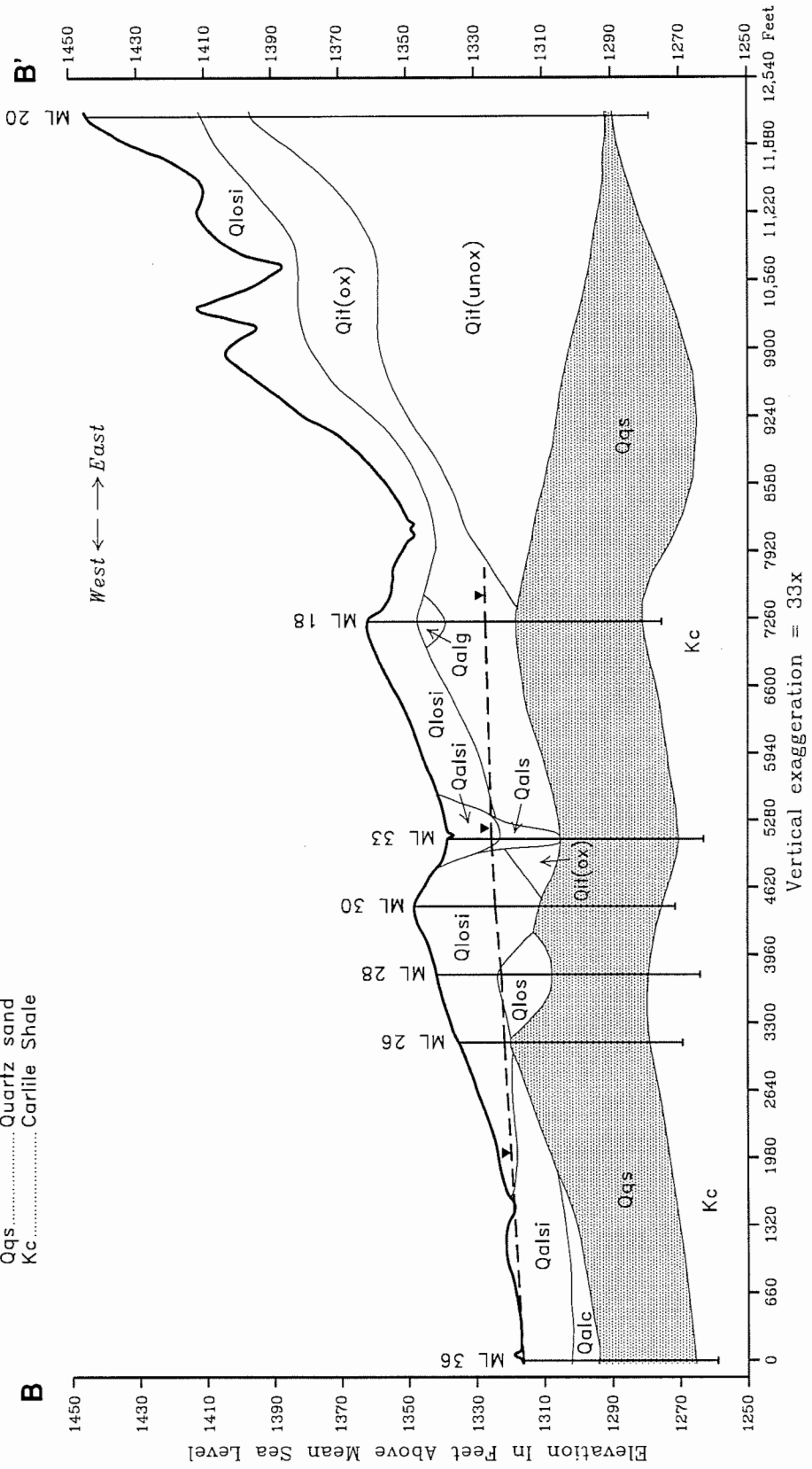
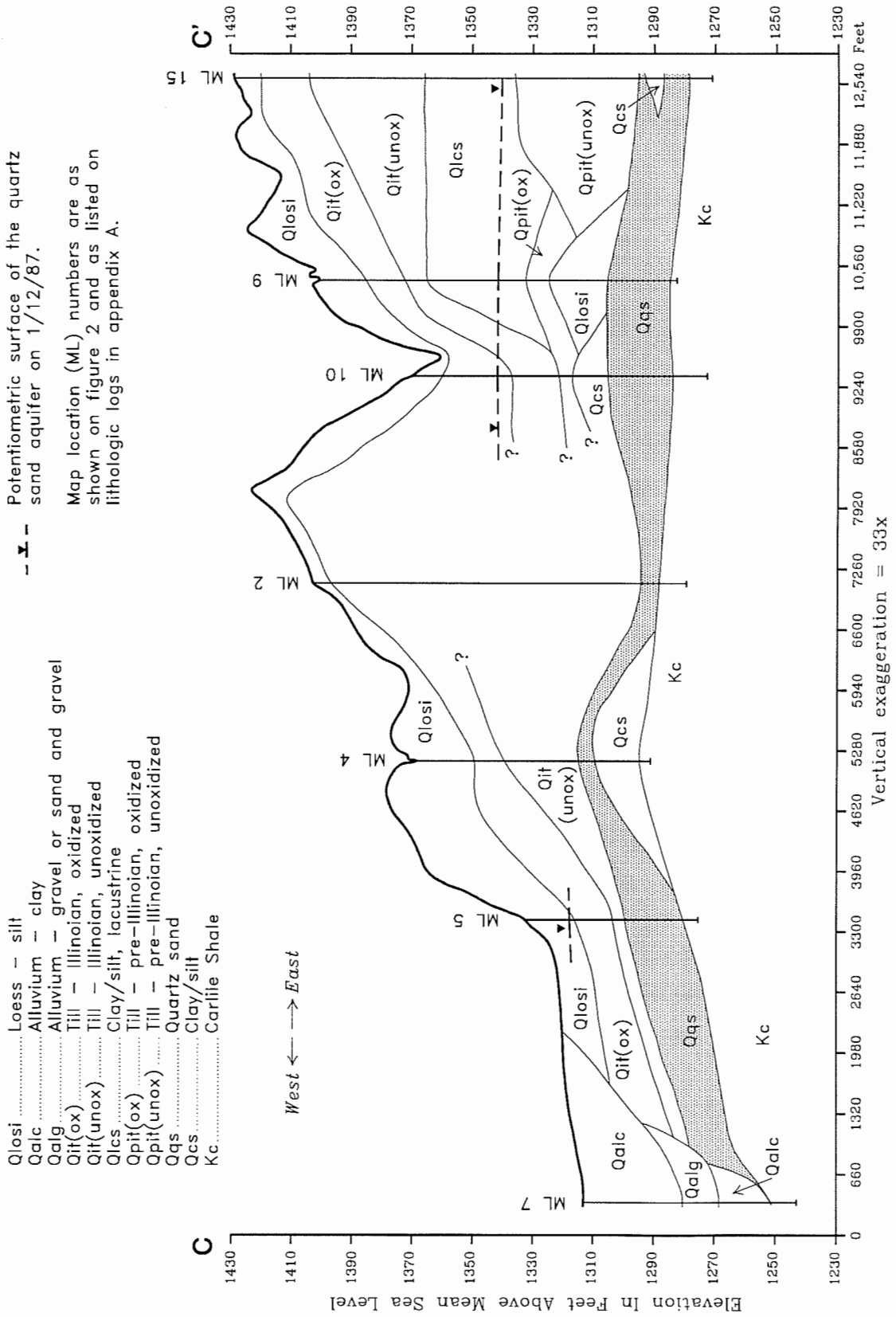
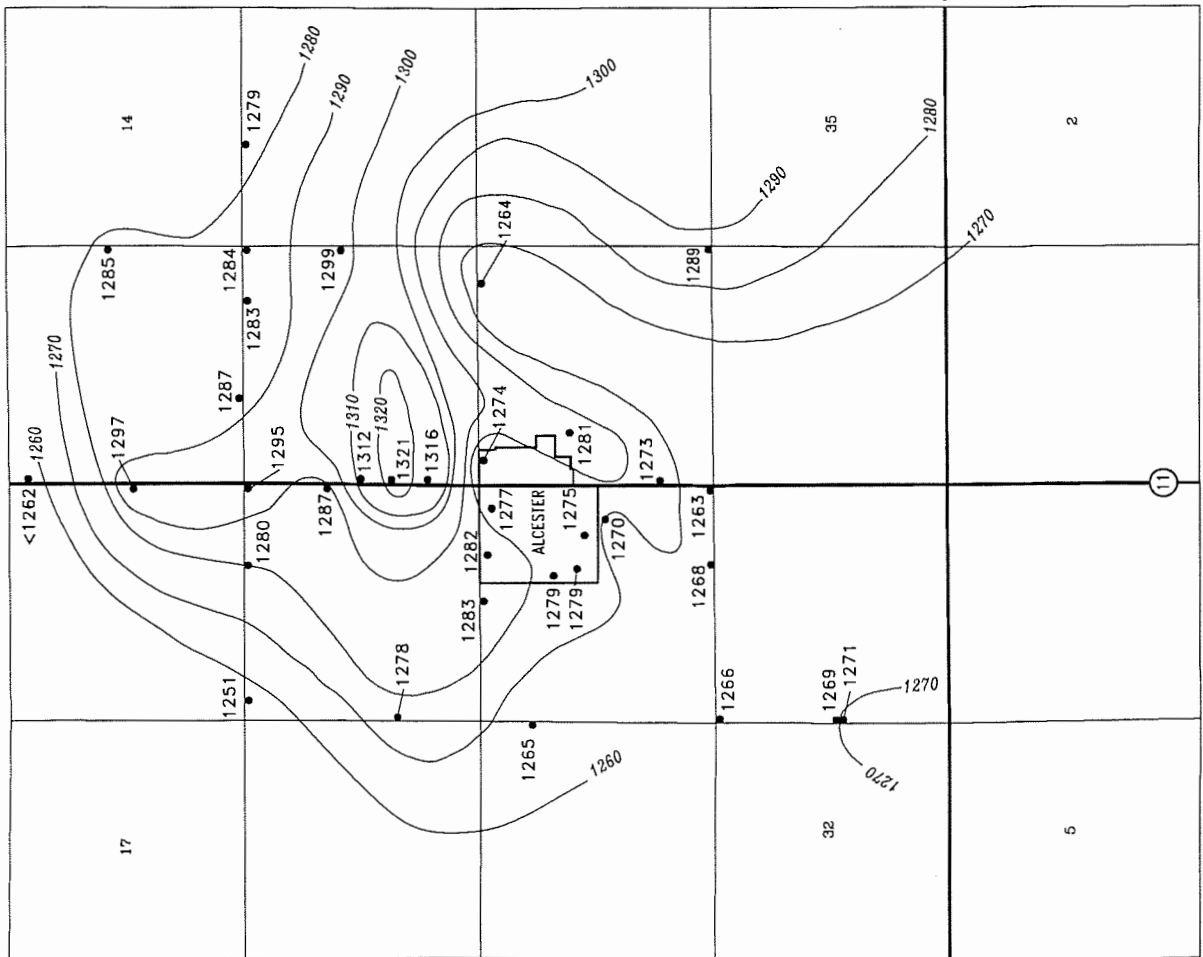


Figure 7. Cross section C-C'

See figure 4 for cross section location.



R. 49 W.



T. 95 N.
T. 94 N.

Figure 8. Configuration of the bedrock (Carlile Shale) surface.

• 1273
Test hole. Number indicates elevation of the bedrock surface in feet above mean sea level.

— 1280
Line connecting points of equal elevation. Contour interval = 10 feet.

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.



