QUALITY OF WATER FROM SURFICIAL-OUTWASH AQUIFERS IN THE BIG SIOUX RIVER BASIN, EASTERN SOUTH DAKOTA

By Stephen J. Lawrence and Steven K. Sando

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
inch	25.4	millimeter
square mile (mi^2)	2.590	square kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Approximately 1,300 square miles of surficial outwash deposits underlie the Big Sioux River basin of eastern South Dakota. This report summarizes the water-quality regime, defines relations among water-quality and hydrogeologic characteristics, and determines the spatial trends for water-quality properties in the basin. Summary statistics, nonparametric analysis of variance, nonparametric correlation, and linear regression techniques were used in analyzing data.

Areal differences in the quality of water in the outwash deposits are determined largely by contact time between ground water and limestone, dolomite, gypsum, and weathering products of those minerals rather than by differences in the mineralogy of the outwash.

Water in the surficial outwash deposits of the basin have dissolved-solids concentrations ranging from 220 to 3,050 milligrams per liter. The dominant ions in the water are calcium, magnesium, sulfate, and bicarbonate. The relation between dissolved solids and specific conductance is curvilinear because of generally large concentrations of sulfate. No relations between hydrogeology and water-quality constituents were observed. Spatial relations between outwash units and their locations in the basin were absent.

Statistical comparisons of concentrations of water-quality constituents were performed among seven outwash units. The Big Sioux-Brookings (east) outwash unit had too few water samples with nitrate-nitrogen concentration less than 2.0 milligrams per liter and was excluded from this analysis. Water samples from the Big Sioux-Brookings (west) outwash unit had concentrations of nearly all chemical constituents that were significantly larger than concentrations in samples from all other outwash units except Brule Creek and Newton Hills.

All outwash units had many water samples that exceeded nitrate-nitrogen levels considered natural background; most outwash units had some samples that approached or exceeded the maximum contaminant level for drinking water of 10 milligrams per liter nitrate nitrogen established by the Environmental Protection Agency. Largest concentrations of nitrate were found in the Big Sioux-Brookings (east) unit with about one-fourth of the samples approaching or exceeding 10 milligrams per liter. Nitrate-nitrogen concentrations were related inversely to concentrations of several major cations and anions.

INTRODUCTION

Studies of ground-water quality, ground-water contamination, and ground-water-contamination potential have increased both in frequency and in effort during the past 20 years. These studies have developed from a realization that many ground-water basins have been contaminated, in some cases extensively, by the activities of man, and also that many aquifers are highly susceptible to contamination by the movement of materials from land surface into underlying aquifers. Surficial aquifers of glacial origin are particularly vulnerable to contamination because highly permeable sands and gravels, common in some glacial deposits, often are overlaid by a relatively thin mantle of soil.

Eastern South Dakota, in particular the Big Sioux River basin, is an example of an area where ground-water resources are susceptible to contamination. The surficial geology is derived from Pleistocene glaciation that resulted in the deposition of sand and gravel that currently are either at or near land surface. These sand and gravel deposits are important aquifers. The most important of these in terms of water-supply development and potential are the outwash deposits that comprise the various units of the Big Sioux aquifer. Agriculture and agriculture-related industries are extensive in this area. The potential for aquifer contamination exists from fertilizers and pesticides (through application or through leakage from storage areas), and by the presence of livestock holding areas and septic-tank fields. Landfills, petroleum pipelines, and underground petroleum-storage tanks are additional sources of present and potential contamination of surficial aquifers in the Big Sioux River basin (South Dakota Department of Water and Natural Resources, 1986).

The U.S. Geological Survey, in cooperation with the South Dakota Geological Survey, began an investigation during 1986 to define the quality of water of surficial-outwash aquifers in the Big Sioux River basin in eastern South Dakota. The purpose of this report is to describe the results of that investigation, including: (1) A baseline statistical summary of major cations, major anions, and trace elements in outwash aquifers; (2) statistical comparisons between outwash study units; and (3) statistical analyses to establish predictive equations for future ground-water-quality monitoring in the Big Sioux River basin.

Description of the Study Area

The Big Sioux River basin originates in northeastern South Dakota and extends southerly along the eastern edge of the State (fig. 1). The basin has a drainage area of about 9,000 mi^2 (Amundson and others, 1985), of which 69 percent is in South Dakota, 16 percent is in Minnesota, and 15 percent is in Iowa. The Big Sioux River flows southerly along the mid-line of the basin and meets the Missouri River at Sioux City, Iowa.

Land use in the basin is primarily agricultural with corn, wheat, soybeans, miscellaneous small grains, and alfalfa as the major crops. Livestock raised in the basin include dairy cattle, beef cattle, and hogs. Several urban areas are in the basin, including the cities of Sioux Falls, Brookings, and Watertown.

Outwash deposits along the Big Sioux River and its tributaries underlie parts of 12 counties in South Dakota. These outwash deposits include the various units of the Big Sioux aquifer, which is one of the more extensively developed aquifers in the State. About 204,000 people (1980 census), or nearly 32 percent of the State's population, live in the Big Sioux River basin. Numerous public water supplies (average use of 20,000 acre-ft/yr) and 16,000 housing units with private wells use water from the Big Sioux aquifer (South Dakota Department of Water and Natural Resources, 1986).

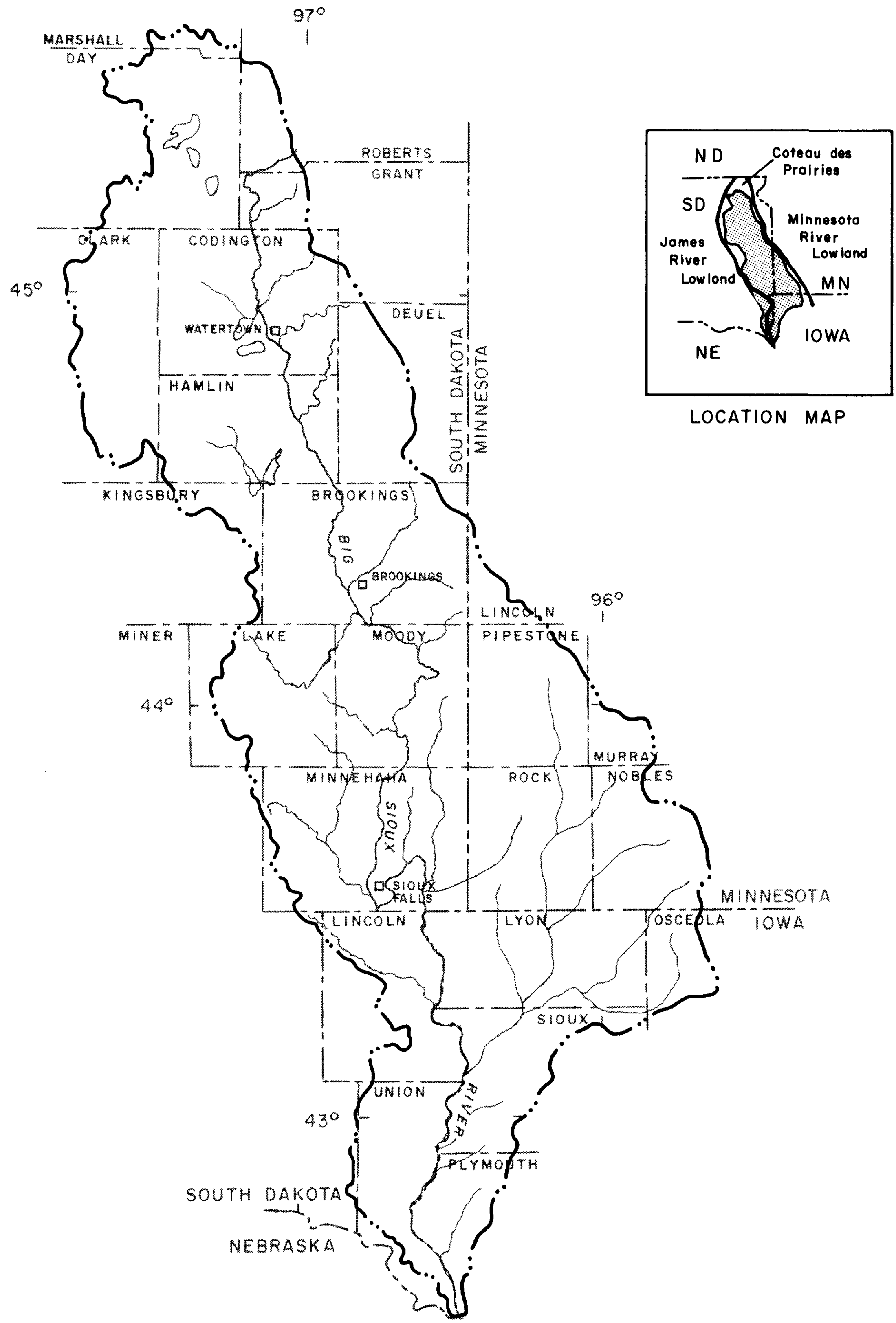

Figure 1.--Location of the Big Sioux River basin.

Climate and Physiography

Climate

The climate of South Dakota typically is continental and is characterized by large seasonal (commonly as low as -20 °F in winter and as high as 100 °F in summer) and daily variations in temperature, minimal winter precipitation, and marginal to adequate rainfall during the growing season. Average annual precipitation in the basin at Brookings is about 21.7 inches. The variability of the monthly precipitation during the study period is shown in figure 2. The median monthly precipitation during the study period (calendar years 1978-86) was greatest during May, June, and August. During the study period, the wettest years were 1984-86 and the driest were 1980 and 1981 (fig. 3).

Physiography

The Big Sioux River drains an extended highland or plateau, the Coteau des Prairies, which is the largest single topographic feature in eastern South Dakota. The coteau is a 200-mi-long, flatiron-shaped constructional remnant from glacial ice sheets that moved south along the eastern edge of South Dakota (Flint, 1971; Leap, 1988). The point of the flatiron begins at the boundary between North Dakota and South Dakota and broadens gradually in approximately a southerly direction to a width of 80 mi at its southern extremity.

Along the northeastern margin, the Coteau has an elevation of more than 2,000 ft above sea level, with elevations tending to decrease in a western direction. Elevations along the western margin generally are 100 to 200 ft lower than along the eastern margin. The general topography of the Coteau is rolling and hummocky because of glacial moraines, stream valleys, and various other geomorphic features such as prairie mounds, disintegration ridges, kames, kame terraces, plateaus, and collapsed features. Leap (1988) describes these features in detail.

Geology

The oldest known rock in the area is the Sioux Quartzite of Precambrian age, which is exposed in the Big Sioux River basin near Sioux Falls and in scattered areas in the central part of the basin. Overlying the quartzite is a thin succession of marine sediments of Cretaceous age, composed mainly of sand, shale, clay, silt, and chalk. The formations included in this succession, although they may not all be present in all parts of the basin, are the Dakota Sandstone, Graneros Shale, Greenhorn Limestone, Carlile Shale, Niobrara Formation, and Pierre Shale (Hedges and others, 1982; Leap, 1988). The Coteau des Prairies is a constructional remnant of Pleistocene glaciation comprised of glacial drift overlying a topographic high of Precambrian quartzite and Cretaceous sediments.

Glacial deposits in the northern part of the Big Sioux River basin form a broad outwash (primarily collapsed) valley that narrows in Minnehaha County and widens in the southern part of the basin, where the outwash merges with the Missouri aquifer in Union County. Glacial drift overlying the Cretaceous sediments may be as thick as 500 ft (Koch, 1980; Beissel and Gilbertson, 1987). More detailed information on the glacial geology of the area can be found in Beissel and Gilbertson (1987) and Leap (1988). The drift can be separated into till, outwash, and glacial-lake deposits (fig. 4). Black till makes up the greatest bulk of the drift in the basin. This till generally is a heterogeneous mixture of silt, sand, and rock fragments within a matrix of

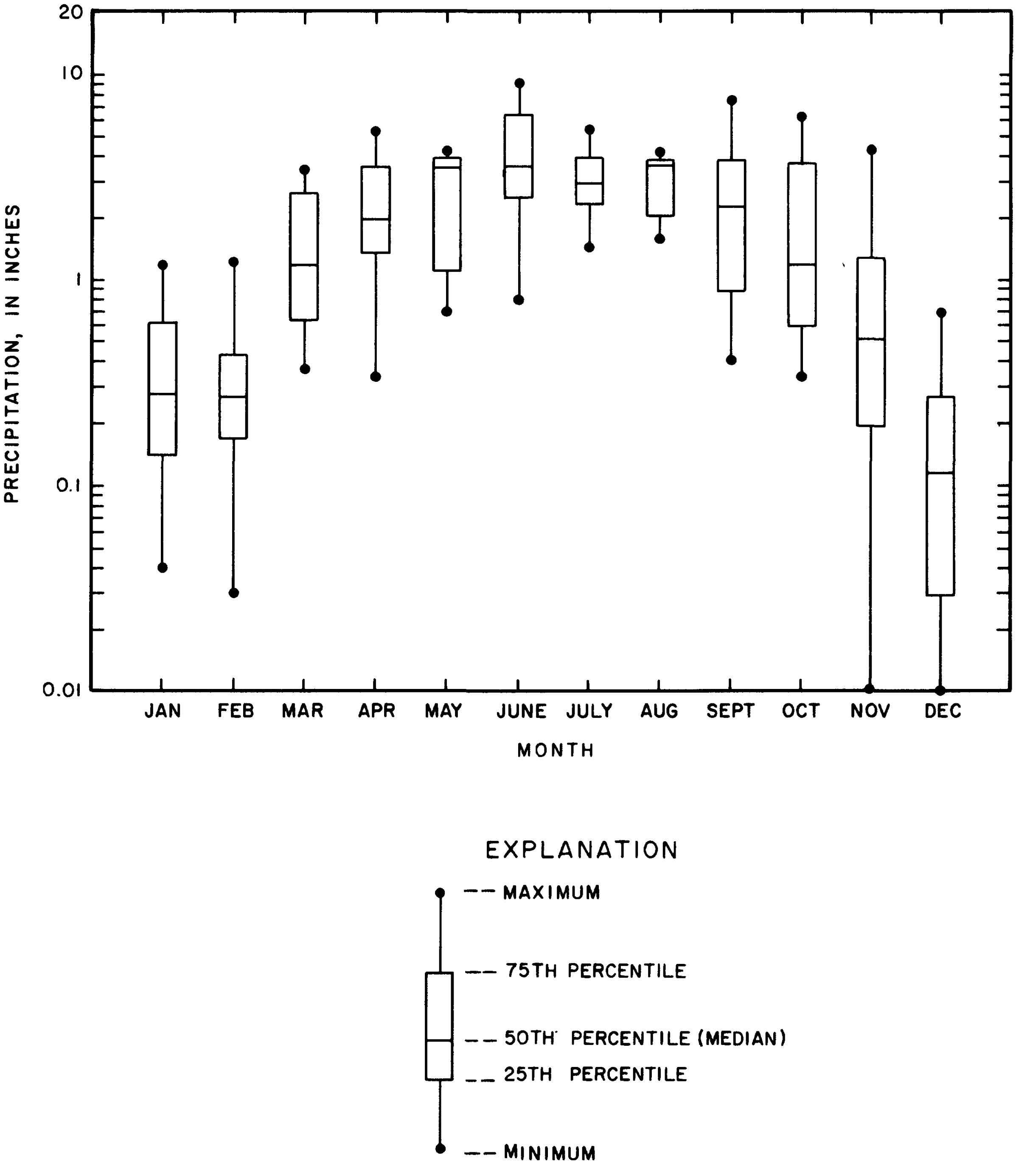

Figure 2.--Distribution of monthly precipitation at Brookings for calendar years 1978-86.