0 1/2 1 Mile

R. 49 W.

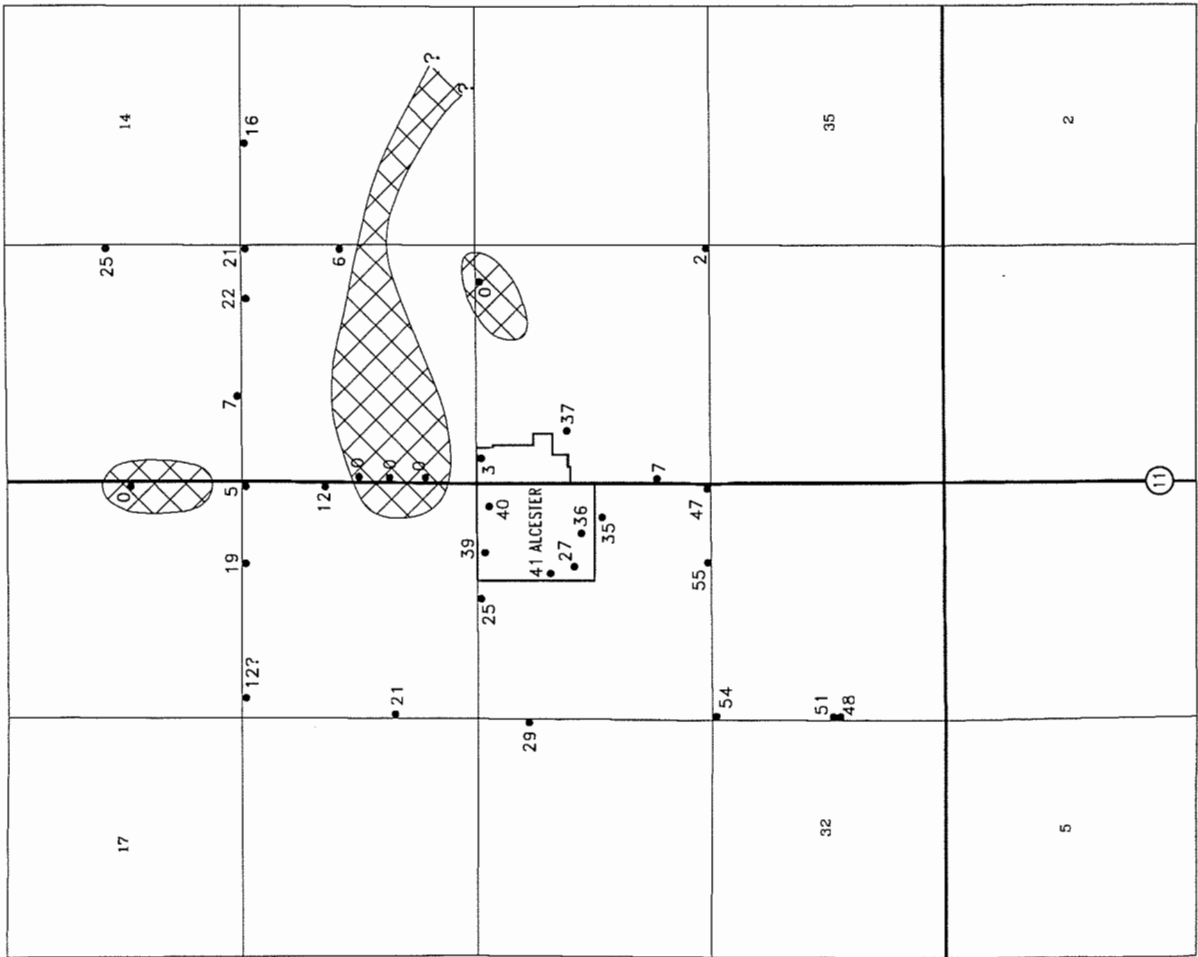


Figure 9. Saturated thickness of the quartz sand aquifer on January 12, 1987.

25 • Monitoring well. Number indicates saturated thickness in feet.

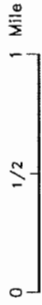


Aquifer absent.

T. 95 N.
T. 94 N.



Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.



R. 49 W.

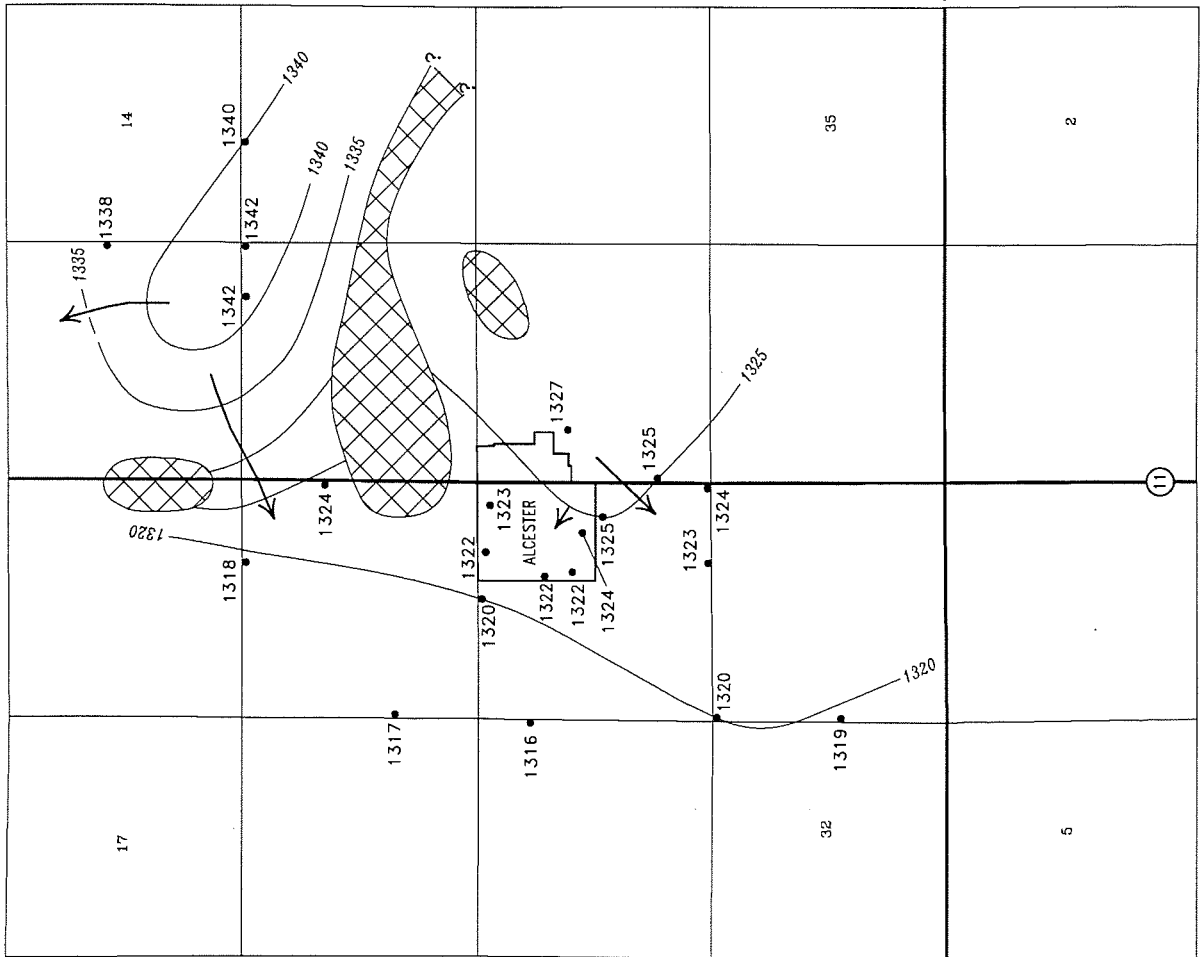


Figure 10. Potentiometric surface of the quartz sand aquifer on January 12, 1987.

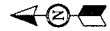
1319 ●
Monitoring well. Number indicates water level in feet above mean sea level.

1325 —
Line connecting points of equal elevation. Dashed where approximate. Contour interval = 5 feet.

↙
Ground water flow direction.

▨
Aquifer absent.

T. 95 N.
T. 94 N.



Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.

R. 49 W.

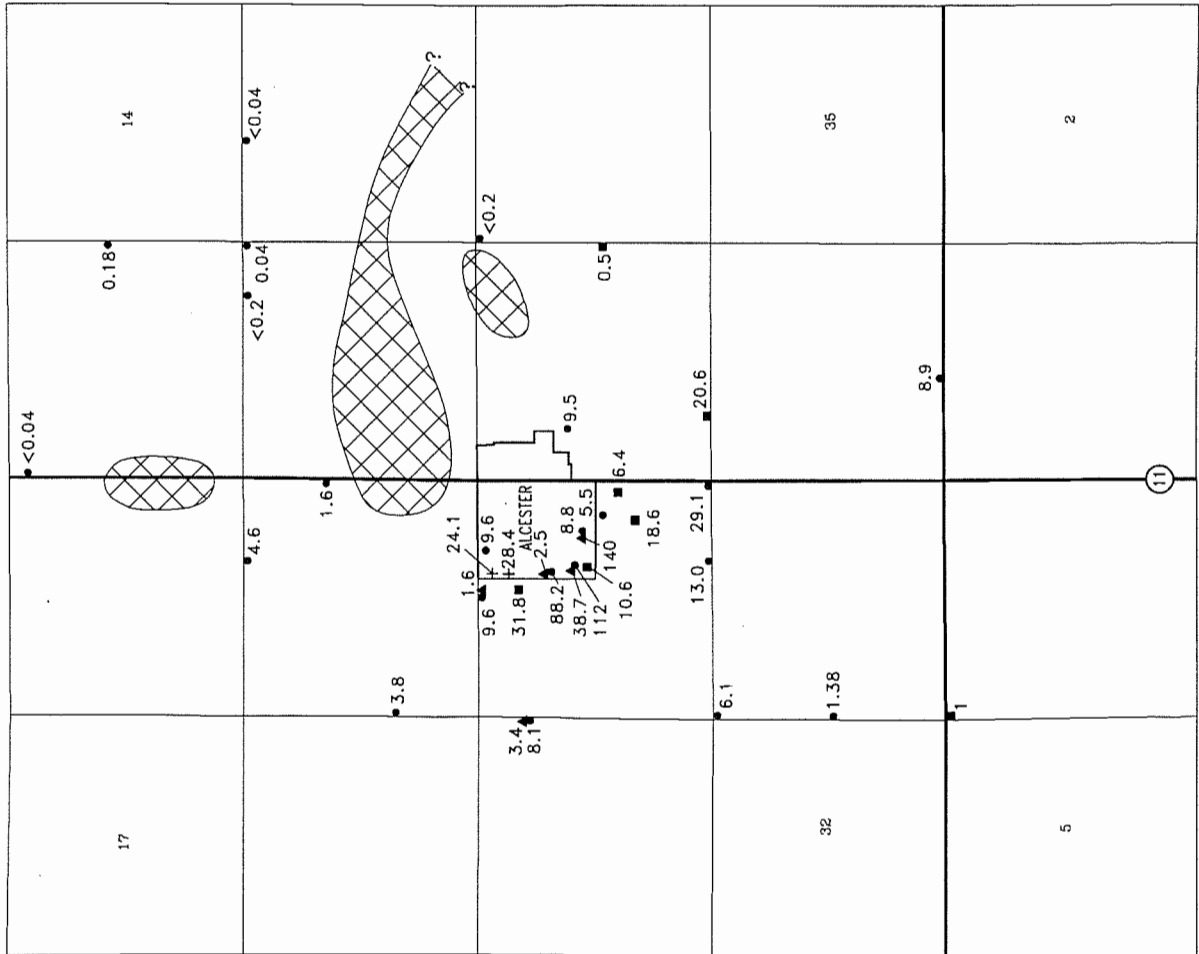


Figure 11. Nitrate-nitrogen concentrations in the quartz sand aquifer.

Monitoring well, screened throughout the aquifer.

9.5

Monitoring well, screened in the top 5 feet of the aquifer.

140

Private well.

20.6

Alcester city well.

24.1



Aquifer absent.

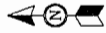
Number indicates concentration of nitrate-nitrogen in parts per million. Where more than one sample was available from a given well, only the highest concentration was used.

See table 1 for water quality analyses.

T. 95
N.

T. 94
N.

Map base adapted from U.S. Geological Survey 7.5 minute quadrangle maps: Alcester and Alcester SE quadrangles.



0 1/2 1 Mile

Figure 12. Nitrate-nitrogen in Alcester city wells.

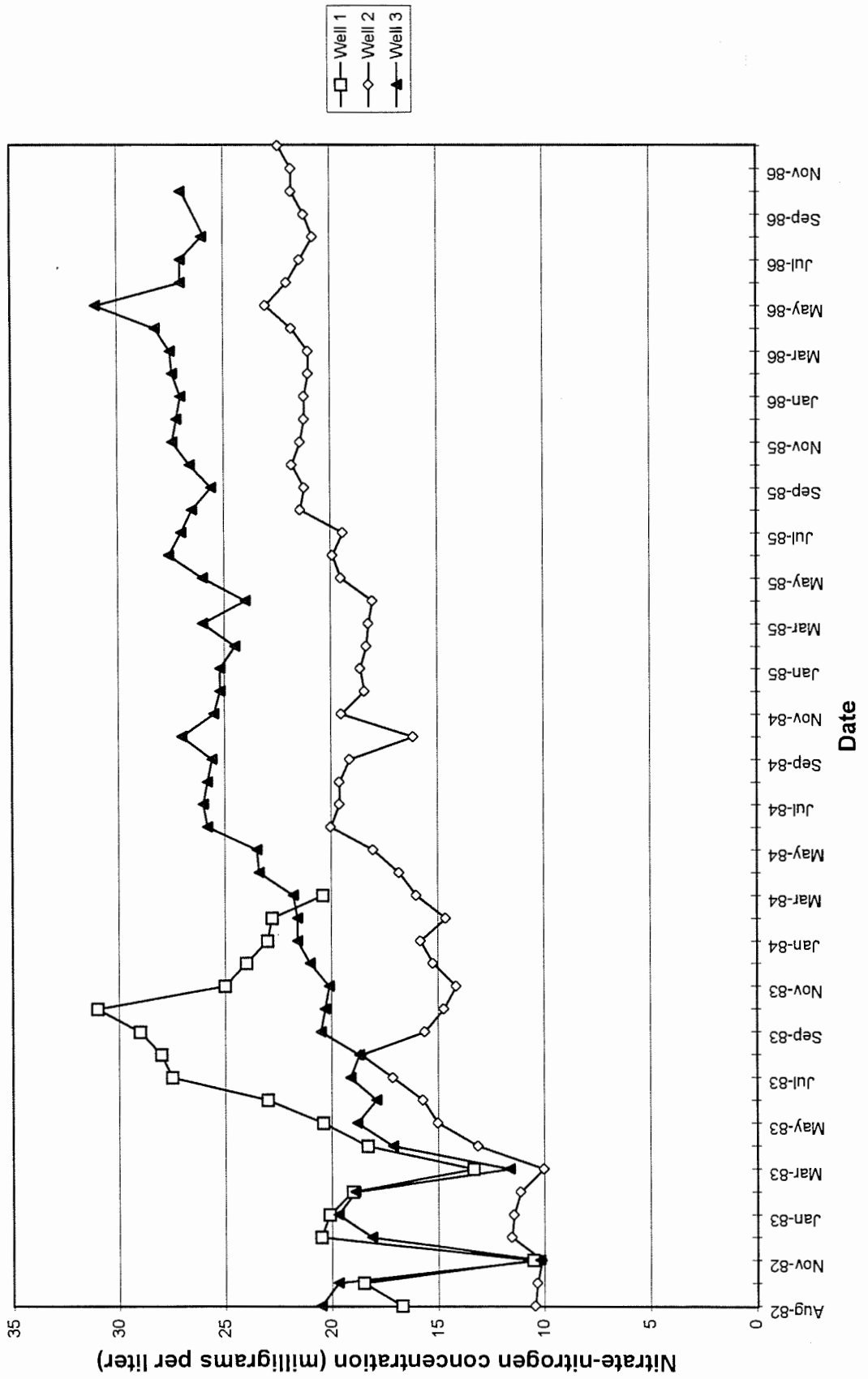


Table 1. Analyses of water samples from the Alcester area

Water sample ²	Map location ³	Location ⁴	Well Name	Sampling method ⁵	Date sampled	Well depth (ft)	Parameter ¹ with concentration in milligrams per liter														Conductivity (umhos) ⁶
							Ca	Mg	Na	K	Fe	Mn	HCO ₃	SO ₄	Cl	F	NO ₂ -N + NO ₃ -N	Hardness as CaCO ₃	Alk-T	TDS	
Standards							0.30 ⁷	0.05 ⁷	250 ⁷	250 ⁷	4.0 ⁸	10.0 ⁸						500 ⁷			
1	---	094N-49W-04BBBB	Private	Hydraulic	03/10/86	145	84	26	11	1.7	<0.05	<0.05	282	119	<2.0	0.12	1	317	231	394	684
2	5	095N-49W-21ABAB	CO-85-119	Air lift	10/17/85	54.8	199	72	32	1.7	<0.05	<0.05	350	526	5	0.31	4.6	793	287	1110	1540
3	6	095N-49W-21ADAD	CO-85-20	Bladder	06/13/85	52.6	171	61	30	7.1	<0.05	0.28	358	452	5	0.35	1.6	678	294	1010	1328
4	8	095N-49W-21CBCB	CO-85-125	Air lift	10/17/85	60.7	127	42	33	5	<0.05	<0.05	335	281	3	0.4	3.8	490	275	682	1054
5	18	095N-49W-27BCDA	CO-85-14	Bladder	06/13/85	85.9	170	68	46	4	<0.05	<0.05	492	340	28	0.46	9.5	705	404	1070	1429
6	---	095N-49W-27CDDC	Private	Cylinder	03/10/86	75	164	54	30	2.4	<0.05	<0.05	336	353	12	0.19	20.6	632	276	840	1219
7	22	095N-49W-28ABAA	CO-85-02	Bladder	06/11/85	82.1	142	57	14	3.2	<0.05	<0.05	517	44	95	0.3	9.6	589	424	726	1174
8	---	095N-49W-28ABBA	City	Submersible	09/09/85	---	143	55	38	5.4	<0.05	<0.05	412	201	45	0.29	24.1	584	338	844	1218
9	23	095N-49W-28ABBB 1	CO-85-03	Bladder	06/11/85	46.6	93	34	44	4.6	<0.05	<0.05	351	133	25	0.53	9.6	372	288	614	890
10	24	095N-49W-28ABBB 2	CO-85-04	Bailer	06/11/85	26.3	61	19	10	1.5	<0.05	<0.05	279	16	9	0.34	1.6	231	229	296	473
11	---	095N-49W-28ABCB	Private	Cylinder	06/25/85	65	133	55	30	4.3	<0.05	<0.05	332	188	38	0.27	31.8	559	272	704	1215
12	---	095N-49W-28ABCA	City	Submersible	09/09/85	---	147	56	37	4.5	<0.05	<0.05	444	182	41	0.69	28.4	598	364	874	1254
13	25	095N-49W-28ACBA 1	CO-85-05	Bailer	06/12/85	20.5	69	22	8	1	<0.05	<0.05	312	19	6	0.27	2.5	263	256	346	508
14	26	095N-49W-28ACBA 2	CO-85-10	Bladder	06/12/85	58.6	180	57	31	3.9	<0.05	<0.05	397	138	65	0.3	52.8	684	326	1110	1446
15	26	095N-49W-28ACBA 2	CO-85-10	Air lift	10/17/85	58.6	238	73	33	5.2	<0.05	<0.05	439	154	67	0.24	88.2	895	360	1254	1820
16	---	095N-49W-28ACDC	Private	Submersible	09/09/85	---	153	50	18	2.4	<0.05	<0.05	311	326	20	0.15	10.6	588	255	806	1094
17	27	095N-49W-28ACDB 1	CO-85-06	Bailer	06/12/85	38.3	146	60	29	4	<0.05	<0.05	433	133	43	0.3	38.7	612	355	866	1277
18	28	095N-49W-28ACDB 2	CO-85-11	Bladder	06/12/85	64	220	73	34	4.2	<0.05	<0.05	397	116	76	0.27	112	850	326	1332	1853
19	28	095N-49W-28ACDB 2	CO-85-11	Air lift	10/17/85	64	163	52	24	3.8	<0.05	<0.05	388	140	48	0.17	33.1	621	318	884	1365
20	30	095N-49W-28ADCB 1	CO-85-12	Air lift	06/12/85	73.4	116	41	44	3	<0.05	<0.05	382	185	16	0.33	8.8	458	313	740	990
21	30	095N-49W-28ADCB 1	CO-85-12	Bladder	06/12/85	73.4	111	38	45	3	<0.05	<0.05	447	128	17	0.4	8.7	434	367	666	992
22	30	095N-49W-28ADCB 1	CO-85-12	Bladder	06/14/85	73.4	149	56	45	4.9	<0.05	<0.05	405	345	9	0.35	2.3	603	332	868	1234
23	31	095N-49W-28ADCB 2	CO-85-13	Bailer	06/12/85	45.4	238	78	53	4.2	<0.05	<0.05	449	110	60	0.2	140	915	368	1386	1893
24	31	095N-49W-28ADCB 2	CO-85-13	Bladder	06/27/85	45.4	213	82	46	3.9	<0.05	<0.05	447	90	54	0.22	122.5	870	367	1210	1853
25	31	095N-49W-28ADCB 2	CO-85-13	Air lift	10/17/85	45.4	177	61	49	4.2	<0.05	<0.05	424	278	29	0.28	31.5	693	348	1040	1564
26	---	095N-49W-28DAAD	Private	Submersible	02/06/87	65	196	62	25	2.3	<0.05	<0.05	357	416	22	0.3	6.4	745	293	978	1256

Table 1 -- continued.