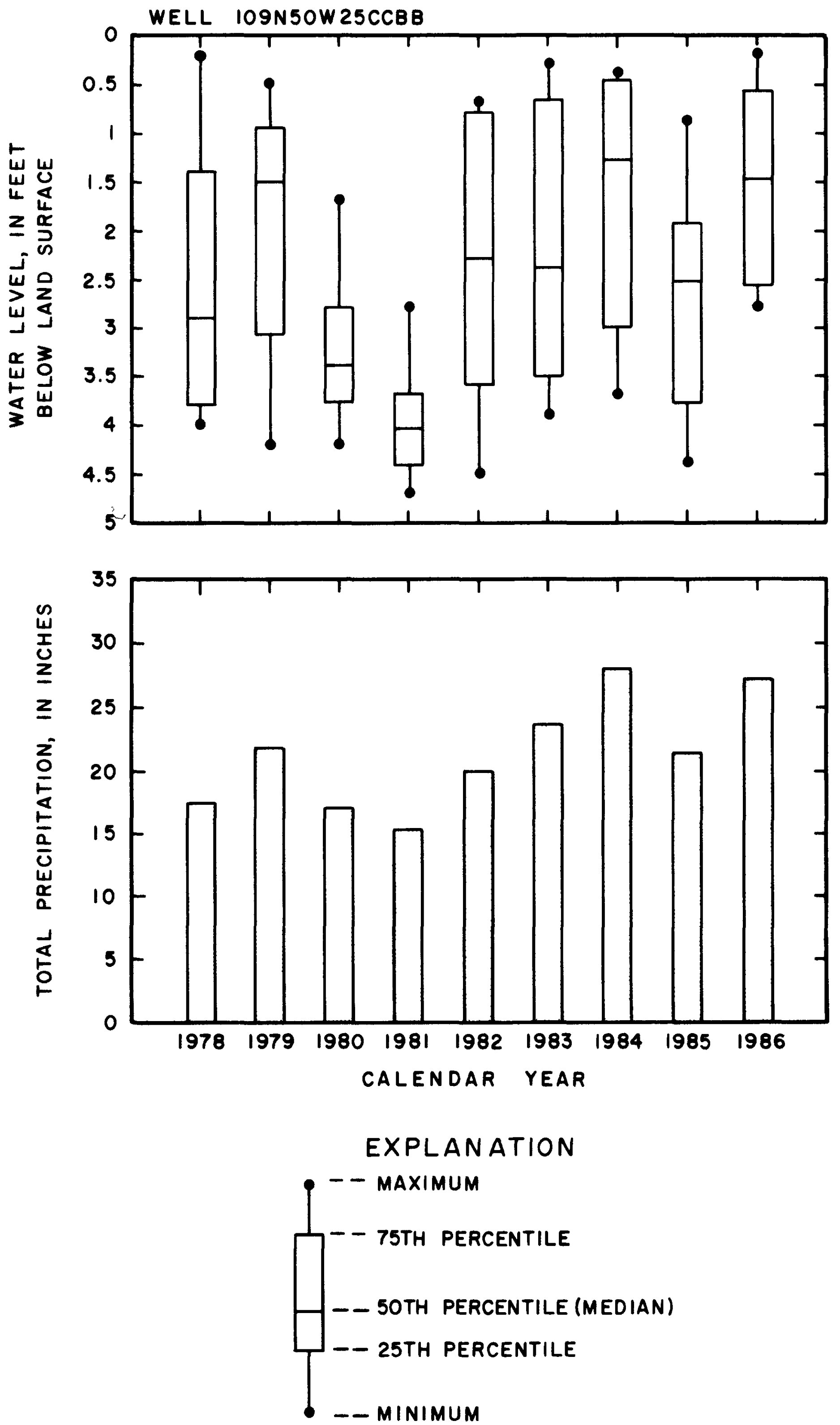

Figure 3.--Depth to water at an observation well near Brookings and total precipitation at the National Weather Service station at Brookings, calendar years 1978-86.

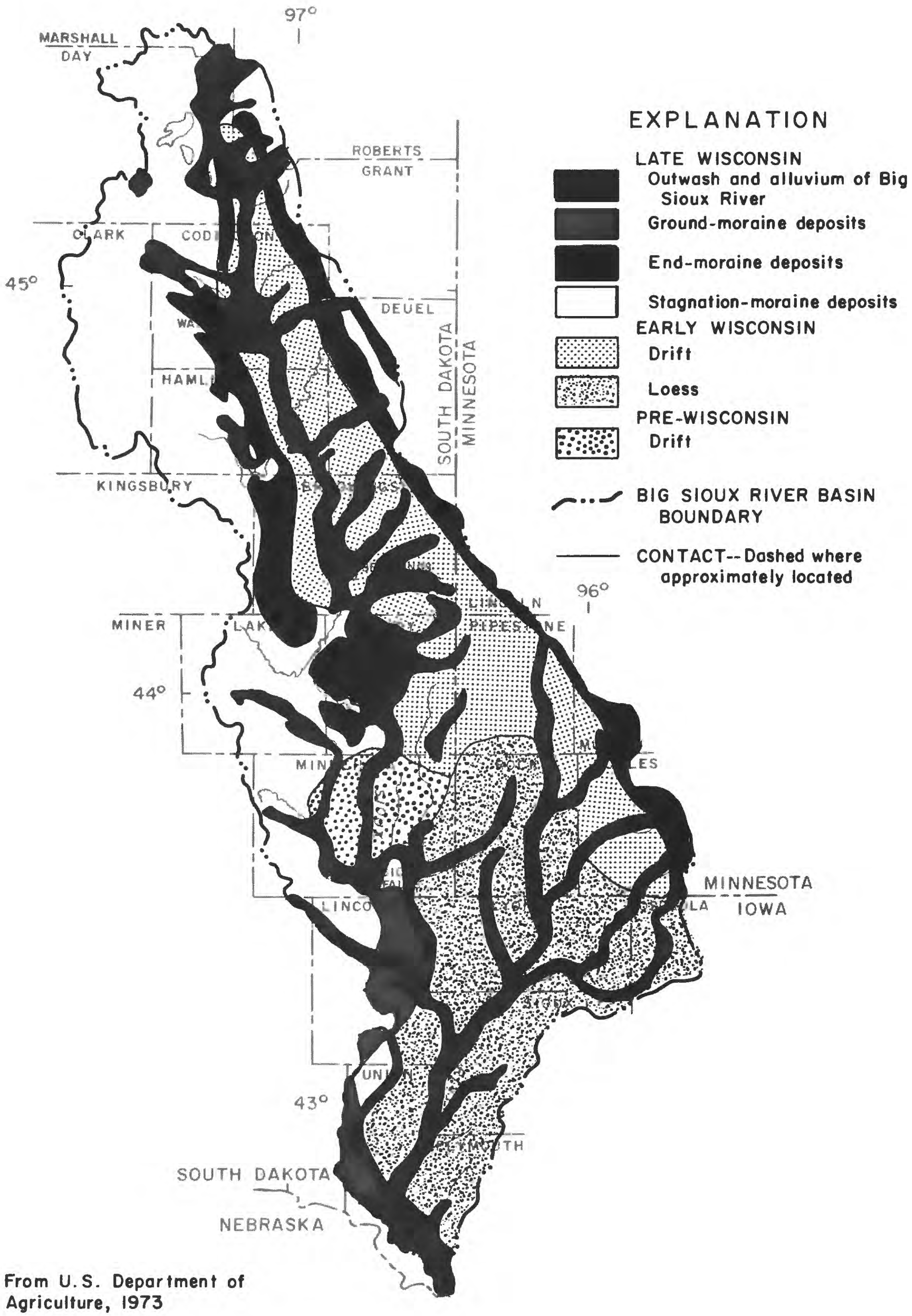

Figure 4.--Pleistocene geology of the Big Sioux River basin.

calcareous clay. The outwash deposits consist of cross-bedded gravel, sand, and silt that range in thickness from a few feet to 200 ft. Outwash is the major source of ground water in the basin; yields to wells in some areas may be large enough for irrigation. Glacial-lake deposits are fine-grained clay and silt that accumulated in temporary lakes or ponds located in till. These lake deposits are relatively impermeable, and range from 4 to 10 ft in thickness.

In general, the outwash deposits in the basin are surficial, unconfined, and glaciofluvial in origin (South Dakota Department of Water and Natural Resources, 1985; Flint, 1955). Outwash underlies about 1,300 mi^2 of the Big Sioux River basin and ranges between 3 and 40 ft in thickness.

Hydrology

Several reports have been published by the U.S. Geological Survey (Koch, 1975, 1980, 1982; Kume, 1985; Hansen, 1986, 1990; and Hamilton, 1989), the South Dakota Geological Survey (Stach and others, 1984), and the South Dakota Department of Water and Natural Resources (1985) that provide in-depth discussions of the ground-water hydrology in the Big Sioux River basin. In general the outwash deposits in the basin are under water-table conditions, except for a small area in the vicinity of T. 112 N., R. 51 W. where the aquifer is confined. The depth to water usually is less than 20 ft (Koch, 1980; Hansen, 1986). Regional recharge to the aquifer is principally the result of infiltrating precipitation, although recharge by seepage from the Big Sioux River and its tributaries occurs locally. Water levels in the aquifer fluctuate in response to seasonal variations in precipitation, pumpage, and evapotranspiration, and to annual variations in precipitation (fig. 3). The major component of regional flow is toward the streams with a minor component paralleling the streams for short distances until intercepted by stream channels.

SAMPLING METHODS AND DATA ANALYSES

Well Placement and Construction

Data from 207 wells were used for this study (table 13, Supplemental Information section at the end of this report). Hydrogeologic data were available for 110 of the wells from which samples were collected. About one-half of the wells were constructed specifically for this study, and the remaining wells had been constructed previously.

The locations of the wells that were constructed were selected by a stratified randomization scheme that began by dividing the basin into north, central, and south sections. Well sites within each of the three sections were selected randomly by township, range within that township, and section within that township and range. At a few of the randomly selected sites, privately owned farmstead wells were available for use. At the remainder of the sites, observation wells were drilled, cased, and screened by the South Dakota Geological Survey following accepted well construction methods (Coker, 1984). The depth of each newly constructed well was determined by the depth at which water-bearing sand and gravel occurred.

Water-Quality Sampling

Ground-water samples used in this study were collected and analyzed by several different State and Federal agencies during 1978-86. About 50 percent of the samples did not have information concerning the collecting or analyzing agency. These samples probably were collected by various divisions of the South Dakota Department of Water and Natural Resources, or by the U.S. Department of Energy as part of the National Uranium Resources Evaluation Program.

About 50 percent of the samples were specifically collected for this study by divisions of the South Dakota Department of Water and Natural Resources (primarily the South Dakota Geological Survey) and by the U.S. Geological Survey. For these samples, well casings were either pumped out or blown out with compressed air prior to sampling. Samples were collected by using a peristaltic pump or bailer when specific-conductance values had stabilized (Coker, 1984). No effort was made to collect samples within a closed system to prevent the out-gassing of carbon dioxide. Field measurements of pH were made sporadically but were not included in the data analysis. The properties and constituents sampled and the methods of sample collection and preservation used by the U.S. Geological Survey and the South Dakota Geological Survey are listed in table 1.

Table 1.--A summary of sample-treatment methods used by the U.S. Geological Survey and the South Dakota Geological Survey during this study

Constituent or physical property	Bottle type[1]		Filtered		Preservation[2]	
	USGS[3]	SDGS[4]	USGS	SDGS	USGS	SDGS
Specific conductance	2	2	no	yes	1	1,2
Dissolved solids	2	2	no	yes	1	1,2
Nitrate-nitrite N	3	2	yes	yes	2,3	2,4
Calcium	1	1	yes	yes	5	5
Magnesium	1	1	yes	yes	5	5
Sodium	1	1	yes	yes	5	5
Potassium	1	1	yes	yes	5	5
Chloride	2	2	yes	yes	1	4
Sulfate	2	2	yes	yes	1	4
Fluoride	2	2	yes	yes	1	4
Iron	1	1	yes	yes	5	5
Manganese	1	1	yes	yes	5	5
Trace metals	1	1	yes	yes	5	5
Mercury	4	1	yes	yes	6	1

[1]Bottle type: 1, polyethylene, acid rinsed; 2, polyethylene, not treated; 3, brown polyethylene; 4, glass.
[2]Preservation: 1, no treatment; 2, cold; 3, mercuric chloride; 4, sulfuric acid; 5, nitric acid; 6, nitric acid/potassium permanganate.
[3]USGS - U.S. Geological Survey.
[4]SDGS - South Dakota Geological Survey.

Quality Assurance

The laboratory analyses of most water samples collected for this study were completed at the South Dakota Geological Survey laboratory in Vermillion, South Dakota. A laboratory quality-assurance program was established using replicate samples, blind field spikes, field blanks, and participation in the U.S. Geological Survey Analytical Quality Assurance Program.