Water sample ² location ³	Map location ³	Location ⁴	Well Name	Sampling method ⁵	Date sampled	Well depth (ft)	Parameter ¹ with concentration in milligrams per liter														Conductivity (umhos) ⁶
							Ca	Mg	Na	K	Fe	Mn	HCO ₃	SO ₄	Cl	F	NO ₂ -N	NO ₃ -N	Hardness as CaCO ₃	Alk-T	
Standards										0.30 ⁷	0.05 ⁷	250 ⁷	250 ⁷	250 ⁷	4.0 ⁸	10.0 ⁸				500 ⁷	
27	33	095N-49W-28DABA	CO-85-08	Air lift	06/12/85	67.7	169	51	22	2	<0.05	<0.05	343	370	18	0.14	5.5	632	281	898	1102
28	33	095N-49W-28DABA	CO-85-08	Bladder	06/12/85	67.7	163	50	22	2.1	<0.05	<0.05	339	347	17	0.15	5	613	278	900	1132
29	33	095N-49W-28DABA	CO-85-08	Bladder	06/14/85	67.7	179	55	28	4.8	<0.05	<0.05	336	417	21	0.28	4.8	673	276	948	1249
30	33	095N-49W-28DABA	CO-85-08	Bladder	06/27/85	67.7	172	65	28	4.9	<0.05	<0.05	347	424	21	0.13	3.2	697	285	950	1266
31	---	095N-49W-28DACA	Private	Submersible	06/27/85	40	105	34	14	2.2	<0.05	<0.05	296	52	49	0.16	18.6	402	243	528	848
32	34	095N-49W-28DCDC	CO-85-07	Bladder	06/13/85	64.1	98	29	23	3.9	<0.05	<0.05	334	98	11	0.2	13	364	274	490	810
33	34	095N-49W-28DCDC	CO-85-07	Bladder	03/03/86	64.1	126	28	17	5.6	<0.05	<0.05	393	98	10	0.19	9.5	430	322	504	790
34	35	095N-49W-28DDDD	CO-85-21	Bladder	06/13/85	120.8	234	69	30	4.6	<0.05	0.1	371	525	24	0.39	19.8	868	304	1248	1573
35	35	095N-49W-28DDDD	CO-85-21	Bladder	02/03/86	120.8	240	72	34	4.7	<0.05	<0.05	368	560	23	0.46	29.1	896	302	1214	1646
36	36	095N-49W-29AADD 1	CO-85-15	Air lift	06/12/85	53.7	92	30	19	2.5	<0.05	0.07	300	116	14	0.3	8	353	246	502	727
37	36	095N-49W-29AADD 1	CO-85-15	Bladder	06/12/85	53.7	89	30	20	2.9	<0.05	0.07	310	105	13	0.27	8.1	346	254	480	741
38	36	095N-49W-29AADD 1	CO-85-15	Bladder	06/14/85	53.7	84	39	17	2.7	<0.05	0.06	302	105	14	0.3	6.8	370	248	476	735
39	37	095N-49W-29AADD 2	CO-85-16	Bailer	06/12/85	27.8	86	31	26	1.9	<0.05	0.32	330	95	27	0.28	3.4	342	271	460	759
40	38	095N-49W-33B8BB	R2-85-92	Bladder	09/05/85	124.8	110	41	19	3.7	<0.05	<0.05	451	67	11	0.38	6.1	444	370	530	853
41	40	095N-49W-33C8BB 2	CO-86-124	Air lift	12/02/86	150	90	24	12	2.2	<0.05	<0.05	271	125	2	0.37	1.38	324	222	424	643
42	---	095N-49W-34CDDC	R2-85-101	Air lift	09/16/85	223	193	58	21	3	<0.05	<0.05	317	483	<2.0	0.37	8.9	721	260	1028	1220
43	1	095N-49W-15ADDA	CO-86-121	Bladder	11/05/86	121	299	83	33	9.2	<0.05	0.98	356	886	2	0.8	0.18	1088	292	1616	1840
44	9	095N-49W-22AAAA	CO-86-119	Bladder	11/04/86	115	217	63	19	6.7	<0.05	0.48	341	592	2	0.31	0.04	801	280	1082	1390
45	10	095N-49W-22AABB	CO-85-121	Air lift	10/17/85	83.6	249	71	31	7.7	0.27	0.64	400	660	7	0.31	<0.2	914	328	1280	1688
46	15	095N-49W-23BAAB	CO-86-120	Bladder	11/04/86	147	190	60	22	7.7	0.07	0.84	368	484	2	0.31	<0.04	722	302	960	1285
47	---	095N-49W-26B8BB	Private	Cylinder	06/25/85	140	288	116	47	13.4	0.31	0.75	451	952	4	0.31	<0.2	1197	370	1700	2095
48	---	095N-49W-15BBBC	UN-80A	Bladder	11/05/86	47.06	206	57	27	5.9	<0.05	0.06	382	507	2	0.45	<0.04	749	313	1080	1337
49	---	095N-48W-33AAAA	R20-85-81	Bladder	11/07/86	31.84	122	34	16	2.3	<0.05	0.2	297	199	10	0.22	5.9	445	244	602	844
50	---	094N-49W-10BCAB	Private	Submersible	07/02/85	632	133	40	116	18.1	3.27	0.09	304	452	23	1.78	<0.2	497	249	960	1388
51	---	095N-49W-17CDDD	Private	Submersible	11/06/86	630	59	17	138	12	6.34	<0.05	308	226	51	1.92	<0.04	217	253	694	1068
52	---	095N-49W-27DAAA	Private	Cylinder	07/02/85	440	90	27	136	16.4	7.44	0.19	293	358	28	2.04	<0.2	336	240	800	1216
53	---	095N-49W-27DAAA	Private	Cylinder	11/06/86	440	101	26	137	17	14.4	0.17	330	390	33	1.83	0.52	359	271	908	1264

Table 1 -- continued.

- ¹ Ca - calcium; Mg - magnesium; Na - sodium; K - potassium; Fe - iron; Mn - manganese; HCO₃ - bicarbonate; SO₄ - sulfate; Cl - chloride; F - fluoride; NO₃-N + NO₂-N - nitrate plus nitrite as nitrogen; Hardness as CaCO₃ - hardness as calcium carbonate; Alk-T - total alkalinity; TDS - total dissolved solids.
- ² The water sample number corresponds to the numbers shown on figure 3. Samples 1-46 are from the quartz sand aquifer as defined in this report. Sample 47 is probably from the quartz sand aquifer. Sample 48 is from the quartz sand aquifer. Sample 49 is from the Big Sioux aquifer. Samples 50-53 are from the Dakota Formation.
- ³ The map location (ML) number corresponds to the ML numbers shown on figure 2 and listed in appendix A.
- ⁴ The location format is explained in appendix A.
- ⁵ The sampling method refers to the manner in which the water sample was withdrawn from the well. **Air lift** - compressed air discharged inside the well casing near the bottom of the well causing water to be ejected from the well; **Bailer** - a cylinder with a check valve that was repeatedly immersed below the water in a well and raised to land surface; **Bladder** - bladder pump; **Cylinder** - cylinder pump; **Hydraulic** - hydraulic pump; **Submersible** - submersible pump.
- ⁶ **umhos** - micromhos per centimeter.
- ⁷ U.S. Environmental Protection Agency (November 1994). Secondary maximum contaminant level. Recommended limit.
- ⁸ U.S. Environmental Protection Agency (November 1994). Maximum contaminant level. Enforceable limit.

Table 2. Analyses for trace metals and radionuclides in Dakota Formation water

Parameter	Maximum limit ¹	Results from well 630 feet deep ²	Results from well 440 feet deep ³
Arsenic	50 µg/L ⁴	<1.0 µg/L	<1.0 µg/L
Barium	1,000 µg/L	<20 µg/L	<20 µg/L
Cadmium	10 µg/L	<1.0 µg/L	<1.0 µg/L
Chromium	50 µg/L	<1.0 µg/L	16.8 µg/L
Lead	50 µg/L	<1.0 µg/L	14.5 µg/L
Mercury	2 µg/L	<0.2 µg/L	<0.2 µg/L
Selenium	10 µg/L	<1.0 µg/L	<1.0 µg/L
Silver	50 µg/L	1.3 µg/L	1.1 µg/L
Radium 226	see below ⁵	2.0 ± 0.6 pCi/L	0.7 + 0.2 pCi/L
Radium 228	see below ⁵	4.3 ± 1.3 pCi/L	1.7 + 0.5 pCi/L

¹ The maximum limits are from the U.S. Environmental Protection Agency's *Drinking Water Regulations and Health Advisories* published in November 1994.

² Sample collected from location of water sample number 51 on figure 3 and table 1.

³ Sample collected from location of water sample numbers 52 and 53 on figure 3 and table 1.

⁴ µg/L - micrograms per liter.

⁵ Five picoCuries per liter (pCi/L) is the limit for radium 226 + 228 combined.

The water samples were collected on 11/06/86.

Table 3. Comparison of the average water quality from the quartz sand aquifer and the Dakota Formation

Parameter	Quartz sand aquifer		Dakota Formation
	Water samples 1-42 ¹	Northeast of Alcester (water samples 43-46)	Water samples 50-53 ²
Conductivity	1112	1551	1240
Total dissolved solids	769	1235	854
Hardness as CaCO ₃	555	881	356
Iron	<0.05 ³	see below ⁴	8.00
Manganese	see below ⁵	0.74	see below ⁶
Sulfate	228	656	356
Nitrate+nitrite as nitrogen	15.2	see below ⁷	see below ⁸
Sodium	27	26	130
Calcium	142	239	98
Magnesium	49	69	28
Potassium	3.6	7.8	15.7
Chloride	see below ⁹	3.25	36
Fluoride	0.31	0.43	1.84
Bicarbonate	367	366	314

Results are presented in milligrams per liter except for conductivity which is in micromhos per centimeter. See table 1 for individual analyses.

¹ Where more than one sample was collected from a well, only the most recent analysis was used in computing the average. Results from 30 samples were used to compute the average.

² Where more than one sample was collected from a well, only the most recent analysis was used in computing the average. Results from three samples were used to compute the average.

³ All samples had reported values of <0.05.

⁴ Two samples had reported values of <0.05. The other two had concentrations of 0.07 and 0.27.

⁵ Twenty-seven samples had reported values of <0.05. Three samples had concentrations of 0.06, 0.28, and 0.32.

⁶ One of the samples had a reported value of <0.05. The other two samples had concentrations of 0.09 and 0.17.

⁷ Two of the samples had reported values of <0.04 and <0.2. The other two samples had concentrations of 0.04 and 0.18.

⁸ Two of the samples had reported values of <0.04 and <0.2. The other sample had a concentration of 0.52.

⁹ Two of the samples had a reported value of <2.0. The other 28 samples had concentrations within the quantification range of the analytical method.

APPENDIX A

Logs of test holes and monitoring wells

MAP LOCATION (ML)

A number arbitrarily assigned to the log according to the order in which it is listed (see **LEGAL LOCATION** and **LOCATION**). This number corresponds to the numbers shown on figure 2.

LATITUDE and LONGITUDE

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

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 **LEGAL LOCATION** and **LOCATION** is as follows. A **LEGAL LOCATION** of NW SE NE SW sec. 15, T. 95 N., R. 49 W. is the same as a **LOCATION** of 095N-49W-15CADB. In some **LOCATIONS**, the smallest quarter section is followed by the number 1, 2, or 3 which designates that more than one test hole or monitoring well may exist at that particular location.

DRILLING COMPANY

SDGS is an abbreviation for the 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 = polyvinyl chloride; **MFG.** = manufactured - indicates a product that is commercially available; **HM.** = an abbreviation for homemade; **SCH.** is an abbreviation for schedule and refers to casing thickness.

CASING DIAMETER

The number is presented in inches.

GROUND SURFACE ELEVATION and CASING TOP ELEVATION

The numbers are presented in feet above mean sea level. **I** - the elevation was determined using a surveying instrument. **T** - the elevation was estimated from a 7.5 minute series topographic map.

County: UNION
 Map Location: 1
 Legal Location: NE SE SE NE sec. 15, T. 095 N., R. 49 W.
 Latitude: 43.0255
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-30-1986
 Ground Surface Elevation: 1403.08 I
 Total Drill Hole Depth: 127
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1405.79 I
 Casing Stick-up: 2.71
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma: X
 Samples:

0	-	16	Silt, yellow-brown, clayey (loess)
16	-	40	Clay, yellow-brown, silty, pebbly; oxidized (till)
40	-	48	Silt, gray; greasy
48	-	69	Clay, yellow-brown, silty, pebbly; oxidized (till)
69	-	93	Silt, multi-colored, white, browns, grays, clayey (mixture of silts and till?)
93	-	118	Sand, white to light-green, fine to coarse; predominately quartz and feldspar
118	-	127	Shale, dark-gray; greasy (Carlile Shale)

Location: 095N-49W-15ADDA

Longitude: 96.3629

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

Test Hole Number: CO-86-121
 SDGS Well Name: CO-86-121

Aquifer:

Screen Length: 20.0
 Casing Diameter: 2.0

Total Casing and Screen: 121.0

Single Point Resistivity: X
 Extra:

County: UNION
 Map Location: 2
 Legal Location: SE SW SE SW sec. 15, T. 095 N., R. 49 W.
 Latitude: 43.0226
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-08-1985
 Ground Surface Elevation: 1403.00 T
 Total Drill Hole Depth: 124
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 095N-49W-15CDCD

Longitude: 96.3714

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

Test Hole Number: CO-85-120

Single Point Resistivity:
 Extra:

0	-	1	Topsoil, black, silty
1	-	6	Silt, yellow-brown, clayey
6	-	109	Clay, yellow-brown, very silty, pebbly; oxidized; mud collar developed at approximately 60 feet so got poor samples after that
109	-	116	Gravel, white, fine to medium; predominately quartz
116	-	124	Shale, dark-gray; hard (Carlile Shale)

County: UNION
 Map Location: 3
 Legal Location: NE NE NE SE sec. 16, T. 095 N., R. 49 W.
 Latitude: 43.0249
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-30-1986
 Ground Surface Elevation: 1356.29 I
 Total Drill Hole Depth: 77
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma: X
 Samples:

Location: 095N-49W-16DAAA

 Longitude: 96.3741

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

 Test Hole Number: CO-86-122

Single Point Resistivity: X
 Extra:

0	-	15	Silt, light-reddish-brown, clayey (loess)
15	-	19	Sand, light-yellowish-brown, fine to medium; mainly quartz and feldspar with small shale fragments
19	-	38	Clay, light-pinkish-grayish-brown, silty; very few pebbles, oxidized (till)
38	-	59	Silt, gray, clayey, sandy (lacustrine?)
59	-	77	Shale, dark-gray; hard, greasy (Carlile Shale)

County: UNION
 Map Location: 4
 Legal Location: NE NE NE NE sec. 21, T. 095 N., R. 49 W.
 Latitude: 43.0225
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-07-1985
 Ground Surface Elevation: 1368.00 T
 Total Drill Hole Depth: 77
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 095N-49W-21AAAA

 Longitude: 96.3730

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

 Test Hole Number: CO-85-118

Single Point Resistivity:
 Extra:

0	-	1	Topsoil, black
1	-	19	Silt, reddish-brown, clayey

19	-	29	Clay, yellow-brown to gray, mottled, silty, pebbly; oxidized (till)
29	-	54	Clay, gray, silty, pebbly; unoxidized (till)
54	-	59	Sand and gravel, greenish-white, sand medium to coarse, gravel fine to medium; predominately quartz and igneous
59	-	73	Clay, light-gray, silty, pebbly
73	-	77	Shale, dark-gray; greasy, hard (Carlile Shale)

County: UNION	Location: 095N-49W-21ABAB
Map Location: 5	
Legal Location: NW NE NW NE sec. 21, T. 095 N., R. 49 W.	
Latitude: 43.0225	Longitude: 96.3804
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: M. THOMPSON	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 10-07-1985	Drilling Method: ROTARY
Ground Surface Elevation: 1331.78 I	
Total Drill Hole Depth: 57	Test Hole Number: CO-85-119
Water Rights Well:	SDGS Well Name: CO-85-119
Other Well Name:	
Basin: BIG SIOUX	Aquifer:
Management Unit:	
Screen Type: PVC, HM. AND MFG.	Screen Length: 19.0
Casing Type: PVC, SCH. 40	Casing Diameter: 2.0
Casing Top Elevation: 1334.18 I	
Casing Stick-up: 2.40	Total Casing and Screen: 54.8
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

0	-	1	Topsoil, black, silty
1	-	16	Silt, reddish-brown, clayey
16	-	29	Clay, yellow-brown, clayey, sandy, pebbly; oxidized (till)
29	-	33	Clay, gray, silty, pebbly; unoxidized (till)
33	-	52	Sand, light-yellowish-gray, fine to medium; predominately quartz
52	-	57	Shale, dark-gray; greasy, hard (Carlile Shale)

County: UNION	Location: 095N-49W-21ADAD
Map Location: 6	
Legal Location: SE NE SE NE sec. 21, T. 095 N., R. 49 W.	
Latitude: 43.0207	Longitude: 96.3741
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: M. THOMPSON	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 06-07-1985	Drilling Method: ROTARY
Ground Surface Elevation: 1337.60 I	

Total Drill Hole Depth: 57
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1339.84 1
 Casing Stick-up: 2.24
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Test Hole Number: CO-85-20
 SDGS Well Name: CO-85-20
 Aquifer:
 Screen Length: 12.0
 Casing Diameter: 2.0
 Total Casing and Screen: 52.6

Single Point Resistivity:
 Extra:

0	-	1	Topsoil, black, silty
1	-	13	Silt, yellow-brown, clayey
13	-	14	Gravel, brown, fine
14	-	24	Clay, yellow-brown, silty, pebbly; oxidized (till)
24	-	39	Clay, gray, silty, pebbly; unoxidized (till)
39	-	51	Sand, gray, fine to medium; predominately quartz
51	-	57	Shale, black; greasy (Carlile Shale)

County: UNION
 Map Location: 7
 Legal Location: NE NW NW NW sec. 21, T. 095 N., R. 49 W.
 Latitude: 43.0225
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: R. GRAVHOLT
 Geologist: L. FRYKMAN
 Date Drilled: 08-28-1985
 Ground Surface Elevation: 1313.00 T
 Total Drill Hole Depth: 70
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 095N-49W-21BBBA
 Longitude: 96.3846
 Driller's Log:
 Geologist's Log: X
 Drilling Method: ROTARY
 Test Hole Number: R2-85-91

Single Point Resistivity:
 Extra:

0	-	1	Topsoil, black
1	-	9	Clay, brown to gray mottling, silty, pebbly
9	-	33	Clay, gray to green mottling, silty
33	-	45	Sand and gravel, variegated, sand coarse, gravel fine to medium; sand and gravel is a mixture of quartz sand and glacial outwash consisting of igneous, metamorphics and carbonate rocks; many clay stringers; poor aquifer material
45	-	62	Clay, gray, silty, sandy
62	-	70	Shale, dark-gray; greasy (Carlile Shale)

County: UNION

Location: 095N-49W-21CBCB

Map Location: 8
 Legal Location: NW SW NW SW sec. 21, T. 095 N., R. 49 W.
 Latitude: 43.0151
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-10-1985
 Ground Surface Elevation: 1336.62 I
 Total Drill Hole Depth: 67
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1338.89 I
 Casing Stick-up: 2.27
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

0	-	2	Topsoil, black
2	-	21	Silt, yellow-brown, clayey (loess)
21	-	27	Gravel, brown, medium
27	-	38	Clay, yellow-brown, silty, pebbly, gravelly; oxidized (till)
38	-	59	Gravel, white, fine to medium; predominately quartz and feldspar
59	-	67	Shale, light-gray; greasy, hard (Carlisle Shale)

Longitude: 96.3850

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

Test Hole Number: CO-85-125
 SDGS Well Name: CO-85-125

Aquifer:

Screen Length: 25.0
 Casing Diameter: 2.0

Total Casing and Screen: 60.7

Single Point Resistivity:
 Extra:

County: UNION
 Map Location: 9
 Legal Location: NE NE NE NE sec. 22, T. 095 N., R. 49 W.
 Latitude: 43.0225
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-28-1986
 Ground Surface Elevation: 1400.34 I
 Total Drill Hole Depth: 118
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1402.56 I
 Casing Stick-up: 2.22

Location: 095N-49W-22AAAA

Longitude: 96.3629

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

Test Hole Number: CO-86-119
 SDGS Well Name: CO-86-119

Aquifer:

Screen Length: 20.0
 Casing Diameter: 2.0

Total Casing and Screen: 115.0

Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:

Spontaneous Potential:
Natural Gamma:
Samples:

Single Point Resistivity:
Extra:

0	-	15	Silt, yellow-brown, clayey (loess)
15	-	22	Clay, yellow-brown, silty, pebbly; oxidized (till)
22	-	26	Clay, gray, silty, pebbly; unoxidized, greasy (till)
26	-	28	Clay, gray with yellow-brown mottling, silty, pebbly; oxidized (till)
28	-	35	Clay, gray, shaley; unoxidized, greasy (till)
35	-	56	Clay, brown; greasy (lacustrine)
56	-	68	Silt, brown, clayey (lacustrine?)
68	-	75	Clay, yellow-brown and gray mottled, silty; oxidized (till)
75	-	95	Silt, brown to yellow-white, clayey (loess?)
95	-	116	Sand, white to light-green, very coarse; predominately quartz and feldspar
116	-	118	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
Map Location: 10
Legal Location: NW NW NE NE sec. 22, T. 095 N., R. 49 W.
Latitude: 43.0226
Land Owner:

Location: 095N-49W-22AABB

Longitude: 96.3644

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: M. THOMPSON

Geologist: L. FRYKMAN

Date Drilled: 10-08-1985

Ground Surface Elevation: 1369.48 1

Total Drill Hole Depth: 97

Water Rights Well:

Other Well Name:

Basin: BIG SIOUX

Management Unit:

Screen Type: PVC, HM. AND MFG.

Casing Type: PVC, SCH. 40

Casing Top Elevation: 1372.18 1

Casing Stick-up: 2.70

Well Maintenance Date:

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Driller's Log:

Geologist's Log: X

Drilling Method: ROTARY

Test Hole Number: CO-85-121

SDGS Well Name: CO-85-121

Aquifer:

Screen Length: 19.0

Casing Diameter: 2.0

Total Casing and Screen: 83.6

Single Point Resistivity:

Extra:

0	-	1	Topsoil, black, silty
1	-	8	Silt, dark-brown, clayey
8	-	24	Clay, yellow-brown, very silty, sandy, pebbly; oxidized (till)
24	-	32	Clay, brownish-gray, silty, pebbly; little sand; oxidized (till)
32	-	48	Clay, light-gray to gray, very shaley, slightly silty; some fine sand towards bottom of layer; unoxidized (till)
48	-	53	Clay, brownish-gray to yellowish-gray, silty, very sandy; oxidized (till)

53 - 64	Silt, greenish-gray, clayey, very sandy
64 - 69	Sand, gray, very fine to fine; some silt
69 - 86	Gravel, greenish-gray, fine to medium; predominately quartz and igneous grains
86 - 97	Shale, dark-gray; greasy (Carlile Shale)

County: UNION	Location: 095N-49W-22ADDA
Map Location: 11	
Legal Location: NE SE SE NE sec. 22, T. 095 N., R. 49 W.	
Latitude: 43.0204	Longitude: 96.3629
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: M. THOMPSON	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 10-08-1985	Drilling Method: ROTARY
Ground Surface Elevation: 1407.00 T	
Total Drill Hole Depth: 117	Test Hole Number: CO-85-122
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

0 - 1	Topsoil, black, silty
1 - 10	Silt, yellow-brown, clayey, becomes very sandy from 6 to 10 feet (loess)
10 - 21	Clay, yellow-brown to gray, mottled, silty, very sandy
21 - 29	Gravel, yellow-brown, fine to medium; contains carbonate and quartz clasts
29 - 42	Clay, yellow-brown to gray, silty, pebbly; oxidized (till)
42 - 102	Clay, gray, silty, pebbly; unoxidized (till)
102 - 108	Sand and gravel, greenish-white, sand coarse, gravel fine; predominately quartz and igneous detritus; has some bluish-gray clay stringers in it
108 - 117	Shale, green; greasy, hard, weathered (Carlile Shale?)