Generally samples were not included in the analyses when the percent difference between cations and anions (in milliequivalents per liter) was greater than 10 percent, except when dissolved-solids and sulfate concentrations were high, in which case 15 percent was used. In regression analysis, values greater than 2.5 standard deviations beyond a computed regression line were scrutinized for analytical errors and were excluded when analytical errors appeared to exist.

In all subsequent sections of this report, except those entitled "Nitrate nitrogen," samples were excluded when nitrate (as nitrogen) or nitrate plus nitrite (as nitrogen) concentrations were larger than 2.0 mg/L (milligrams per liter). The 2.0-mg/L threshold was determined as a compromise to prevent the inclusion of samples considered to be affected by man or livestock and to ensure that enough samples remained for a reasonable analysis. The natural or background concentrations of nitrate (as nitrogen) in ground-water samples in the basin were considered to be less than the detection limit of 0.10 mg/L. Sections of this report entitled "Nitrate nitrogen" address the spatial variability of nitrate-nitrogen concentrations, as well as relations between nitrate nitrogen and hydrogeologic and water-quality variables. Including those samples with nitrate-nitrogen or nitrate-plus-nitrite nitrogen concentrations larger than 2.0 mg/L was essential in investigating these topics.

Data Analysis

Water-quality data typically are skewed, which means they are distributed asymmetrically around the mean or median. Traditional statistical procedures which often assume a normal distribution of data may not be appropriate when analyzing water-quality data. The quartile skew coefficient, which is a robust measure of the skewness of a data set, was used to test the distribution of the water-quality data analyzed in this study. Quartile skew coefficients (table 2) indicated most parameters were positively skewed and so nonparametric statistical procedures generally were used during the data analysis. An alpha level of 0.05 was used in all statistical analyses.

A Spearman rank correlation analysis was used to find statistically significant relations among the parameters collected. Linear regression was used to determine the relation between specific conductance and selected water-quality constituents which were significantly correlated with conductance. Well logs were used to develop classes for depth to sand and gravel and thickness of sands or gravel. A Kruskal-Wallis nonparametric one-way analysis of variance on ranks was used to determine whether significant differences existed in water-quality constituents among classes of these hydrogeologic variables. When significant differences were detected among classes of hydrogeologic variables, Dunn's multiple comparison procedure was used to identify significant differences between individual pairs of classes of hydrogeologic variables. The Kruskal-Wallis analysis of variance and Dunn's multiple comparison procedures also were used to test for differences in water-quality constituents among the eight study units.

Table 2.--Quartile skew coefficients for selected water-quality constituents or physical properties for ground-water samples in the Big Sioux River basin

Constituent or physical property	Number	Quartile skew coefficient[1]
Well depth	124	0.215
Depth to water	87	0.061
Specific conductance	221	0.200
Alkalinity	214	0.090
Dissolved solids	161	0.113
Calcium	222	0.203
Magnesium	221	0.048
Sodium	222	0.250
Potassium	215	0.333
Sulfate	223	0.168
Chloride	222	0.340
Fluoride	104	-0.362
Nitrate-nitrite N	162	0.585
Boron	129	0.143
Iron	153	0.664
Manganese	107	0.108

[1]Quartile skew coefficient (Kenney and Keeping, 1954) is a robust measure of skewness and is calculated by the formula:

$$qs = \frac{(X.75-X.50) - (X.50-X.25)}{X.75-X.25}$$

where: qs = quartile skew coefficient, and
X.ZZ = value of the specified parameter which was greater than or equal to ZZ percent of the values for that parameter.

As indicated earlier, ground-water samples used in this study were collected and analyzed by several agencies. This sometimes caused difficulties in integrating all samples into a single data set.

For most of the samples, dissolved nitrite plus nitrate nitrogen was the only form of nitrogen which was determined. However, a number of samples were analyzed only for dissolved nitrate nitrogen or for total nitrate nitrogen. For the study, all three of these forms of nitrogen were considered to represent dissolved nitrate nitrogen. Samples that had been analyzed for both dissolved nitrate nitrogen and dissolved nitrite nitrogen indicated that dissolved nitrite-nitrogen concentrations were negligible as compared to dissolved nitrate-nitrogen concentrations.

Another problem encountered in developing a single data set involved the distinction between the dissolved and total recoverable fractions of some constituents. Most samples were known to have been filtered, and constituents were specified as being in the dissolved fraction. However, some samples were either unfiltered or were not known to have been filtered, and the constituents were specified as total recoverable. For constituents where dissolved concentrations were much larger than suspended concentrations, the total recoverable fraction was considered to represent the dissolved fraction. This policy was used for the following constituents: potassium, nitrate, arsenic, boron, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, and zinc.

There were inconsistencies among analyzing agencies regarding the handling of values less than detection limits, especially for samples obtained during the early part of the 1978-86 collection period. For a few samples, values less than detection limits were entered into the U.S. Geological Survey water-quality data base as either zero values or as "not detected," with no detection limit specified. Where possible, the analyzing agency for these samples was contacted to obtain information concerning the detection limit. When the analyzing agency for a sample was not specified, the most frequently occurring detection limit for a particular constituent was substituted for a zero-concentration or "not-detected" value.

Chemical analyses of water samples were grouped by well location to test for spatial differences in water-quality constituents. Eight distinct units were identified--Big Sioux outwash deposits along the main stem Big Sioux River and seven tributary outwash deposits (figs. 5 and 6 and table 3).

The Kruskal-Wallis procedure and Dunn's multiple comparison procedure were used to determine if there are significant differences in water-quality parameters among the various units. Additional analyses, such as summary statistics, boxplots, and calculation of water types and their spatial placement, are included. Because censored data (data less than a given detection limit) were present (specifically iron, manganese, all other trace metals, nitrate, potassium, and chloride data), a log-probability regression procedure was used to provide estimates of means and 25th, 50th, and 75th percentiles (Helsel and Gilliom, 1985).

Table 3.--Management units commonly used by South Dakota for outwash deposits in the Big Sioux River basin and corresponding designations used in this report

Management units (Hedges and others, 1982)	Study units (This report)
Big Sioux aquifer-North Big Sioux aquifer-Central Big Sioux aquifer-Brookings (in part) Big Sioux aquifer-South Big Sioux aquifer-Moody Big Sioux aquifer-Sioux Falls	Main stem Big Sioux
Antelope Valley	Antelope Valley aquifer
Big Sioux aquifer-Brookings (in part)	Big Sioux-Brookings (east)
Big Sioux aquifer-Brookings (in part)	Big Sioux-Brookings (west)
Big Sioux aquifer-North Deer Creek Big Sioux aquifer-Six Mile Creek Big Sioux aquifer-Unnamed Creek	Big Sioux-Deer Creek
Big Sioux aquifer-Aurora	Big Sioux-Aurora
Big Sioux aquifer-North Skunk Creek Big Sioux aquifer-Middle Skunk Creek Big Sioux aquifer-Southern Skunk Creek	Big Sioux-Skunk Creek
Brule Creek Newton Hills	Brule Creek and Newton Hills aquifer

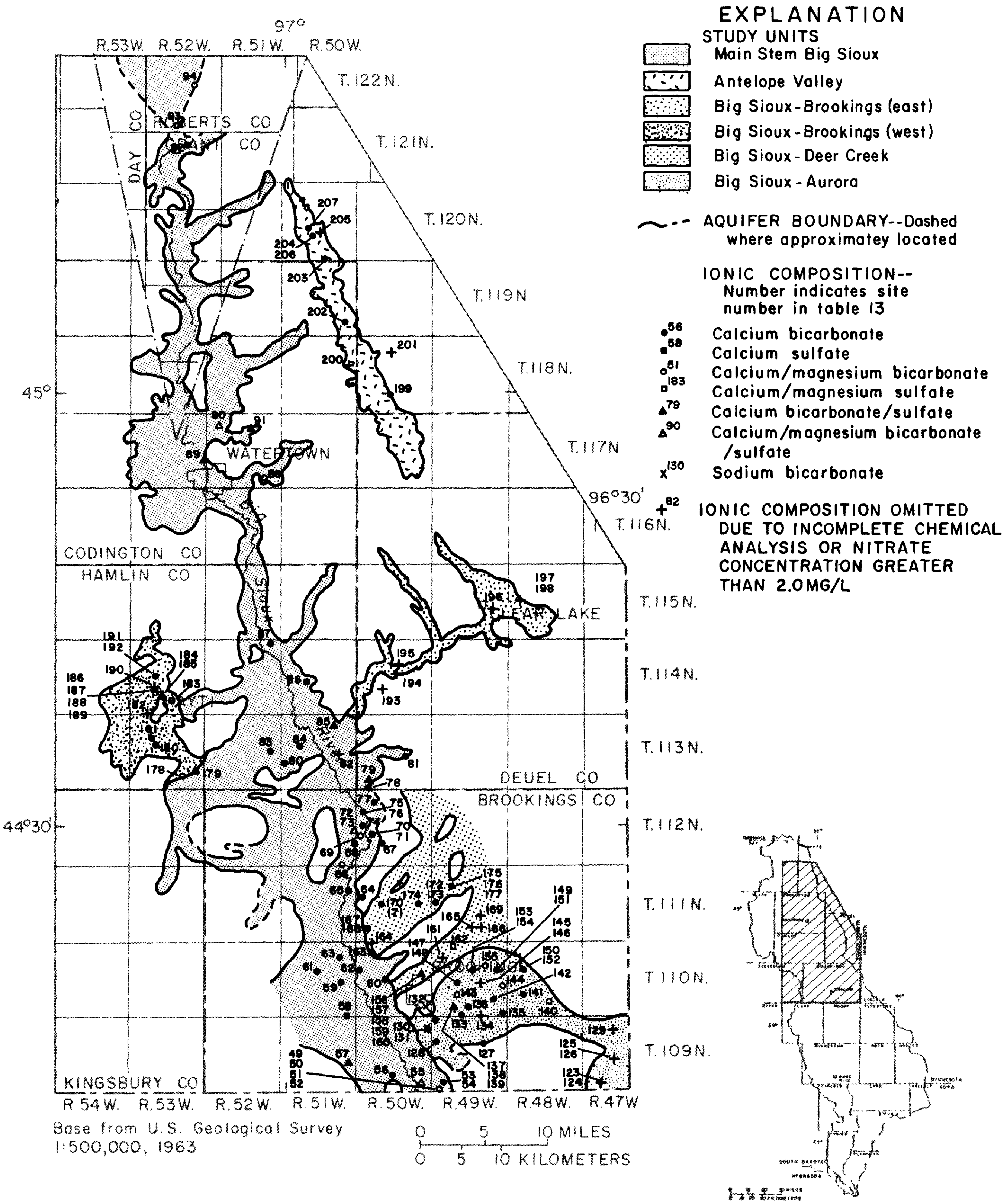

Figure 5.--Northern and central part of the Big Sioux River basin, study units, and dominant ions in water for sampled wells.

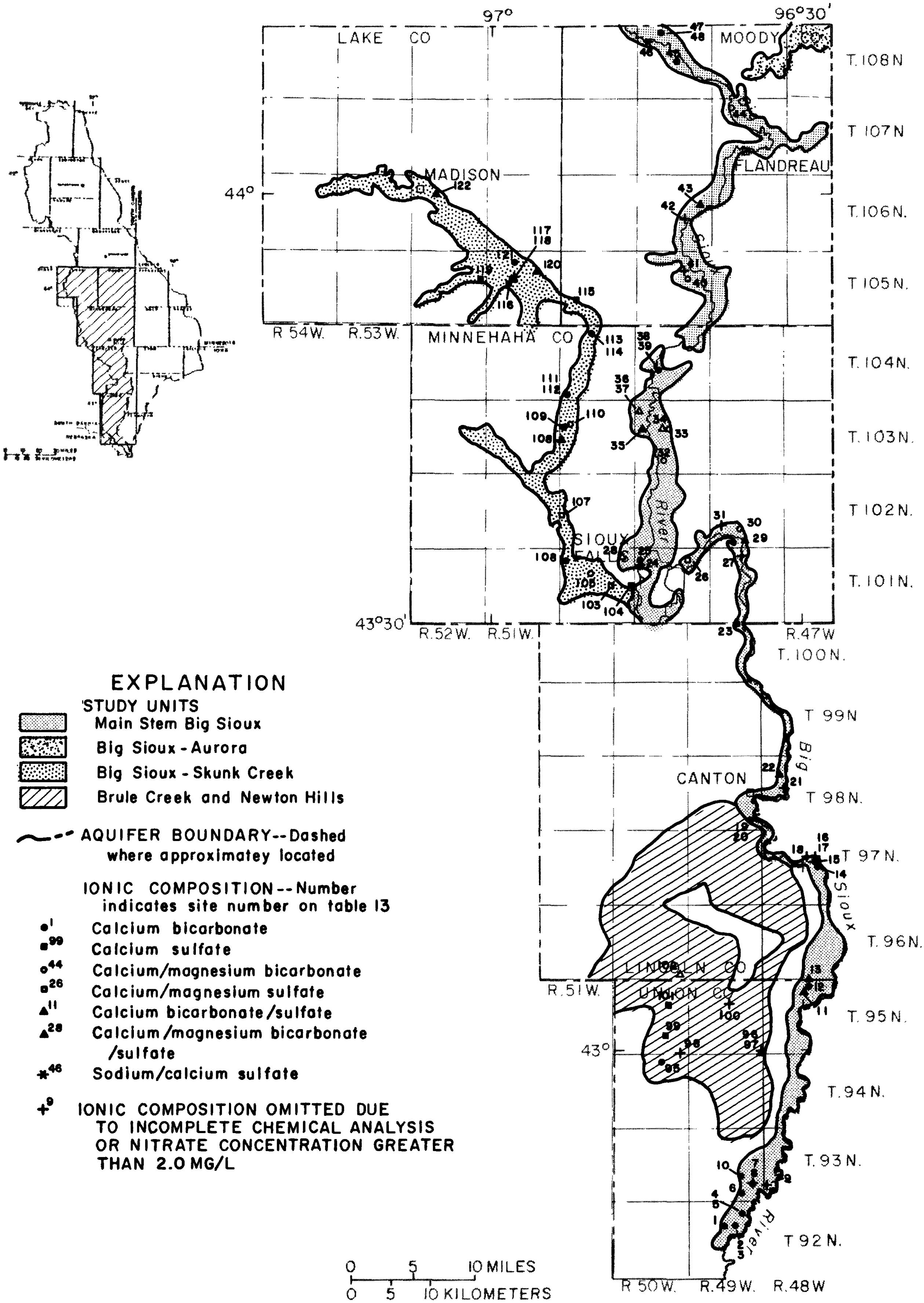

Figure 6.--Southern and central part of the Big Sioux River basin, study units, and dominant ions in water for sampled wells.