County: UNION	Location: 095N-49W-22CBBB
Map Location: 12	
Legal Location: NW NW NW SW sec. 22, T. 095 N., R. 49 W.	
Latitude: 43.0156	Longitude: 96.3739
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: M. THOMPSON	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 06-06-1985	Drilling Method: ROTARY
Ground Surface Elevation: 1355.00 T	
Total Drill Hole Depth: 47	Test Hole Number: CO-85-19
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

0 - 2	Topsoil, black
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2	-	3	Gravel, brown, fine to medium
3	-	18	Silt, yellow-brown, clayey (loess)
18	-	19	Gravel, brown, medium
19	-	26	Clay, yellow-brown, silty, pebbly; oxidized (till)
26	-	43	Clay, gray, silty, pebbly; unoxidized (till)
43	-	47	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
 Map Location: 13
 Legal Location: NW SW NW SW sec. 22, T. 095 N., R. 49 W.
 Latitude: 43.0149
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 06-06-1985
 Ground Surface Elevation: 1383.00 T
 Total Drill Hole Depth: 67
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 095N-49W-22CBCB

Longitude: 96.3739

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

Test Hole Number: CO-85-18

Single Point Resistivity:
 Extra:

0	-	1	Topsoil, black
1	-	10	Silt, yellow-brown, clayey (loess)
10	-	36	Clay, yellow-brown, silty, pebbly; oxidized (till)
36	-	62	Clay, gray, silty, pebbly; unoxidized (till)
62	-	67	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
 Map Location: 14
 Legal Location: NW NW SW SW sec. 22, T. 095 N., R. 49 W.
 Latitude: 43.0143
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 06-06-1985
 Ground Surface Elevation: 1405.00 T
 Total Drill Hole Depth: 97
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 095N-49W-22CCBB

Longitude: 96.3739

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

Test Hole Number: CO-85-17

Single Point Resistivity:
 Extra:

0	-	2	Topsoil, black, silty
2	-	23	Silt, yellow-brown, sandy, clayey; small thin gravel stringer encountered
23	-	46	Clay, yellow-brown, silty, pebbly; oxidized (till)

46 - 89 Clay, gray, silty, pebbly; unoxidized (till)
 89 - 97 Shale, dark-gray; hard (Carlile Shale)

County: UNION
 Map Location: 15
 Legal Location: NW NE NE NW sec. 23, T. 095 N., R. 49 W.
 Latitude: 43.0225
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 10-29-1986
 Ground Surface Elevation: 1428.56 I
 Total Drill Hole Depth: 158
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1430.76 I
 Casing Stick-up: 2.20
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

0 - 9 Silt, yellow-brown, clayey (loess)
 9 - 25 Clay, yellow-brown, silty, pebbly; oxidized (till)
 25 - 63 Clay, gray, silty, pebbly; unoxidized (till)
 63 - 93 Silt, gray, clayey, sandy (lacustrine)
 93 - 104 Clay, gray, silty, sandy, pebbly; unoxidized (till)
 104 - 108 Silt, gray, slightly sandy
 108 - 125 Clay, gray, silty, pebbly; unoxidized (till)
 125 - 134 Clay, gray, very silty, becomes progressively sandier; unoxidized (till?)
 134 - 136 Sand, fine to medium, rounded; quartz
 136 - 142 Silt, light-gray, clayey, sandy
 142 - 150 Sand, white to light-green, medium to coarse; few pebbles, predominately quartz and feldspar
 150 - 158 Shale, dark-gray; greasy (Carlile Shale)

Location: 095N-49W-23BAAB

Longitude: 96.3559

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

Test Hole Number: CO-86-120
 SDGS Well Name: CO-86-120

Aquifer:

Screen Length: 5.0
 Casing Diameter: 2.0

Total Casing and Screen: 147.0

Single Point Resistivity:
 Extra:

County: UNION
 Map Location: 16
 Legal Location: NE NW NE NE sec. 27, T. 095 N., R. 49 W.
 Latitude: 43.0132
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON

Location: 095N-49W-27AABA

Longitude: 96.3642

Driller's Log:

Geologist: L. FRYKMAN
Date Drilled: 10-09-1985
Ground Surface Elevation: 1395.00 T
Total Drill Hole Depth: 137
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-85-123

Single Point Resistivity:
Extra:

0	-	33	Silt, yellow-brown to reddish-brown, clayey (loess)
33	-	42	Clay, yellow-brown to gray, silty, pebbly; oxidized (till)
42	-	63	Clay, olive-gray, silty, pebbly; unoxidized (till)
63	-	81	Clay, gray, silty, pebbly; unoxidized (till)
81	-	86	Gravel, brown, fine to medium
86	-	103	Clay, gray, silty, very gravelly; unoxidized (till)
103	-	131	Clay, light-gray, silty, sandy, gravelly; unoxidized (till)
131	-	137	Shale, dark-gray; greasy, hard (Carlile Shale)

County: UNION
Map Location: 17
Legal Location: NE NW NW NW sec. 27, T. 095 N., R. 49 W.
Latitude: 43.0133
Land Owner:

Location: 095N-49W-27BBBA
Longitude: 96.3733

Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 06-03-1985
Ground Surface Elevation: 1417.00 T
Total Drill Hole Depth: 147
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-85-09

Single Point Resistivity:
Extra:

0	-	11	Silt, yellow-brown, very sandy (loess)
11	-	14	Clay, yellow-brown, silty, pebbly; oxidized (till)
14	-	21	Clay, gray, silty; unoxidized
21	-	36	Clay, dark-brown with gray, mottled, silty, pebbly; oxidized (till)
36	-	49	Clay, dark-gray, silty, pebbly; unoxidized (till)
49	-	63	Clay, light-gray with yellow-brown, mottled, silty, pebbly; oxidized (till)
63	-	69	Clay, dark-gray to black to light-gray, silty, slightly pebbly; very hard, unoxidized (till)
69	-	70	Gravel, brown, medium, poorly sorted
70	-	110	Clay, light-gray, silty, pebbly; poorly sorted gravel at 84 to 86 feet; unoxidized (till)
110	-	125	Clay, gray, very silty; soft (loess?)
125	-	140	Sand, light-brown, fine to very fine; coarse sand stringer at 138 to 139 feet; may be lightly cemented from 139 to 140 feet
140	-	143	Sand, white, coarse, subrounded; contains light-green clasts, mainly igneous fragments-quartz
143	-	147	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
 Map Location: 18
 Legal Location: NE SE SW NW sec. 27, T. 095 N., R. 49 W.
 Latitude: 43.0112
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 06-05-1985
 Ground Surface Elevation: 1361.88 I
 Total Drill Hole Depth: 87
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1365.14 I
 Casing Stick-up: 3.28
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

0	-	1	Topsoil, black, silty
1	-	15	Silt, yellow-brown, clayey; oxidized
15	-	24	Gravel, brown, fine to medium
24	-	44	Clay, yellow-brown, silty (till?)
44	-	81	Sand and gravel, white, fine sand, fine to medium gravel; predominately quartz
81	-	87	Shale, dark-gray; greasy (Carlisle Shale)

Location: 095N-49W-27BCDA

Longitude: 96.3723

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

Test Hole Number: CO-85-14
 SDGS Well Name: CO-85-14

Aquifer:

Screen Length: 35.0
 Casing Diameter: 2.0

Total Casing and Screen: 85.9

Single Point Resistivity:
 Extra:

County: UNION
 Map Location: 19
 Legal Location: NW NW SW SW sec. 27, T. 095 N., R. 49 W.
 Latitude: 43.0053
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 06-07-1985
 Ground Surface Elevation: 1373.82 I
 Total Drill Hole Depth: 107
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40

Location: 095N-49W-27CCBB

Longitude: 96.3739

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

Test Hole Number: CO-85-22
 SDGS Well Name: CO-85-22

Aquifer:

Screen Length: 7.0
 Casing Diameter: 2.0

Casing Top Elevation: 1376.65 I
Casing Stick-up: 2.83
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203

Total Casing and Screen: 103.5

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Single Point Resistivity:

Extra:

0	-	1	Topsoil, black
1	-	8	Silt, yellow-brown, clayey (loess)
8	-	36	Clay, yellow-brown, silty, pebbly; oxidized (till)
36	-	67	Clay, gray, silty, pebbly; unoxidized (till)
67	-	94	Clay, tan, silty, pebbly, gravelly; oxidized (till)
94	-	101	Sand and gravel, white, coarse sand, fine gravel; predominately quartz and feldspar
101	-	107	Shale, dark-gray; greasy (Carlisle Shale)

County: UNION

Map Location: 20

Legal Location: SE SE SE SE sec. 27, T. 095 N., R. 49 W.

Latitude: 43.0041

Land Owner:

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: M. THOMPSON

Geologist: L. FRYKMAN

Date Drilled: 10-09-1985

Ground Surface Elevation: 1445.00 T

Total Drill Hole Depth: 167

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Location: 095N-49W-27DDDD

Longitude: 96.3631

Driller's Log:

Geologist's Log: X

Drilling Method: ROTARY

Test Hole Number: CO-85-124

Single Point Resistivity:

Extra:

0	-	1	Topsoil, black, silty
1	-	34	Silt, yellow-brown, clayey (loess)
34	-	49	Clay, yellow-brown, silty, pebbly, gravelly; oxidized (till)
49	-	78	Clay, gray, silty, pebbly; unoxidized (till)
78	-	122	Clay, olive-gray, silty, pebbly; unoxidized (till)
122	-	154	Clay, gray, silty, pebbly; unoxidized, rock at 154 feet (till)
154	-	156	Gravel, white, fine to medium; predominately quartz
156	-	167	Shale, light-gray; greasy, hard (Carlisle Shale)

County: UNION

Map Location: 21

Legal Location: NW NE NE NE sec. 28, T. 095 N., R. 49 W.

Latitude: 43.0130

Land Owner:

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: D. ANDERSON

Location: 095N-49W-28AAAB

Longitude: 96.3746

Driller's Log:

Geologist: L. FRYKMAN
Date Drilled: 05-28-1985
Ground Surface Elevation: 1417.13 I
Total Drill Hole Depth: 158
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1419.03 I
Casing Stick-up: 1.90
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential: X
Natural Gamma: X
Samples:

0	-	15	Silt, yellow-brown, clayey (loess)
15	-	43	Clay, yellow-brown, silty, sandy, pebbly; oxidized (till)
43	-	62	Silt, yellow-brown, very sandy (loess?)
62	-	72	Clay, yellow-brown, silty, very sandy; oxidized (till)
72	-	78	Clay, dark-gray, silty, sandy; gives a very pronounced kick to the right on the natural-gamma electric log
78	-	100	Clay, light-gray to dark-brown, silty, sandy; unoxidized (till)
100	-	140	Sand, white, fine to coarse; sand composed predominately of white quartz, pink and light-green feldspars, no shale clasts noticed
140	-	158	Shale, gray; greasy (Carlile Shale)

County: UNION
Map Location: 22
Legal Location: NE NE NW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0132
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 05-29-1985
Ground Surface Elevation: 1365.41 I
Total Drill Hole Depth: 96
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1368.19 I
Casing Stick-up: 2.78
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:

Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-85-01
SDGS Well Name: CO-85-01
Aquifer:
Screen Length: 40.0
Casing Diameter: 2.0
Total Casing and Screen: 140.6
Single Point Resistivity: X
Extra:

Location: 095N-49W-28ABAA
Longitude: 96.3800
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-85-02
SDGS Well Name: CO-85-02
Aquifer:
Screen Length: 33.0
Casing Diameter: 2.0
Total Casing and Screen: 82.1

Spontaneous Potential: X
Natural Gamma: X
Samples:

0	-	5	Topsoil, black
5	-	17	Silt, reddish-brown, clayey (loess)
17	-	27	Silty, brown, clayey, very sandy (till)
27	-	30	Clay, reddish-brown, silty (paleosol)
30	-	44	Clay, yellowish-brown, very silty (till)
44	-	83	Sand, white, medium to coarse; composed of white quartz, pink and light-green feldspars, no shale clasts noticed
83	-	96	Shale, gray; greasy (Carlisle Shale)

Single Point Resistivity: X
Extra:

County: UNION
Map Location: 23
Legal Location: NW NW NW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0132
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 05-29-1985
Ground Surface Elevation: 1338.75 I
Total Drill Hole Depth: 57
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1341.00 I
Casing Stick-up: 2.25
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0	-	3	Topsoil, black
3	-	20	Silt, yellowish-brown, reddish-brown from 10 to 16 feet, mottled, clayey, very sandy from 16 to 20 feet (loess)
20	-	45	Sand, white, coarse, pebbly; composed of white quartz, pink and light-green feldspars and quartz, no shale clasts noticed
45	-	47	Clay, dark-red-brown, silty (paleosol?)
47	-	56	Clay, white, very silty, sandy
56	-	57	Shale, dark-gray; greasy (Carlisle Shale)

Location: 095N-49W-28ABBB 1

Longitude: 96.3815

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

Test Hole Number: CO-85-03
SDGS Well Name: CO-85-03

Aquifer:

Screen Length: 25.0
Casing Diameter: 2.0

Total Casing and Screen: 46.6

Single Point Resistivity:
Extra:

County: UNION
Map Location: 24
Legal Location: NW NW NW NE sec. 28, T. 095 N., R. 49 W.