QUALITY OF WATER FROM SURFICIAL-OUTWASH AQUIFERS

Physicochemical

The quality of ground water in the Big Sioux River basin generally is similar to the quality of water from glaciated areas in other parts of the upper Midwest (Freeze and Cherry, 1979; Hem, 1985). A statistical summary of ground-water-quality parameters in the Big Sioux River basin is given in table 4. Dissolved-solids concentrations ranged from 220 to 3,050 mg/L. Specific conductance for samples from all wells ranged from 400 to 3,100 μS/cm (microsiemens per centimeter at 25 °Celsius). Dissolved-solids concentrations and specific conductance were highly correlated (table 5). The number of samples used in the correlation analysis for each parameter is presented in table 6.

Table 4.--Summary statistics for selected water-quality constituents in ground water and for selected hydrogeologic variables of the Big Sioux River basin

[Units in milligrams per liter except as indicated]

Variable	Number of samples	Minimum	Maximum	Mean	Standard deviation	Median
Depth to water (feet)	87	0.00	22.25	8.94	4.54	8.70
Well depth (feet)	124	12.90	98.00	35.89	17.04	32.10
Specific conductance (microsiemens per centimeter at 25 °Celsius)	221	400	3,100	920	460	800
Dissolved alkalinity	214	53.0	786	287	110	278
Dissolved solids	161	220	3,050	670	486	540
Dissolved calcium	222	33	480	120	74	100
Dissolved magnesium	221	7.0	160	44	25	39
Dissolved sodium	222	2.6	160	27	28	18
Dissolved potassium	215	<0.10	30	4.5	4.3	3.0
Dissolved bicarbonate	213	64.0	958	345	133	332
Dissolved sulfate	223	9.0	1,800	230	270	150
Dissolved chloride	222	1.0	160	14	21	7.3
Dissolved fluoride	104	0.06	1.0	0.30	0.13	0.30
Dissolve nitrate	162	<0.01	1.90	0.290	0.465	0.086
Dissolved iron (micrograms per liter)	153	<10	23,000	1,400	2,500	450
Dissolved manganese (micrograms per liter)	107	<2	5,000	850	780	700

Table 5.--Spearman rank correlation coefficients for selected hydrogeologic and water-quality variables for outwash deposits in the Big Sioux River basin

[The level of significance (alpha) is 0.05. NS = Not significant at alpha = 0.05]

Variable	Well depth	Depth to water	Specific conductance	Alka-linity	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Dissolved potassium
Well depth	1.0000	NS	NS	NS	NS	NS	0.1702	0.2710
Depth to water		1.0000	NS	NS	NS	NS	NS	NS
Specific conductance			1.0000	0.6020	0.8990	0.8331	0.6795	0.4450
Alkalinity				1.0000	0.6471	0.4473	0.4551	0.3257
Dissolved calcium					1.0000	0.6750	0.5384	0.3924
Dissolved magnesium						1.0000	0.6309	0.3729
Dissolved sodium							1.0000	0.6044
Dissolved potassium								1.0000

	Bicar-bonate	Dissolved sulfate	Dissolved chloride	Dissolved fluoride	Dissolved solids	Dissolved arsenic	Dissolved boron	Dissolved cadmium
Well depth	NS	NS	NS	NS	NS	0.2689	NS	NS
Depth to water	NS	NS	NS	NS	NS	NS	NS	NS
Specific conductance	0.5889	0.7729	0.2237	NS	0.9343	NS	0.2445	NS
Alkalinity	0.9907	0.1737	NS	0.1943	0.4462	NS	0.2990	NS
Dissolved calcium	0.6383	0.6911	NS	NS	0.8764	NS	0.2080	0.3136
Dissolved magnesium	0.4279	0.7535	0.2302	NS	0.8589	NS	0.3024	NS
Dissolved sodium	0.4371	0.5870	0.3132	NS	0.6176	NS	0.3999	NS
Dissolved potassium	0.3106	0.4052	0.1532	-0.1727	0.4085	NS	NS	NS
Bicarbonate	1.0000	0.1534	NS	0.2092	0.4279	NS	0.2812	NS
Dissolved sulfate		1.0000	0.1190	NS	0.8641	NS	NS	0.3348
Dissolved chloride			1.0000	NS	0.1381	NS	0.2251	-0.2150
Dissolved fluoride				1.0000	NS	NS	NS	NS
Dissolved solids					1.0000	NS	0.2169	NS
Dissovled arsenic						1.0000	NS	0.2980
Dissolved boron							1.0000	NS
Dissolved cadmium								1.0000

Variable	Dissolved chromium	Dissolved iron	Dissolved lead	Dissolved manganese	Dissolved mercury	Dissolved nickel	Dissolved selenium	Dissolved zinc
Well depth	NS	0.1887	0.2292	NS	NS	NS	NS	NS
Depth to water	NS	-0.3114	NS	NS	NS	NS	NS	NS
Specific conductance	0.3774	0.1733	NS	0.3793	NS	NS	NS	NS
Alkalinity	0.4591	NS	NS	0.3468	NS	NS	NS	NS
Dissolved calcium	0.5319	0.2477	NS	0.4908	0.2706	NS	NS	NS
Dissolved magnesium	0.3983	0.1856	-0.2366	0.3229	NS	NS	NS	NS
Dissolved sodium	0.3433	NS	NS	0.3018	NS	NS	NS	NS
Dissolved potassium	0.3242	NS	NS	0.3289	NS	NS	NS	NS
Bicarbonate	0.4421	NS	NS	0.3620	NS	NS	NS	NS
Dissolved sulfate	0.4577	0.2287	NS	0.3405	NS	NS	NS	NS
Dissolved chloride	NS	NS	NS	NS	NS	NS	NS	-0.3602
Dissolved fluoride	NS	NS	0.2224	NS	NS	NS	NS	0.2306
Dissolved solids	0.5112	0.2769	NS	0.4657	NS	NS	NS	NS
Dissolved arsenic	0.2521	0.4117	NS	0.2800	0.6534	0.4378	0.4027	NS
Dissolved boron	0.4055	NS	NS	NS	NS	NS	NS	NS
Dissolved cadmium	0.2885	NS	NS	0.2559	NS	0.2526	NS	0.4435
Dissolved chromium	1.0000	NS	NS	0.3962	0.3730	0.3778	0.2507	NS
Dissolved iron		1.0000	NS	0.4765	NS	NS	NS	NS
Dissolved lead			1.0000	NS	0.2541	NS	0.3010	0.2421
Dissolved manganese				1.0000	NS	0.2452	NS	NS
Dissolved mercury					1.0000	0.5198	0.7500	NS
Dissolved nickel						1.0000	0.6443	NS
Dissolved selenium							1.0000	NS
Dissolved zinc								1.0000

Table 6.--Number of samples used in Spearman rank correlation analysis

Variable	Well depth	Depth to water	Specific conductance	Alka- linity	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Dissolved potassium
Well depth	124	79	118	118	118	117	118	117
Depth to water		87	87	86	87	87	87	87
Specific conductance			221	212	221	220	221	214
Alkalinity				214	213	212	213	212
Dissolved calcium					222	221	222	215
Dissolved magnesium						221	221	215
Dissolved sodium							222	215
Dissolved potassium								215

Variable	Bicar- bonate	Dissolved sulfate	Dissolved chloride	Dissolved fluoride	Dissolved solids	Dissolved arsenic	Dissolved boron	Dissolved cadmium
Well depth	117	119	117	72	102	53	90	64
Depth to water	85	87	87	66	87	42	74	56
Specific conductance	212	221	218	102	160	52	128	61
Alkalinity	211	214	210	95	152	51	126	61
Dissolved calcium	213	222	219	103	161	52	128	61
Dissolved magnesium	212	221	218	103	160	52	128	61
Dissolved sodium	213	222	219	103	161	52	128	61
Dissolved potassium	212	215	212	97	154	52	128	61
Bicarbonate	213	213	210	94	153	51	127	60
Dissolved sulfate		223	219	104	161	52	129	62
Dissolved chloride			219	103	161	49	125	61
Dissolved fluoride				104	101	48	62	62
Dissolved solids					161	48	119	61
Dissovled arsenic						58	48	50
Dissolved boron							129	58
Dissolved cadmium								66

Variable	Dissolved chromium	Dissolved iron	Dissolved lead	Dissolved manganese	Dissolved mercury	Dissolved nickel	Dissolved selenium	Dissolved zinc
Well depth	66	91	63	73	48	62	67	70
Depth to water	57	72	55	63	40	57	57	62
Specific conductance	66	151	61	105	45	66	67	71
Alkalinity	66	144	60	98	45	66	67	71
Dissolved calcium	66	152	61	106	45	66	67	71
Dissolved magnesium	66	151	61	105	45	66	67	71
Dissolved sodium	66	152	61	106	45	66	67	71
Dissolved potassium	66	145	61	99	45	66	67	71
Bicarbonate	65	144	60	98	44	65	66	70
Dissolved sulfate	67	153	61	107	46	67	68	72
Dissolved chloride	63	149	61	103	45	63	64	68
Dissolved fluoride	63	103	61	101	46	63	64	68
Dissolved solids	62	145	61	99	45	62	63	67
Dissolved arsenic	57	52	52	51	37	51	58	54
Dissolved boron	62	110	57	65	45	63	63	61
Dissolved cadmium	65	62	63	61	48	62	66	63
Dissolved chromium	73	67	66	66	52	66	73	68
Dissolved iron		153	61	107	46	67	68	72
Dissolved lead			67	60	50	60	67	62
Dissolved manganese				107	45	66	67	70
Dissolved mercury					52	45	52	48
Dissolved nickel						67	67	64
Dissolved selenium							74	69
Dissolved zinc								76

A regression equation was developed to provide a basin-wide predictive model relating specific conductance to dissolved-solids concentrations (fig. 7). Even though this model is curvilinear and bears little resemblance to the expected linear relations described in the literature (Hem, 1985), it can be used to predict dissolved-solids concentrations from specific-conductance measurements. The curvature is the result of the retention of water molecules within the crystal structure of the sulfate salts in the residue, when dissolved-solids concentrations are determined as residue on evaporation at 180 °Celsius. The greater the concentration of sulfate the more water remains after evaporation. This creates a heavier than expected residue from samples having a given specific conductance. Water in the crystal structure cannot be removed except by temperatures in excess of 180 °Celsius, which would convert carbonates (including initial bicarbonates converted to carbonates during heating) to carbon dioxide and introduce error into the results. Therefore, the sum of constituents is a more appropriate measure of dissolved-solids concentrations when ground water in the basin tends to be high in sulfates. Unfortunately, the sum of constituents could not be used for determinations of dissolved-solids concentrations in this study, because silica was not determined for most samples.

Dissolved-solids concentrations and specific conductance were highly correlated with calcium, magnesium, and sulfate but only moderately correlated to sodium, potassium, bicarbonate, and chloride (table 5). Regression models were developed for specific conductance and calcium, magnesium, and sulfate concentrations (figs. 8-10). Each of these relations generally show an increase in the scattering of data as specific conductance and the concentration of ions increase. This increase in variability may be due to a combination of measurement error, analytical error, interferences during the analysis, and the increasing presence of neutral ion pairs as specific conductance increases. The models can be used to provide acceptable estimates of these ions based only on specific conductance.

Major Cations and Anions

The most frequently occurring ionic composition for wells located in the eight outwash units are presented in figures 5 and 6. Classes of dominant ions indicated on these figures were developed using the following guidelines: the most abundant cation (or anion) alone is listed as dominant when that ion exceeded the next most abundant cation (or anion) by 10 percent or greater; the two most abundant cations (or anions) are listed as dominant when the most abundant cation (or anion) exceeded the next most abundant cation (or anion) by less than 10 percent; when the two most abundant cations (or anions) are listed, the order of listing does not necessarily reflect relative abundance.

Sixty-two percent of samples with sufficient data showed a dominance of either calcium or calcium and magnesium, and bicarbonate ions; about 19 percent showed a dominance of calcium or calcium and magnesium, and bicarbonate and sulfate ions; about 16 percent showed a dominance of calcium or calcium and magnesium, and sulfate ions; and about 3 percent showed a dominance of other combinations of ions. A few samples showed a dominance or codominance of sodium ions; these samples may be from wells completed in one of the confined or buried aquifers that underlie the Big Sioux River basin or may indicate upwelling of deep ground water through confining layers.