Location: 095N-49W-28ABBB 2

Latitude: 43.0132
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 05-29-1985
Ground Surface Elevation: 1338.75 I
Total Drill Hole Depth: 25
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1341.05 I
Casing Stick-up: 2.30
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0	-	3	Topsoil, black
3	-	20	Silt, yellow-brown, clayey, very sandy from 16 to 20 feet; mottled (loess)
20	-	25	Sand, white, coarse; composed of white quartz, pink and light-green feldspars and quartz, no shale clasts noticed

County: UNION
Map Location: 25
Legal Location: NE NW SW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0118
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 05-30-1985
Ground Surface Elevation: 1335.17 I
Total Drill Hole Depth: 20
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1337.94 I
Casing Stick-up: 2.77
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:

Longitude: 96.3814

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

Test Hole Number: CO-85-04
SDGS Well Name: CO-85-04

Aquifer:

Screen Length: 5.0
Casing Diameter: 2.0

Total Casing and Screen: 26.3

Single Point Resistivity:
Extra:

Location: 095N-49W-28ACBA 1

Longitude: 96.3809

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

Test Hole Number: CO-85-05
SDGS Well Name: CO-85-05

Aquifer:

Screen Length:
Casing Diameter: 2.0

Total Casing and Screen: 20.5

Single Point Resistivity:

Natural Gamma:
Samples:

0	-	2	Topsoil, black
2	-	15	Silt, yellow-brown, clayey (loess)
15	-	20	Sand, white, fine; composed of white quartz, pink feldspar

Extra:

County: UNION
Map Location: 26
Legal Location: NE NW SW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0118

Location: 095N-49W-28ACBA 2

Land Owner:
Project: ALCESTER NITRATE STUDY

Longitude: 96.3809

Drilling Company: SDGS
Driller: M. THOMPSON
Geologist: L. FRYKMAN
Date Drilled: 06-04-1985
Ground Surface Elevation: 1335.16 1

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

Total Drill Hole Depth: 66
Water Rights Well:

Test Hole Number: CO-85-10
SDGS Well Name: CO-85-10

Other Well Name:
Basin: BIG SIOUX

Aquifer:

Management Unit:
Screen Type: PVC, HM. AND MFG.

Screen Length: 39.0
Casing Diameter: 2.0

Casing Type: PVC, SCH. 40
Casing Top Elevation: 1338.11 1
Casing Stick-up: 2.95

Total Casing and Screen: 58.6

Well Maintenance Date:
USGS Hydrological Unit Code: 10170203

Electric Log Information:
Spontaneous Potential:

Single Point Resistivity:

Natural Gamma:
Samples:

Extra:

0	-	2	Topsoil, black
2	-	15	Silt, yellow-brown, clayey (loess)
15	-	56	Sand, white, fine to medium; predominately quartz
56	-	66	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
Map Location: 27
Legal Location: NW SE SW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0112

Location: 095N-49W-28ACDB 1

Land Owner:
Project: ALCESTER NITRATE STUDY

Longitude: 96.3805

Drilling Company: SDGS
Driller: D. ANDERSON
Geologist: L. FRYKMAN
Date Drilled: 05-30-1985
Ground Surface Elevation: 1341.23 1

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

Total Drill Hole Depth: 36
Water Rights Well:

Test Hole Number: CO-85-06
SDGS Well Name: CO-85-06

Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1342.88 I
Casing Stick-up: 2.65
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0	-	4	Topsoil, dark-brown
4	-	17	Silt, yellow-brown, clayey; some sand, oxidized; moist
17	-	25	Sand, light-gray-brown, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; moist (loess)
25	-	35	Sand, yellowish-gray, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; saturated (loess)
35	-	43	Sand, white, fine to medium; predominately quartz

Aquifer:
Screen Length: 5.0
Casing Diameter: 2.0
Total Casing and Screen: 38.3
Single Point Resistivity:
Extra:

County: UNION
Map Location: 28
Legal Location: NW SE SW NE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0112
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: M. THOMPSON
Geologist: L. FRYKMAN
Date Drilled: 06-04-1985
Ground Surface Elevation: 1341.24 I
Total Drill Hole Depth: 77
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1343.90 I
Casing Stick-up: 2.66
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0	-	4	Topsoil, dark-brown
4	-	17	Silt, yellow-brown, clayey; some sand, oxidized; moist
17	-	25	Sand, light-gray-brown, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; moist (loess)

Location: 095N-49W-28ACDB 2
Longitude: 96.3804
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-85-11
SDGS Well Name: CO-85-11
Aquifer:
Screen Length: 26.0
Casing Diameter: 2.0
Total Casing and Screen: 64.0
Single Point Resistivity:
Extra:

25	-	35	Sand, yellowish-gray, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; saturated (loess)
35	-	62	Sand, white, fine to medium; predominately quartz
62	-	77	Shale, dark-gray; greasy (Carlile Shale)

County: UNION	Location: 095N-49W-28ACDB 3
Map Location: 29	
Legal Location: NW SE SW NE sec. 28, T. 095 N., R. 49 W.	
Latitude: 43.0112	Longitude: 96.3805
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: K. WUNDER	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 01-28-1986	Drilling Method: AUGER
Ground Surface Elevation: 1341.00 T	
Total Drill Hole Depth: 43	Test Hole Number: A2-86-01
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

0	-	4	Topsoil, dark-brown
4	-	17	Silt, yellow-brown, clayey; some sand, oxidized; moist (loess)
17	-	25	Sand, light-gray-brown, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; moist (loess)
25	-	35	Sand, yellowish-gray, very fine, very silty, clayey; composed mainly of quartz sand; oxidized; saturated (loess)
35	-	43	Sand, white, fine to medium; predominately quartz

County: UNION	Location: 095N-49W-28ADCB 1
Map Location: 30	
Legal Location: NW SW SE NE sec. 28, T. 095 N., R. 49 W.	
Latitude: 43.0110	Longitude: 96.3754
Land Owner:	
Project: ALCESTER NITRATE STUDY	
Drilling Company: SDGS	
Driller: M. THOMPSON	Driller's Log:
Geologist: L. FRYKMAN	Geologist's Log: X
Date Drilled: 06-04-1985	Drilling Method: ROTARY
Ground Surface Elevation: 1348.13 I	
Total Drill Hole Depth: 77	Test Hole Number: CO-85-12
Water Rights Well:	SDGS Well Name: CO-85-12
Other Well Name:	
Basin: BIG SIOUX	Aquifer:
Management Unit:	
Screen Type: PVC, HM. AND MFG.	Screen Length: 27.0
Casing Type: PVC, SCH. 40	Casing Diameter: 2.0
Casing Top Elevation: 1350.63 I	
Casing Stick-up: 2.50	Total Casing and Screen: 73.4
Well Maintenance Date:	

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

0	-	1	Topsoil, black
1	-	37	Silt, yellow-brown, clayey; oxidized (loess)
37	-	73	Sand and gravel, white, medium to coarse sand, fine to medium gravel; predominately quartz and feldspar
73	-	77	Shale, dark-gray; greasy (Carlile Shale)

Single Point Resistivity:

Extra:

County: UNION

Map Location: 31

Legal Location: NW SW SE NE sec. 28, T. 095 N., R. 49 W.

Latitude: 43.0110

Land Owner:

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: M. THOMPSON

Geologist: L. FRYKMAN

Date Drilled: 06-04-1985

Ground Surface Elevation: 1347.98 I

Total Drill Hole Depth: 47

Water Rights Well:

Other Well Name:

Basin: BIG SIOUX

Management Unit:

Screen Type: PVC, MFG.

Casing Type: PVC, SCH. 40

Casing Top Elevation: 1350.77 I

Casing Stick-up: 2.79

Well Maintenance Date:

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

0	-	1	Topsoil, black
1	-	37	Silt, yellow-brown, clayey; oxidized (loess)
37	-	47	Sand and gravel, white, medium to coarse sand, fine to medium gravel;

Location: 095N-49W-28ADCB 2

Longitude: 96.3755

Driller's Log:

Geologist's Log: X

Drilling Method: ROTARY

Test Hole Number: CO-85-13

SDGS Well Name: CO-85-13

Aquifer:

Screen Length: 5.0

Casing Diameter: 2.0

Total Casing and Screen: 45.4

Single Point Resistivity:

Extra:

County: UNION

Map Location: 32

Legal Location: NW SW SE NE sec. 28, T. 095 N., R. 49 W.

Latitude: 43.0110

Land Owner:

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: M. JARRETT

Geologist: L. FRYKMAN

Location: 095N-49W-28ADCB 3

Longitude: 96.3754

Driller's Log:

Geologist's Log: X

Date Drilled: 09-29-1986
Ground Surface Elevation: 1348.00 T
Total Drill Hole Depth: 38
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Drilling Method: AUGER
Test Hole Number: A1-86-329

Single Point Resistivity:
Extra:

0	-	1	Topsoil, black, silty
1	-	5	Silt, light-tan-brown; moist (loess)
5	-	13	Silt, tan-brown, clayey; moist
13	-	18	Clay, pale-whitish-gray-brown, very silty; moist (loess?)
18	-	20	Clay, whitish-gray-brown, very silty; moist (loess?)
20	-	28	Clay, pale-whitish-gray-brown, very silty; moist (loess?)
28	-	34	Silt, whitish-gray, very clayey, very sandy; moist, sand is fine (loess?)
34	-	38	Sand, whitish-gray, fine to medium, silty; saturated, predominately quartz

County: UNION
Map Location: 33
Legal Location: NE NW NE SE sec. 28, T. 095 N., R. 49 W.
Latitude: 43.0104
Land Owner:

Location: 095N-49W-28DABA

Longitude: 96.3749

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: D. ANDERSON

Geologist: L. FRYKMAN

Date Drilled: 06-03-1985

Ground Surface Elevation: 1338.26 1

Total Drill Hole Depth: 75

Water Rights Well:

Other Well Name:

Basin: BIG SIOUX

Management Unit:

Screen Type: PVC, HM. AND MFG.