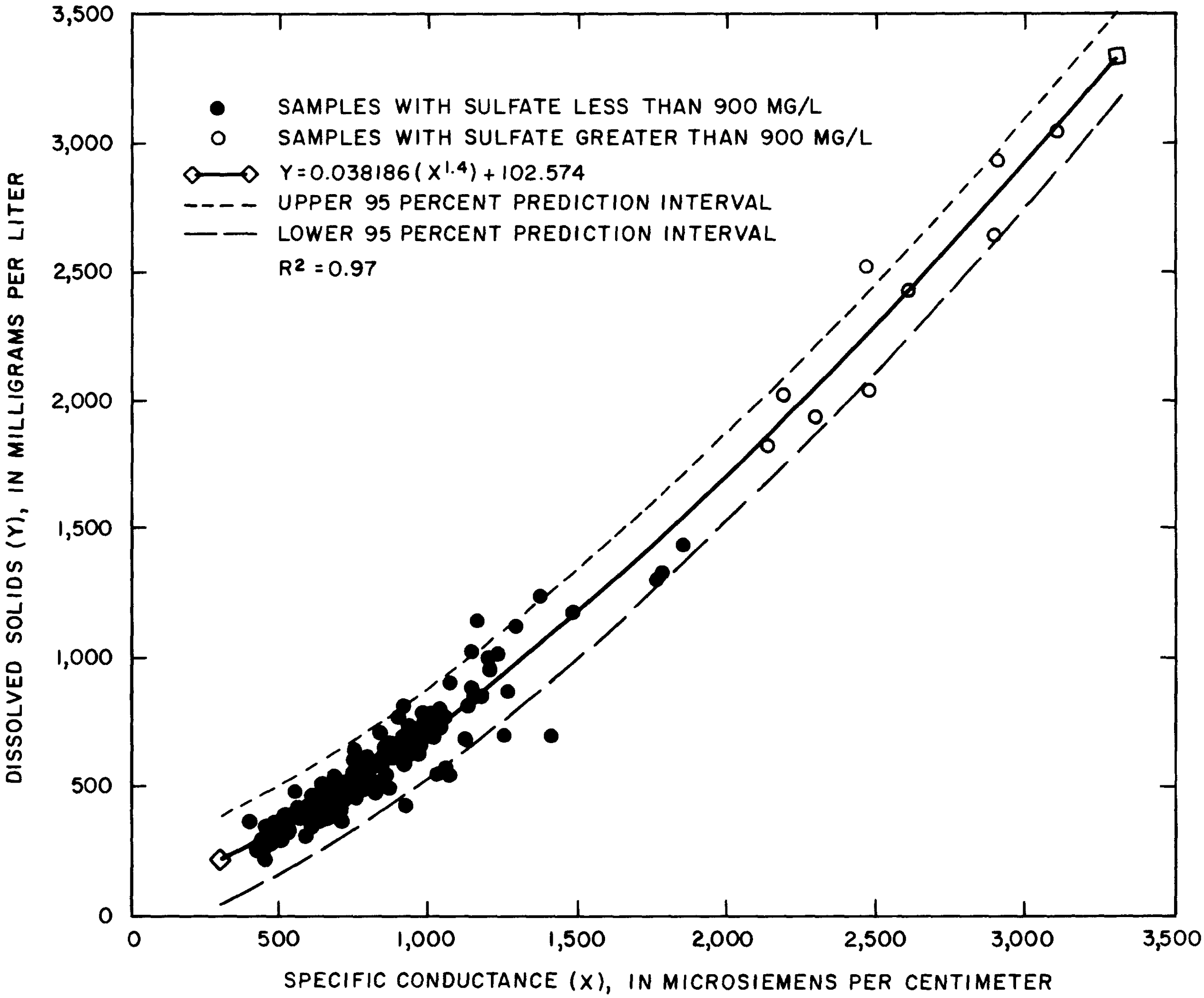

Figure 7.--Relation between dissolved-solids concentrations and specific conductance in ground-water samples with nitrate concentrations less than 2.0 mg/L from the Big Sioux River basin, 1978-86.

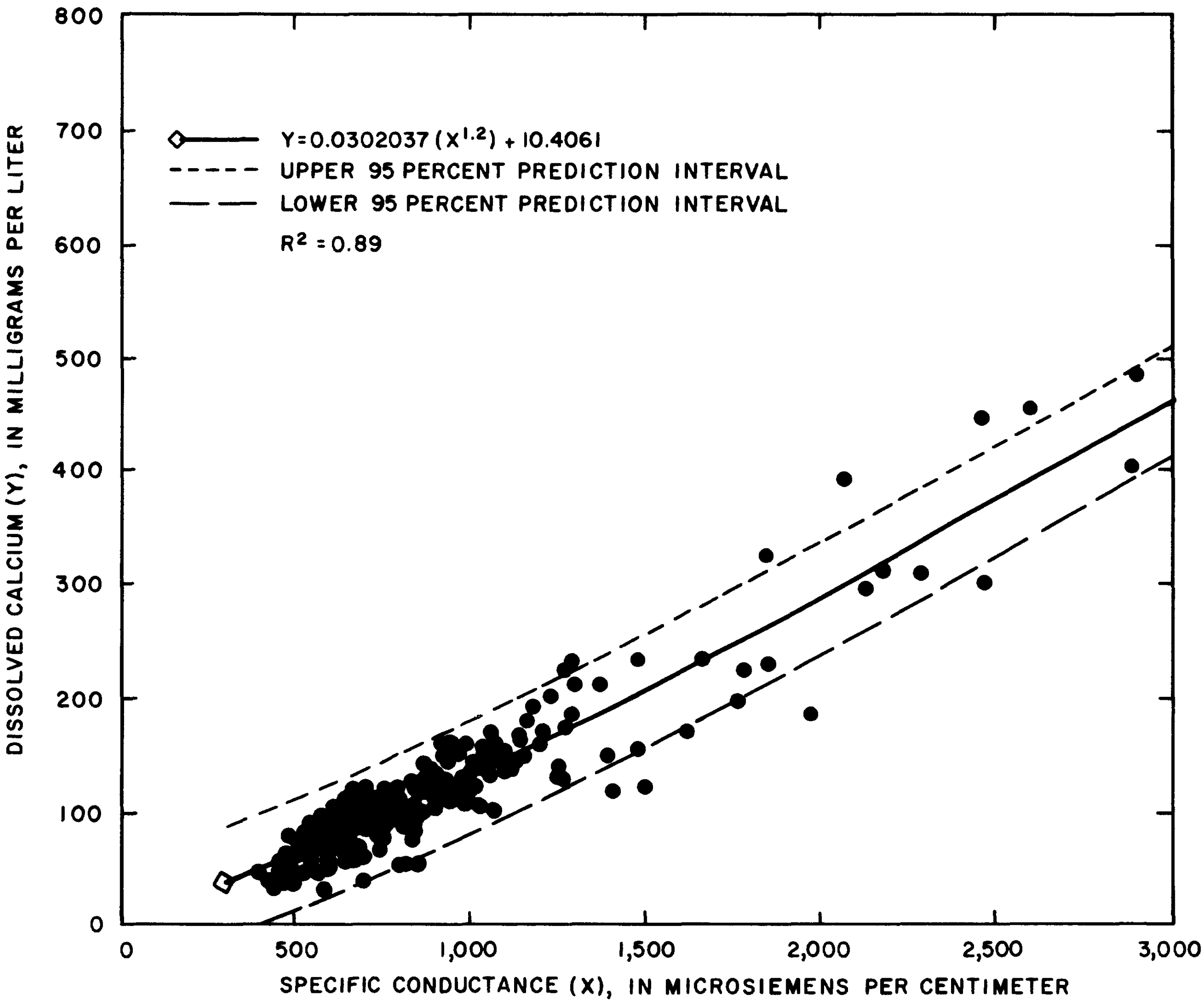

Figure 8.--Relation between dissolved-calcium concentrations and specific conductance in ground-water samples with nitrate concentrations less than 2.0 mg/L from the Big Sioux River basin, 1978-86.

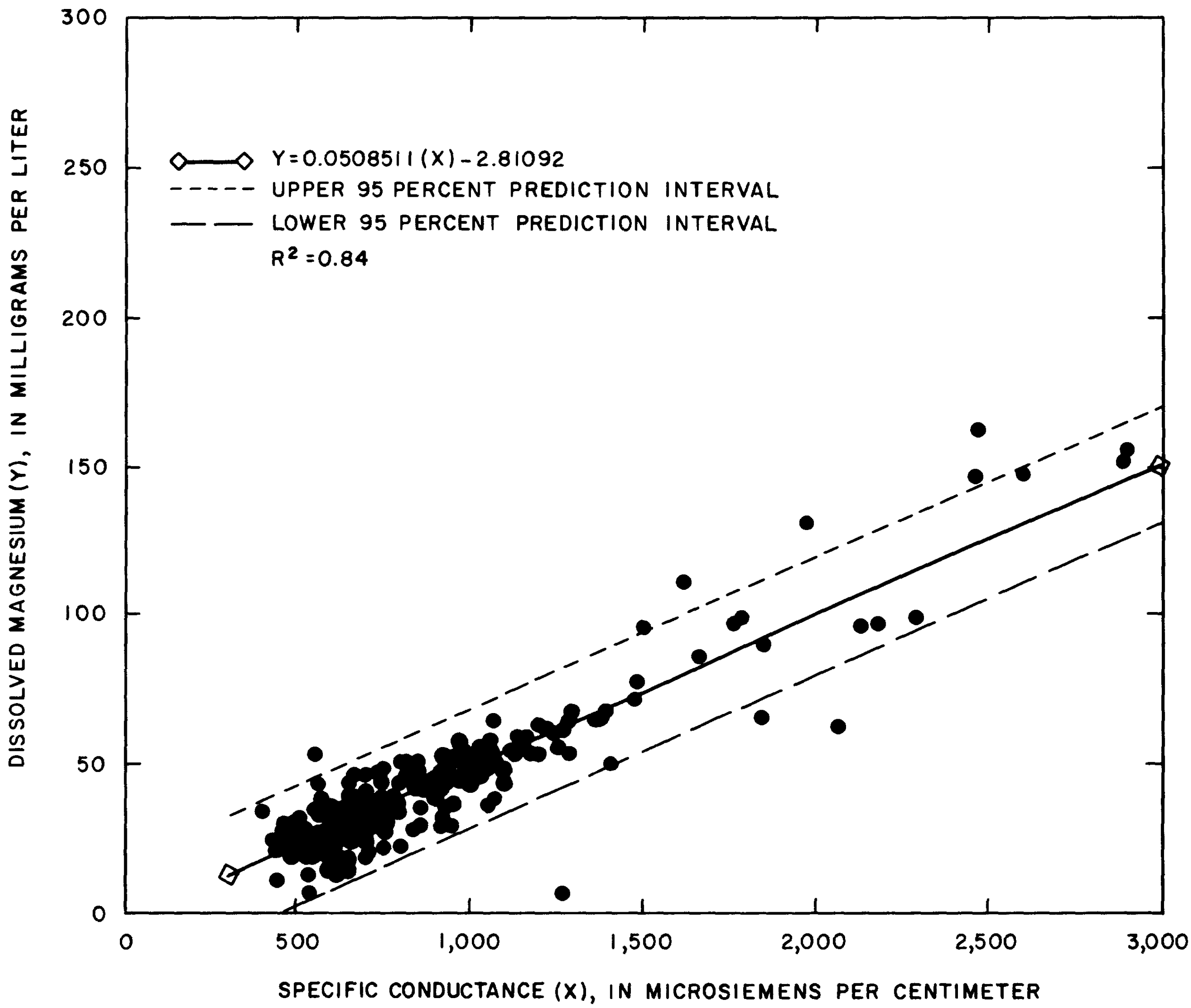

Figure 9.--Relation between dissolved-magnesium concentrations and specific conductance in ground-water samples with nitrate concentrations less than 2.0 mg/L from the Big Sioux River basin, 1978-86.

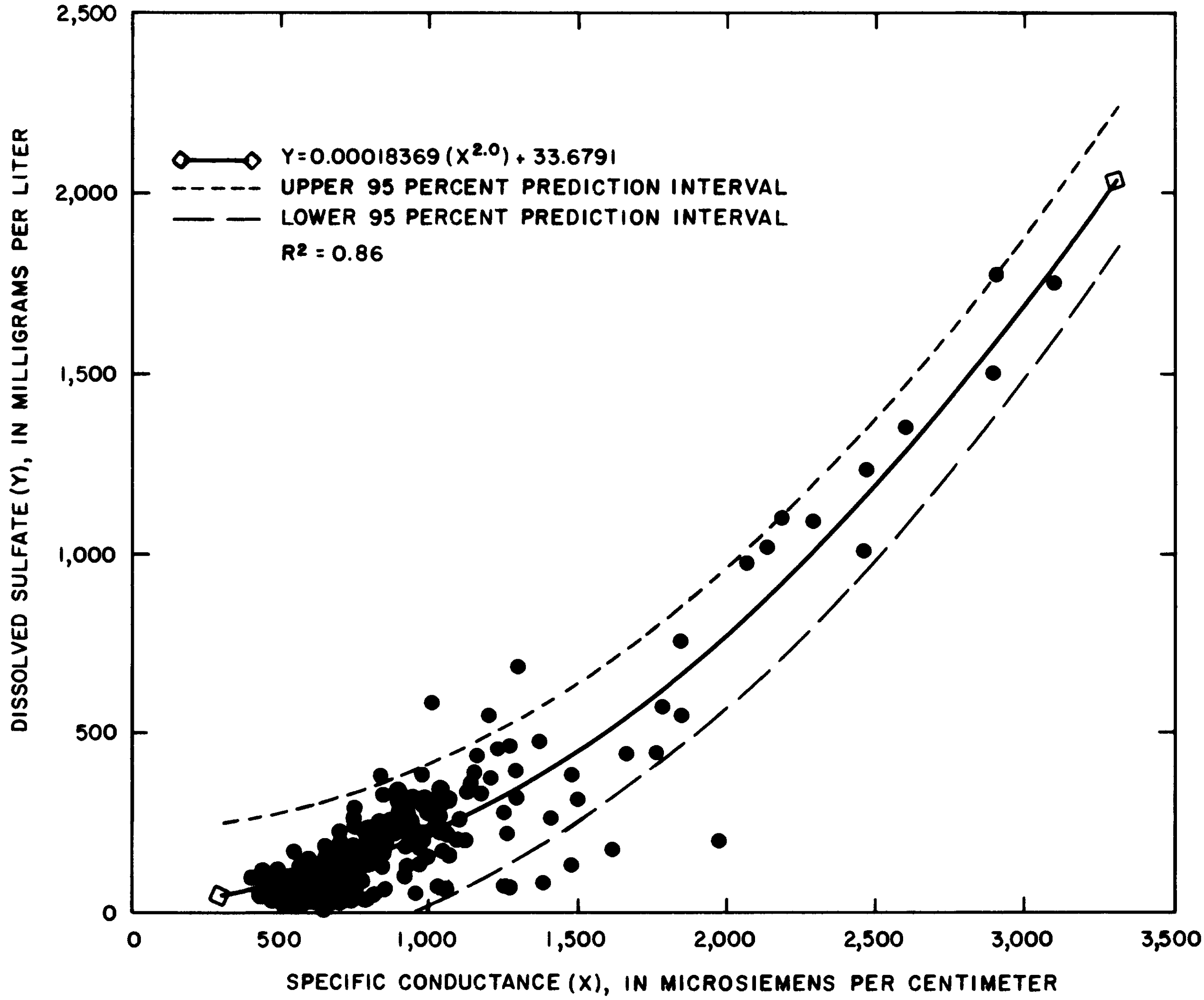

Figure 10.--Relation between dissolved-sulfate concentrations and specific conductance in ground-water samples with nitrate concentrations less than 2.0 mg/L from the Big Sioux River basin, 1978-86.

The spatial distribution of dominant ions in ground water is highly variable within the basin (figs. 5 and 6). Sometimes a well with a calcium bicarbonate type water occurred within 1 mi of a well with a calcium sulfate type of water. For most wells with multiple samples, ionic proportions were similar for all samples collected during the sampling period. However, at several wells with multiple samples, the most abundant cation alternated between calcium and magnesium; and the most abundant anion alternated between bicarbonate and sulfate. Conclusive reasons for this phenomenon cannot be determined from this study. Differences in sample-collection methods (pumped as opposed to bailed samples) or a recent influx of recharge could have produced the anomalies. Wells nearest to the inferred outer boundaries and wells downgradient from the confluence with small tributary outwash deposits tended to have larger dissolved-solids concentrations and a greater dominance of sulfate, as opposed to bicarbonate, than wells that were away from those areas. It is possible that thin layers of sand and gravel along the outer boundaries of the aquifer and thin tributary outwash deposits result in a greater interaction between ground water and till that produces water having greater concentrations of minerals. Furthermore, water moving from those thin tributary outwash deposits into the main stem Big Sioux outwash could influence the water quality both at the confluence and at a short distance downgradient in the main stem outwash. Samples with large mineral concentrations may represent water that has followed longer flow paths, perhaps moving upwards from deeper parts of the outwash.

Relations between water-quality variables, well depth, and depth to the water table were determined using Spearman rank correlation analysis (table 5). With the exception of a weak relation for potassium concentrations and well depth ($r = 0.271$) and for sodium and well depth ($r = 0.170$), the analysis indicates that sampling depth, as determined by well depth, was not a significant factor influencing the presence of major cations and anions in water from the outwash deposits. These relations imply that no significant stratigraphic differences in water quality exist within the outwash. However, a report by the South Dakota Department of Water and Natural Resources (1985) indicates that water samples from eight paired wells that were nested according to depth had larger concentrations of most constituents in the deeper wells. Although not enough data are available for a statistical comparison, these results could indicate that deeper wells intercept water that has traveled longer distances than water intercepted by shallow wells or has a longer residence time within the aquifer.

Potassium generally was detected at small concentrations (median concentration of 3.0 mg/L) and with small variability in the study (table 4). Potassium concentrations in ground water generally are low, not only because of uptake by vegetation as recharge water infiltrates through the soil, but also because of the slow dissolution of potassium ions from feldspar and clay minerals. Larger potassium concentrations with depth could indicate a slight buildup of potassium ions in the deeper parts of the outwash due to rapid movement of fertilizer-derived potassium through the root zone prior to uptake by plants. Larger concentrations also could represent water samples taken from longer flow paths than water sampled at shallower depths.

The significant positive correlation between the major cations, particularly calcium, and bicarbonate and sulfate ions indicates a common mineral source. Bicarbonate may show a general lack of a strong relation with other ions because of carbon-dioxide fluctuations related to microbial respiration within the outwash. It would be premature to identify a specific source or sources at this time without more in-depth geochemical studies. However, some broad generalizations can be made. It is probable that dissolution of soluble cations has occurred as precipitation infiltrates through the overlying soil and, in some cases, fractured or decomposed till. As infiltration occurs, cation exchange probably exerts at least some control on calcium, magnesium, and sodium concentrations in that water. However, cation exchange does not seem to influence ion concentrations once infiltrating water reaches the sand or gravel deposits, because a negative correlation between calcium and magnesium and sodium is not seen (Henderson, 1984). The abundance of calcium, magnesium, bicarbonate, and sulfate ions may indicate at least some influence from limestone, dolomitic limestone, and gypsum or the weathering and precipitation products of those minerals (Hem, 1985). Indeed, Lee (1958) lists limestone, dolomite, shale, chert, feldspars, and miscellaneous other minerals as comprising the aquifer geology in the areas of this study. Because sodium and chloride are present at low concentrations and are related only weakly, the mineral halite probably is not present to any significant degree. Calculated saturation indices indicate that the water samples used in this study were oversaturated with respect to the minerals aragonite and calcite, generally saturated with respect to dolomite, and generally undersaturated with respect to fluorite, halite, and gypsum (table 7). The apparent presence of gypsum actually may be the result of pyrite oxidation releasing sulfide ions that are oxidized to sulfate. The wide range of iron concentrations seem to support this assumption, but no specific data exist to confirm pyrite oxidation as a source of sulfate and iron.

The concentrations of fluoride and chloride ions generally were negligible within the basin. Dissolved-fluoride concentrations generally were small, detected within a narrow range throughout the study (table 4), and were much lower than the Environmental Protection Agency's maximum contaminant level of 4.0 mg/L (U.S. Environmental Protection Agency, 1986a). Fluoride was negatively related to potassium and positively related to bicarbonate (table 5). Although these relations are statistically significant, they probably are not strong enough to provide a meaningful interpretation.

Chloride concentrations generally were low, but at least one sample had a chloride concentration greater than 100 mg/L (table 4). Such a large concentration is uncommon and may indicate contaminated water from an unknown source. Chloride concentrations were significantly correlated, albeit slightly, with magnesium, sodium, potassium, and sulfate concentrations (table 5). Chlorides in this study may arise from the dissolution of chloride-containing minerals that naturally are a minor component of the soils, till, and sand or gravel deposits in the basin.

Trace Elements

Trace-element concentrations were more difficult to analyze because of the presence of values less than a given detection limit. A significant bias is incorporated into the data set if values less than detection limit are either deleted or retained without the less-than symbol. This bias affects statistical correlation and hypothesis testing and estimation of distributional parameters. A log-probability regression method which improves estimates of distributional parameters when data that are less than detection limits are present (Helsel and Gilliom, 1985) was used to estimate means and percentiles for trace-element data. Non-parametric procedures using rank substitution were used for correlation and hypothesis testing. For constituents which had data with multiple detection limits, the largest, most frequently occurring detection limit was selected as the detection limit for the analysis. Values less than that detection limit were assigned the value of one-half the detection limit prior to ranking. A few samples had less-than detection values with detection limits greater than the selected detection limit; these values were discarded from the analysis.

Table 7.--Summary of mineral-saturation indices for ground-water samples by study units in the Big Sioux River basin

[Assumed conditions: Dissolved oxygen, 0.1 milligrams per liter; pH, 7.6; temperature, 11 °Celsius. Values greater than 0.1 indicate oversaturation and subsequently precipitation conditions; values from +0.1 to -0.1 indicate saturation where precipitation or dissolution conditions are indeterminate; values less than -0.1 indicate undersaturation and subsequently dissolution conditions]

Study unit	Calcite ($CaCO_3$)	Dolomite ($CaMg(CO_3)_2$)	Aragonite ($CaCO_3$)	Ferric hydroxide amorphous ($Fe(OH)_3$)	Goethite ($HFeO_2$)	Halite ($NaCl$)	Siderite ($FeCO_3$)	Rhodochrosite ($MnCO_3$)	Fluorite (CaF_2)	Gypsum ($CaSO_4$)
Main stem Big Sioux	0.378	-0.156	0.224	1.944	7.835	-8.093	0.241	-0.073	-1.717	-1.330
Big Sioux-Brookings (west)	.727	.552	.373	2.051	7.942	-7.298	.455	.267	-1.997	-.499
Big Sioux-Deer Creek	.445	-.063	.291	2.244	8.135	-8.430	.552	-.019	-1.808	-1.169
Big Sioux-Aurora	.432	-.014	.277	2.130	8.021	-7.913	.461	-.255	-2.030	-1.358
Big Sioux-Skunk Creek	.398	-.114	.244	1.609	7.500	-8.144	-.128	-.119	-1.634	-1.051
Brule Creek and Newton Hills	.431	-.046	.277	2.064	7.955	-8.310	.307	-.209	-1.033	-.839

Almost all trace-element concentrations in the basin appear to be well below the Federal or State standards for drinking water, and many samples had non-detectable concentrations (fig. 11; table 13, Supplemental Information section). Dissolved arsenic was positively related to well depth, and dissolved cadmium, chromium, iron, manganese, mercury, nickel, and selenium (table 5). Dissolved chromium was positively related to all major ions except dissolved chloride and fluoride and to all trace elements except dissolved iron, lead, and zinc. Dissolved lead was positively related to well depth, and dissolved fluoride, mercury, selenium, and zinc, and negatively related to dissolved magnesium. Dissolved selenium was positively related to dissolved arsenic, chromium, lead, mercury, and nickel. Dissolved zinc was positively related to dissolved fluoride, cadmium, and lead, and negatively related to dissolved chloride.

The relations for the trace elements and other variables summarized in table 5 may be an artifact of the presence of so many data points that were less than the detection limit. However, the number of samples that contained iron and manganese concentrations greater than the detection limit may be large enough for statistical analysis (tables 5 and 6).

Iron and manganese concentrations ranged from less than 10 to 23,000 $\mu g/L$ (micrograms per liter) and from less than 2 to 5,000 $\mu g/L$, respectively (table 4). These values are well within the range found in many uncontaminated ground waters throughout the United States. Iron concentrations from samples in the outwash deposits frequently exceeded the U.S. Environmental Protection Agency recommended limits for water ingestion of 300 $\mu g/L$, and manganese concentrations frequently exceeded the U.S. Environmental Protection Agency secondary maximum contaminant limit of 50 $\mu g/L$ (U.S. Environmental Protection Agency, 1986b). Iron concentrations showed a small negative correlation with water-table elevation. In other words, the higher the water table the lower the dissolved-iron concentration. This probably is related to the oxidation and subsequent precipitation of dissolved iron at the oxygen-rich conditions found at higher water-table elevations. Indeed, calculated saturation indices show that most samples were oversaturated with respect to amorphous iron hydroxide, which would favor precipitation under oxidizing conditions (table 7). Goethite also is shown to precipitate under those conditions; however, the precipitation of iron hydroxides is thermodynamically favored over the formation of goethite. Iron hydroxides will form goethite given a sufficient period of time. Iron concentrations may arise from the oxidation of pyrite found within quartz fragments which comprise the sand and gravel deposits in the basin (Lee, 1958), which would account for at least some of the large sulfate concentrations found in the study. However, iron also may be derived from secondary minerals in the form of ferric hydroxides or ferric oxyhydroxides deposited by glacial activity. It is likely that iron is alternately dissolved and precipitated in response to oxidizing and reducing conditions as the rise and fall of the water table inundates and exposes new areas of the aquifer.

Manganese concentrations were correlated significantly with all measured variables except for chloride, fluoride, boron, and lead concentrations, as well as depth to water and well depth (table 5). The slight, but significant, relations between the major cations and manganese may indicate a common mineral source or sources. Small amounts of manganese often are associated as an impurity in limestone, dolomite, and gypsum. Manganese also is found in silicate minerals, often substituting for calcium and magnesium (Hem, 1985). Manganese concentrations were correlated with iron concentrations, which follow the general trend reported by other studies (Hem, 1985). This

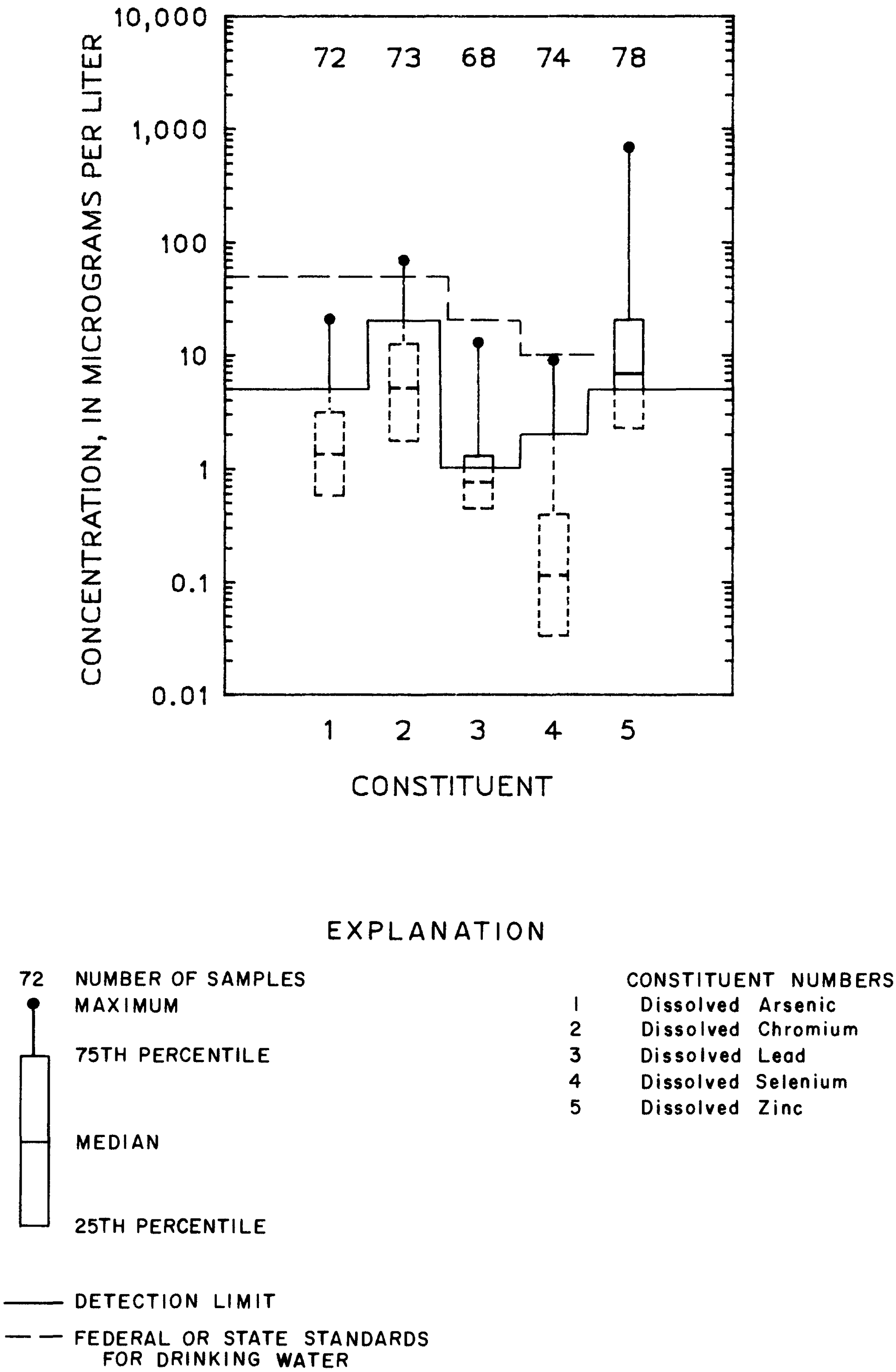

Figure 11.--Distribution of selected trace elements in ground-water samples with nitrate concentrations less than 2.0 mg/L from the Big Sioux River basin, 1978-86.

correlation is due to the similar redox controls on the solubility of both elements. No explanation can be found to show why iron is related to depth to water and manganese is not, given the correlation between iron and manganese and similar controls on solubility.