Casing Type: PVC, SCH. 40

Casing Top Elevation: 1340.82 1

Casing Stick-up: 2.56

Well Maintenance Date:

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Driller's Log:

Geologist's Log: X

Drilling Method: ROTARY

Test Hole Number: CO-85-08

SDGS Well Name: CO-85-08

Aquifer:

Screen Length: 30.0

Casing Diameter: 2.0

Total Casing and Screen: 67.7

Single Point Resistivity:

Extra:

0	-	5	Topsoil, black
5	-	15	Silt, yellow-brown, clayey, very sandy from 13 to 15 feet (alluvium)
15	-	33	Sand, dark-brown, fine to medium, poorly sorted
33	-	68	Sand, white, fine to coarse, poorly sorted; predominately quartz and feldspar
68	-	75	Shale, dark-gray; greasy (Carlisle Shale)

County: UNION

Location: 095N-49W-28DCDC

Map Location: 34
 Legal Location: SW SE SW SE sec. 28, T. 095 N., R. 49 W.
 Latitude: 43.0041
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: D. ANDERSON
 Geologist: L. FRYKMAN
 Date Drilled: 05-30-1985
 Ground Surface Elevation: 1342.99 I
 Total Drill Hole Depth: 95
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40
 Casing Top Elevation: 1345.27 I
 Casing Stick-up: 2.28
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Longitude: 96.3807

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

Test Hole Number: CO-85-07
 SDGS Well Name: CO-85-07

Aquifer:

Screen Length: 40.0
 Casing Diameter: 2.0

Total Casing and Screen: 64.1

Single Point Resistivity:
 Extra:

0	-	9	Topsoil, black, silty, clayey, sandy
9	-	16	Silt, yellow-brown, clayey, very sandy from 15 to 16 feet; oxidized (alluvium)
16	-	20	Sand, brown, fine to medium, very silty, clayey (alluvium)
20	-	24	Gravel, white, fine; has white silt or clay stringer; predominately quartz grains
24	-	33	Sand, white, medium to coarse; with some gravel; predominately quartz grains
33	-	66	Sand, white, coarse; contains quartz and feldspar
66	-	75	Sand, white, fine; with white clay stringers; predominately quartz
75	-	95	Shale, dark-gray; greasy (Carlile Shale)

County: UNION
 Map Location: 35
 Legal Location: SE SE SE SE sec. 28, T. 095 N., R. 49 W.
 Latitude: 43.0041
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON
 Geologist: L. FRYKMAN
 Date Drilled: 06-07-1985
 Ground Surface Elevation: 1386.29 I
 Total Drill Hole Depth: 127
 Water Rights Well:
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit:
 Screen Type: PVC, HM. AND MFG.
 Casing Type: PVC, SCH. 40

Location: 095N-49W-28DDDD

Longitude: 96.3740

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

Test Hole Number: CO-85-21
 SDGS Well Name: CO-85-21

Aquifer:

Screen Length: 46.0
 Casing Diameter: 2.0

Casing Top Elevation: 1388.39 I
Casing Stick-up: 2.10
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Total Casing and Screen: 120.8

Single Point Resistivity:
Extra:

0	-	1	Topsoil, black
1	-	10	Silt, yellow-brown, clayey (loess)
10	-	34	Clay, yellow-brown, silty, pebbly; oxidized (till)
34	-	73	Clay, gray, silty, pebbly; unoxidized (till)
73	-	76	Clay, tan, silty, pebbly; hit hard spot at 73 feet, rock(?); oxidized (till)
76	-	123	Sand and gravel, white, coarse sand, fine gravel; predominately quartz and feldspar
123	-	127	Shale, dark-gray; greasy (Carlisle Shale)

County: UNION
Map Location: 36
Legal Location: SE SE NE NE sec. 29, T. 095 N., R. 49 W.
Latitude: 43.0120

Location: 095N-49W-29AADD 1

Longitude: 96.3851

Land Owner:
Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS
Driller: M. THOMPSON

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

Geologist: L. FRYKMAN
Date Drilled: 06-05-1985
Ground Surface Elevation: 1315.97 I
Total Drill Hole Depth: 57

Test Hole Number: CO-85-15
SDGS Well Name: CO-85-15

Water Rights Well:
Other Well Name:

Aquifer:

Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.

Screen Length: 28.0
Casing Diameter: 2.0

Casing Type: PVC, SCH. 40
Casing Top Elevation: 1318.60 I
Casing Stick-up: 2.63

Total Casing and Screen: 53.7

Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:

Single Point Resistivity:
Extra:

Spontaneous Potential:
Natural Gamma:
Samples:

0	-	2	Topsoil, black, silty
2	-	14	Silt, yellow-brown to dark-brown, clayey; oxidized (alluvium)
14	-	22	Clay, gray, very silty (alluvium)
22	-	51	Sand and gravel, white, sand coarse, gravel fine to medium; sand had iron concretions; predominately quartz with a few small clay stringers
51	-	57	Shale, dark-gray; greasy (Carlisle Shale)

County: UNION

Location: 095N-49W-29AADD 2

Map Location: 37
Legal Location: SE SE NE NE sec. 29, T. 095 N., R. 49 W.
Latitude: 43.0120
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: M. THOMPSON
Geologist: L. FRYKMAN
Date Drilled: 06-05-1985
Ground Surface Elevation: 1316.13 I
Total Drill Hole Depth: 27
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1318.43 I
Casing Stick-up: 2.30
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0	-	2	Topsoil, black, silty
2	-	14	Silt, yellow-brown to dark-brown, clayey; oxidized (alluvium)
14	-	22	Clay, gray, very silty (alluvium)
22	-	27	Sand and gravel, white, sand coarse, gravel fine to medium; predominately quartz

Longitude: 96.3851

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

Test Hole Number: CO-85-16
SDGS Well Name: CO-85-16

Aquifer:

Screen Length: 5.0
Casing Diameter: 2.0

Total Casing and Screen: 27.8

Single Point Resistivity:
Extra:

County: UNION
Map Location: 38
Legal Location: NW NW NW NW sec. 33, T. 095 N., R. 49 W.
Latitude: 43.0039
Land Owner:
Project: ALCESTER NITRATE STUDY
Drilling Company: SDGS
Driller: C. SCHMIG
Geologist: L. FRYKMAN
Date Drilled: 08-28-1985
Ground Surface Elevation: 1389.17 I
Total Drill Hole Depth: 140
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, HM. AND MFG.
Casing Type: PVC, SCH. 40
Casing Top Elevation: 1392.87 I
Casing Stick-up: 3.70
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203

Location: 095N-49W-33BBBB

Longitude: 96.3850

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

Test Hole Number: R2-85-92
SDGS Well Name: R2-85-92

Aquifer:

Screen Length: 60.0
Casing Diameter: 2.0

Total Casing and Screen: 124.8

Electric Log Information:

Spontaneous Potential:
Natural Gamma: X
Samples:

Single Point Resistivity: X
Extra:

0	-	1	Topsoil, black
1	-	17	Silt, yellow-brown, clayey, sandy; oxidized (loess)
17	-	29	Clay, brown to yellow-brown, silty, sandy; firm, oxidized (till)
29	-	40	Clay, light-gray to brown, mottled, silty, sandy, pebbly; firm, oxidized (till)
40	-	47	Sand, brown, medium to coarse
47	-	51	Clay, pinkish-brown, silty, sandy; oxidized (paleosol?)
51	-	57	Clay, light-brown to gray-brown, mottled, silty, sandy; oxidized (till)
57	-	123	Sand and gravel, pinkish-white, coarse sand, fine gravel; predominately quartz and feldspar; various clay lenses at 81 to 84 feet and more below 100 feet
123	-	140	Shale, dark-gray; greasy (Carlisle Shale)

County: UNION

Location: 095N-49W-33CBBB 1

Map Location: 39

Legal Location: NW NW NW SW sec. 33, T. 095 N., R. 49 W.

Latitude: 43.0013

Longitude: 96.3850

Land Owner:

Project: ALCESTER NITRATE STUDY

Drilling Company: SDGS

Driller: M. THOMPSON

Geologist: L. FRYKMAN

Date Drilled: 10-31-1986

Ground Surface Elevation: 1411.94 1

Total Drill Hole Depth: 157

Water Rights Well:

Other Well Name:

Basin: BIG SIOUX

Management Unit:

Screen Type: PVC, HM. AND MFG.

Casing Type: PVC, SCH. 40

Casing Top Elevation: 1414.07 1

Casing Stick-up: 2.13

Well Maintenance Date:

USGS Hydrological Unit Code: 10170203

Electric Log Information:

Spontaneous Potential:

Natural Gamma: X

Samples:

Driller's Log:

Geologist's Log: X

Drilling Method: ROTARY

Test Hole Number: CO-86-123

SDGS Well Name: CO-86-123

Aquifer:

Screen Length: 45.0

Casing Diameter: 2.0

Total Casing and Screen: 136.0

Single Point Resistivity: X

Extra:

0	-	4	Silt, yellow-brown, clayey (loess)
4	-	24	Sand, brown, fine to medium; glacial outwash sand
24	-	31	Clay, yellow-brown, very silty, pebbly; oxidized (till)
31	-	44	Clay, yellow-brown and gray mottled, silty, pebbly; oxidized (till)
44	-	52	Clay, brown and greenish-gray, mottled, silty, pebbly; oxidized, greasy (till)
52	-	63	Clay, gray, silty, pebbly; unoxidized, very greasy (till)
63	-	82	Silt, pinkish-brown; hard (loess?)
82	-	90	Sand, white to pinkish-white, fine to medium; predominately quartz and feldspar
90	-	136	Sand, white to pinkish-white, medium to coarse; fine pebbles, predominately quartz and feldspar

136 - 138 Clay, yellowish-green; greasy
 138 - 141 Sand, white to pinkish-white, fine; predominately quartz and feldspar
 141 - 157 Shale, dark-gray, some reddish-yellow on top of formation; greasy (Carlile Shale)

County: UNION Location: 095N-49W-33CBBB 2
 Map Location: 40
 Legal Location: NW NW NW SW sec. 33, T. 095 N., R. 49 W.
 Latitude: 43.0013 Longitude: 96.3850
 Land Owner:
 Project: ALCESTER NITRATE STUDY
 Drilling Company: SDGS
 Driller: M. THOMPSON Driller's Log:
 Geologist: L. FRYKMAN Geologist's Log: X
 Date Drilled: 11-24-1986 Drilling Method: ROTARY
 Ground Surface Elevation: 1412.56 I
 Total Drill Hole Depth: 147 Test Hole Number: CO-86-124
 Water Rights Well: SDGS Well Name: CO-86-124
 Other Well Name:
 Basin: BIG SIOUX Aquifer:
 Management Unit:
 Screen Type: PVC, HM. AND MFG. Screen Length: 55.0
 Casing Type: PVC, SCH. 40 Casing Diameter: 2.0
 Casing Top Elevation: 1415.18 I
 Casing Stick-up: 2.62 Total Casing and Screen: 150.0
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential: Single Point Resistivity:
 Natural Gamma: Extra:
 Samples:

0 - 2 Topsoil, black
 2 - 14 Sand, light-brown, medium; glacial outwash sand
 14 - 28 Clay, yellow-brown, silty, pebbly; oxidized (till)
 28 - 31 Clay, gray, silty, pebbly; unoxidized (till)
 31 - 53 Clay, yellow-brown, very silty, pebbly; oxidized (till)
 53 - 54 Clay, greenish-gray, silty, pebbly; unoxidized (till)
 54 - 65 Clay, gray, silty, pebbly; unoxidized (till)
 65 - 81 Silt, pinkish-brown; bits of organic material (loess)
 81 - 86 Silt, light-yellowish-gray, sandy; some quartzite pebbles
 86 - 134 Sand, pinkish-white, medium to coarse; fine pebbles, predominately quartz and feldspar,
 some shale pebbles
 134 - 135 Clay, yellow-brown, sandy
 135 - 144 Sand, pinkish-white, medium to coarse; predominately quartz and feldspar
 144 - 147 Shale, dark-gray; greasy (Carlile Shale)