Nitrate Nitrogen

Even though samples with nitrate-nitrogen concentrations greater than 2.0 mg/L were eliminated from the analyses discussed thus far, the number of samples (about 50) with nitrate concentrations greater than 2.0 mg/L was sufficient to be addressed. Of primary interest was the relation between nitrate concentrations and hydrogeologic and water-quality variables.

All variables except well depth, depth to water, chloride, and fluoride were found to show a slight negative correlation with nitrate concentrations (table 8). In other words, when nitrate concentrations increased, the concentrations of negatively correlated parameters decreased. These relations indicate that a dilution effect may occur when large nitrate concentrations are present. How such an effect could occur is unknown. It's possible that precipitation rapidly infiltrating through soils beneath and downgradient from feedlots, septic systems, or recently fertilized agricultural land is a factor. This recharge water would be low in all cations and anions except nitrate and ammonium.

Table 8.--Spearman rank correlation coefficients relating nitrate-nitrogen concentrations to hydrogeologic and water-quality variables for outwash deposits in the Big Sioux River basin

[NS, no significant correlation; alpha = 0.05]

	NO_3-N	Number of samples
Well depth	NS	140
Depth to water	NS	92
Specific conductance	-0.233	203
Alkalinity, dissolved	-0.277	195
Solids, dissolved	-0.145	188
Calcium, dissolved	-0.191	204
Magnesium, dissolved	-0.239	203
Sodium, dissolved	-0.282	204
Potassium, dissolved	-0.291	193
Sulfate, dissolved	-0.259	207
Chloride, dissolved	0.116	204
Fluoride, dissolved	NS	132
Iron, dissolved	-0.439	194
Manganese, dissolved	-0.608	140

Water-Quality/Hydrogeologic Relations

Given the limited data available, the statistical analysis of relations between water-quality constituents and hydrogeologic characteristics produced generally ambiguous results. The Kruskal-Wallis one-way analysis of variance on ranks was used to test for differences between concentrations of water-quality constituents in three classes of depth to sand or gravel (less than

10, 10 to 30, greater than 30 ft). The results of this analysis are presented in table 9. Only potassium and chloride showed significant differences in concentrations between the three depth to sand or gravel classes. Boxplots showing the distribution of potassium in the different depth to sand or gravel classes are presented in figure 12. Dunn's multiple comparison procedure indicated that potassium concentrations in the greater than 30-ft depth to sand or gravel were significantly larger than in the less than 10-ft class. Boxplots showing the distribution of chloride in the different depth to sand or gravel classes also are presented in figure 12. Dunn's multiple comparison procedure indicated that chloride concentrations in the less than 10-ft depth to sand or gravel class were significantly higher than in the greater than 30-ft class.

Although differences in potassium and chloride concentrations between the depth to sand or gravel classes were significant, these constituents are relatively minor components with respect to total dissolved solids in the Big Sioux River basin. Caution should be exercised in attempting to draw broad conclusions about geochemical processes in the different depth to sand or gravel classes based on these results. The large variability in the concentrations combined with the large differences in sample sizes for the different depth classes may have resulted in anomalous statistical results.

Table 9.--Results of Kruskal-Wallis one-way analysis of variance on ranks for tests of differences between concentrations of water-quality constituents in three classes of depth to sand or gravel (less than 10, 10 to 30, greater than 30 feet)

Constituent	Total number of samples	Degrees of freedom	Test statistic chi-square value	Probability of greater chi-square value
Specific conductance	100	97	0.0479	0.9760
Dissolved solids	94	91	0.1767	0.9155
Calcium	100	97	0.2092	0.9010
Magnesium	100	97	0.9161	0.6320
Sodium	100	97	2.9627	0.2270
Potassium	98	95	7.5912	0.0225
Bicarbonate	97	94	2.0640	0.3563
Sulfate	100	97	0.6542	0.7210
Chloride	100	97	7.8301	0.0199
Fluoride	54	51	5.1408	0.0765
Arsenic	38	35	3.1547	0.2065
Boron	89	86	0.5371	0.7645
Cadmium	49	46	0.2505	0.8823
Chromium	49	46	1.5330	0.4646
Iron	82	79	0.9737	0.6146
Lead	50	47	0.0711	0.9651
Manganese	53	50	0.9008	0.6374
Nickel	49	46	0.3619	0.8345
Selenium	50	47	0.3509	0.8391
Zinc	47	44	1.9311	0.3808

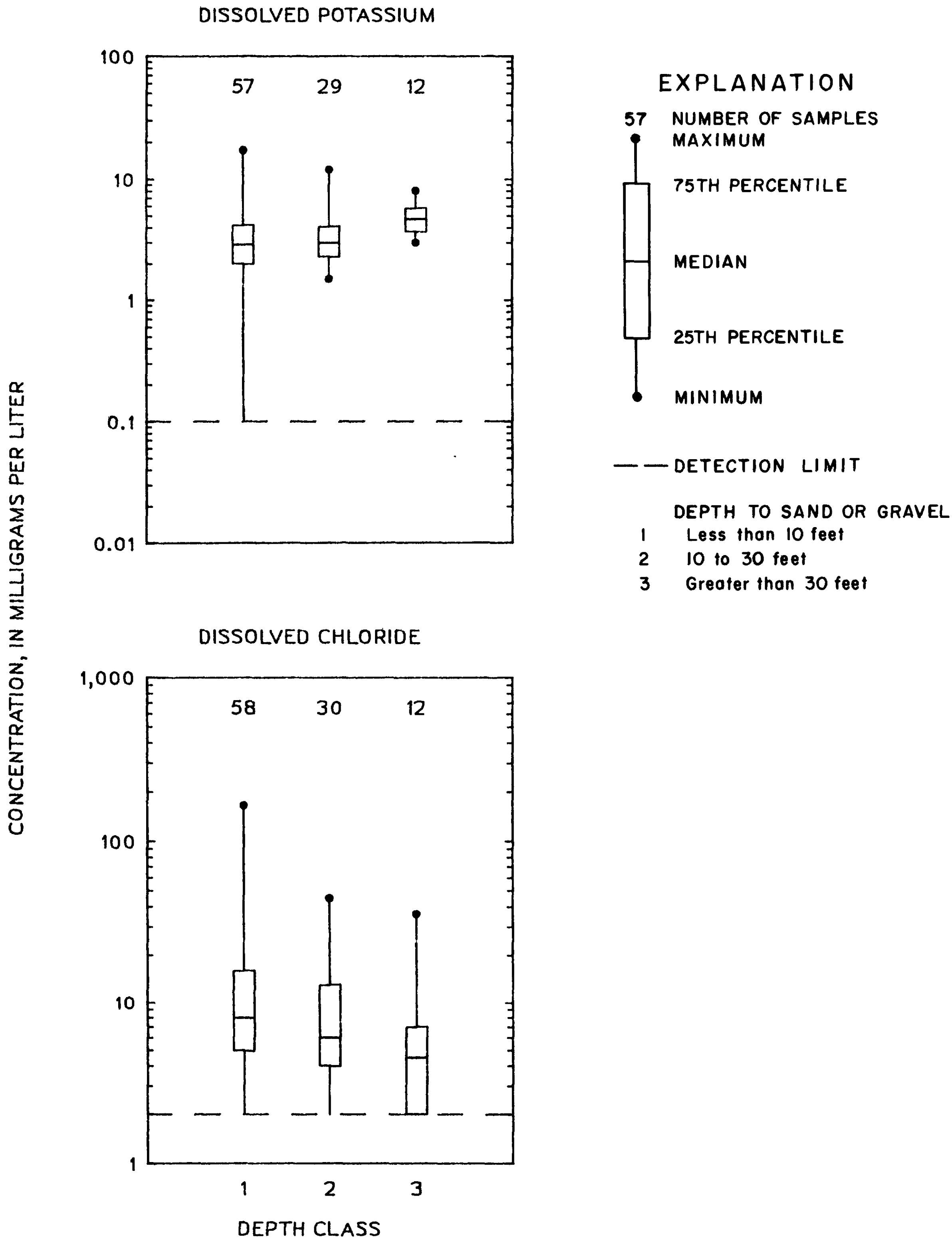

Figure 12.--Distribution of dissolved potassium and dissolved chloride in ground-water samples with nitrate concentrations less than 2.0 mg/L for three classes of depth to sand or gravel in the Big Sioux River basin, 1978-86.

The Kruskal-Wallis one-way analysis of variance on ranks also was used to test for differences between concentrations of water-quality constituents in five classes of sand or gravel thickness (5 to 15, 15.1 to 26, 26.1 to 35, 35.1 to 46, and greater than 46 ft). The results of this analysis are presented in table 10. Only boron and manganese showed significant differences in concentrations between the five sand or gravel thickness classes. Boxplots showing the distribution of boron in the different sand or gravel thickness classes are presented in figure 13. Dunn's multiple comparison procedure indicated that the 26- to 35-ft sand or gravel thickness class had significantly lower boron concentrations than the greater than 46-ft thickness class.

Boxplots showing the distribution of manganese in the different sand or gravel thickness classes also are presented in figure 13. Dunn's multiple comparison procedure failed to detect significant differences between individual pairs of thickness classes which indicates that although there is statistically significant difference between manganese concentrations in all of the thickness classes, differences in manganese concentrations between individual thickness classes are not large enough to be statistically detected. This probably is due to the small sample sizes.

Table 10.--Results of Kruskal-Wallis one-way analysis of variance on ranks for tests of differences between concentrations of water-quality constituents in five classes of sand or gravel thickness

Constituent	Total number of samples	Degrees of freedom	Test statistic chi-square value	Probability of greater chi-square value
Specific conductance	103	98	3.6720	0.4522
Dissolved solids	96	91	4.0770	0.3957
Calcium	103	98	4.5123	0.3411
Magnesium	103	98	4.0381	0.4009
Sodium	103	98	2.4313	0.6570
Potassium	101	96	1.4656	0.8327
Bicarbonate	100	95	9.4300	0.0512
Sulfate	103	98	1.7607	0.7797
Chloride	102	97	5.8328	0.2120
Fluoride	54	49	5.7201	0.2210
Arsenic	39	34	2.5974	0.6273
Boron	92	87	13.5002	0.0091
Cadmium	49	44	2.1644	0.7056
Chromium	50	45	4.2634	0.3715
Iron	84	79	7.7680	0.1005
Lead	50	45	8.9042	0.0635
Manganese	54	49	11.1242	0.0252
Nickel	50	45	2.0045	0.7349
Selenium	51	46	2.4153	0.6599
Zinc	48	43	3.1914	0.5263

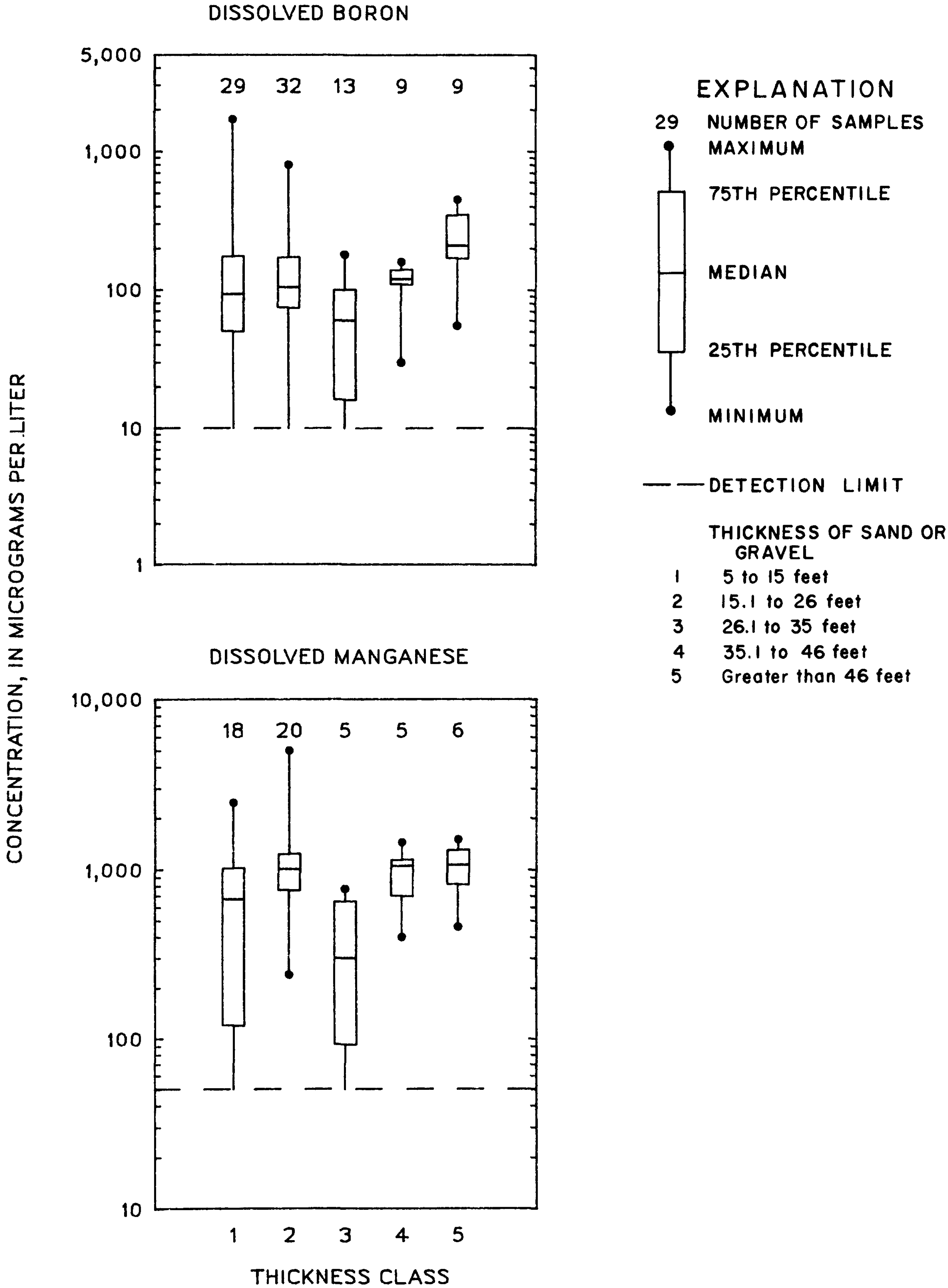

Figure 13.--Distribution of dissolved boron and dissolved manganese in ground-water samples with nitrate concentrations less than 2.0 mg/L for five thickness classes of outwash deposits in the Big Sioux River basin, 1978-86.

AREAL DISTRIBUTION OF WATER-QUALITY CHARACTERISTICS

In order to determine the areal distribution of water-quality characteristics in the basin, all 207 wells used in the basin-wide analysis were separated into eight study units. These study units are shown in table 3 and figures 5 and 6.

Major Cations and Anions

Dominant ions in water samples varied between and within the outwash aquifers (fig. 14). Calcium bicarbonate was the most frequently occurring ionic composition for water samples from the main stem Big Sioux, the Big Sioux-Skunk Creek, the Big Sioux-Aurora, the Big Sioux-Deer Creek, and the Antelope Valley units. Calcium sulfate was the most frequently occurring ionic composition for water samples from the Big Sioux-Brookings (west), and Brule Creek and Newton Hills units. One sample each from the main stem Big Sioux unit, the Big Sioux-Aurora unit, and the Big Sioux-Skunk Creek unit showed sodium was the dominant or codominant cation (fig. 14). These samples may indicate an area where wells were constructed in a deeper aquifer, or where upward leakage from a deeper, more mineralized aquifer, such as the Dakota Formation, is occurring. Those three samples are not typical of the surficial outwash deposits in the Big Sioux basin.

The Kruskal-Wallis one-way analysis of variance on ranks was used to test for differences between concentrations of water-quality constituents in the eight study units. The results of this analysis are presented in table 11. Significant differences in concentrations of all constituents except arsenic, cadmium, chromium, lead, nickel, selenium, and zinc were indicated. Boxplots showing the distribution of specific conductance and concentrations of dissolved solids, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, boron, iron, and manganese are presented in figure 15.

Although there is a considerable amount of variation in concentrations of constituents within and between study units, qualitative comparison of boxplots in figure 15 indicates some general relations with respect to concentrations of constituents. The Big Sioux-Brookings (east) unit had too few samples with nitrate concentration lower than 2.0 mg/L and is excluded from this discussion. Five units (main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Aurora, Big Sioux-Deer Creek, and Antelope Valley) generally had similar concentrations of most water-quality constituents, while the Big Sioux-Brookings (west) and the Brule Creek and Newton Hills units generally had higher concentrations of most constituents than the other five units.

Results of Dunn's multiple comparison procedure (table 12) indicated concentrations of most water-quality constituents were higher in the Big Sioux-Brookings (west) unit than in the five units with generally similar concentrations for most constituents. It is possible that water in the Big Sioux-Brookings (west) unit has a much longer residence time than water in the other units.

There were few significant differences in water-quality constituents between the main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Aurora, Big Sioux-Deer Creek, and Antelope Valley units (table 12). The similarities probably indicate similar geology, mineralogy, and hydrology among these five units. The variability which does exist may represent differences in the local distribution of secondary minerals (clays or amorphous calcite and dolomite) or the effect of glacial till or clay inclusions.

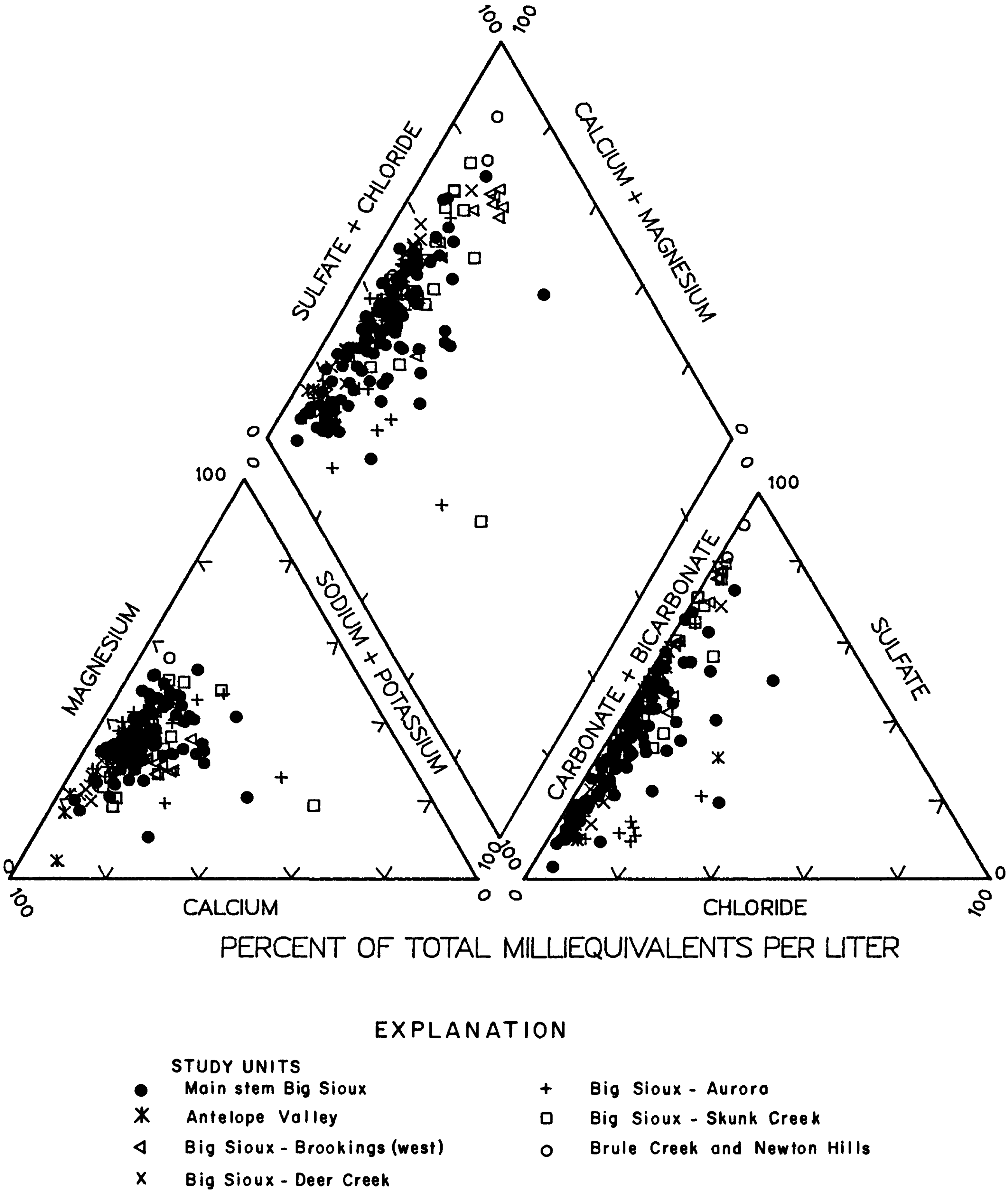

Figure 14.--Trilinear plot showing major cations and anions in ground-water samples with nitrate concentrations less than 2.0 mg/L from study units in the Big Sioux River basin, 1978-86.

Table 11.---Results of Kruskal-Wallis one-way analysis of variance on ranks for tests of differences between concentrations of water-quality constituents in eight study units in the Big Sioux River basin

Constituent	Total number of samples	Degrees of freedom	Test statistic chi-square value	Probability of greater chi-square value
Specific conductance	221	213	36.9202	0.000
Dissolved solids	161	153	45.1861	0.000
Calcium	222	214	38.8395	0.000
Magnesium	221	213	40.3021	0.000
Sodium	222	214	27.1297	0.000
Potassium	215	207	40.3861	0.000
Bicarbonate	213	205	13.1844	0.040
Sulfate	223	215	54.3721	0.000
Chloride	219	211	21.6100	0.001
Fluoride	104	96	28.3362	0.000
Arsenic	58	50	2.9347	0.817
Boron	129	121	30.3441	0.000
Cadmium	66	58	6.8565	0.457
Chromium	73	65	9.2294	0.2562
Iron	153	145	24.8204	0.001
Lead	67	59	5.3976	0.494
Manganese	107	99	33.4079	0.000
Nickel	67	59	3.7281	0.966
Selenium	74	66	2.2189	0.902
Zinc	76	68	10.7865	0.2098

Table 12.--Statistically significant (alpha = 0.05) results of Dunn's multiple comparison procedure to test for differences in concentrations of water-quality constituents between study units in the Big Sioux River basin

[Study units: 1 = main stem Big Sioux; 2 = Antelope Valley; 3 = Big Sioux-Brookings (east); 4 = Big Sioux-Brookings (west); 5 = Big Sioux-Deer Creek; 6 = Big Sioux-Aurora; 7 = Big Sioux-Skunk Creek; 8 = Brule Creek and Newton Hills]

Water-quality constituent	Significant differences between study units
Specific conductance	4 greater than 1, 5, 6, 7
Dissolved solids	4 greater than 1, 5, 6, 7; 5 greater than 1
Calcium	4 greater than 1, 5, 6, 7
Magnesium	4 greater than 1, 3, 5, 6
Sodium	4 greater than 1, 3, 5, 6
Potassium	4 greater than 1, 5, 6; 7 greater than 5, 6
Bicarbonate	4 greater than 1
Sulfate	4 greater than 1, 3, 5, 6; 7 greater than 1, 6; 8 greater than 1
Chloride	4 greater than 1, 3, 5, 6, 7
Fluoride	1 greater than 4, 6
Boron	4 greater than 5, 7; 1 greater than 7
Iron	5 greater than 1, 3, 7
Manganese	4 greater than 1, 3, 6; 5 greater than 3, 6

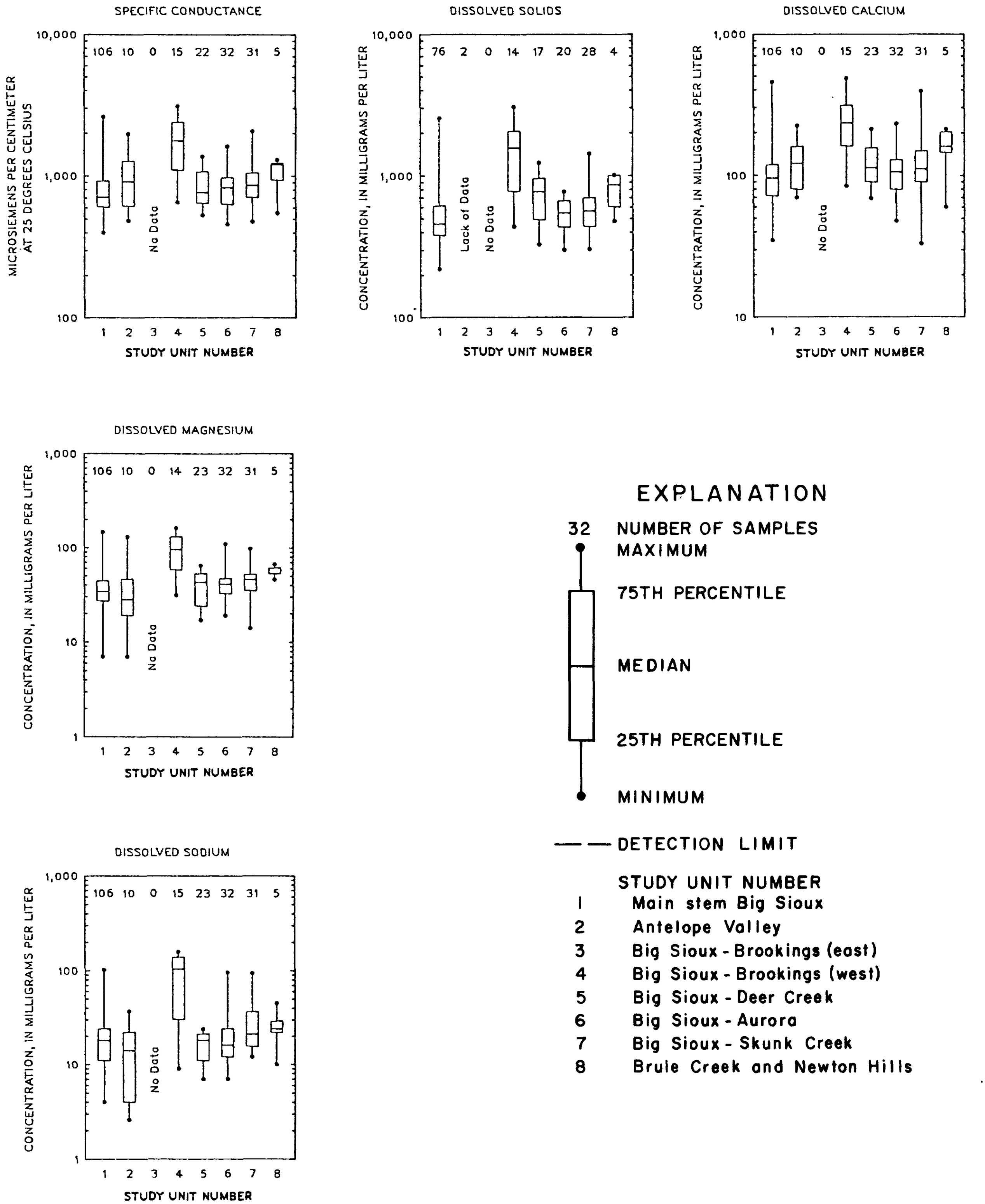

Figure 15.--Distribution of selected water-quality constituents in ground-water samples with nitrate concentrations less than 2.0 mg/L from eight study units in the Big Sioux River basin, 1978-86.

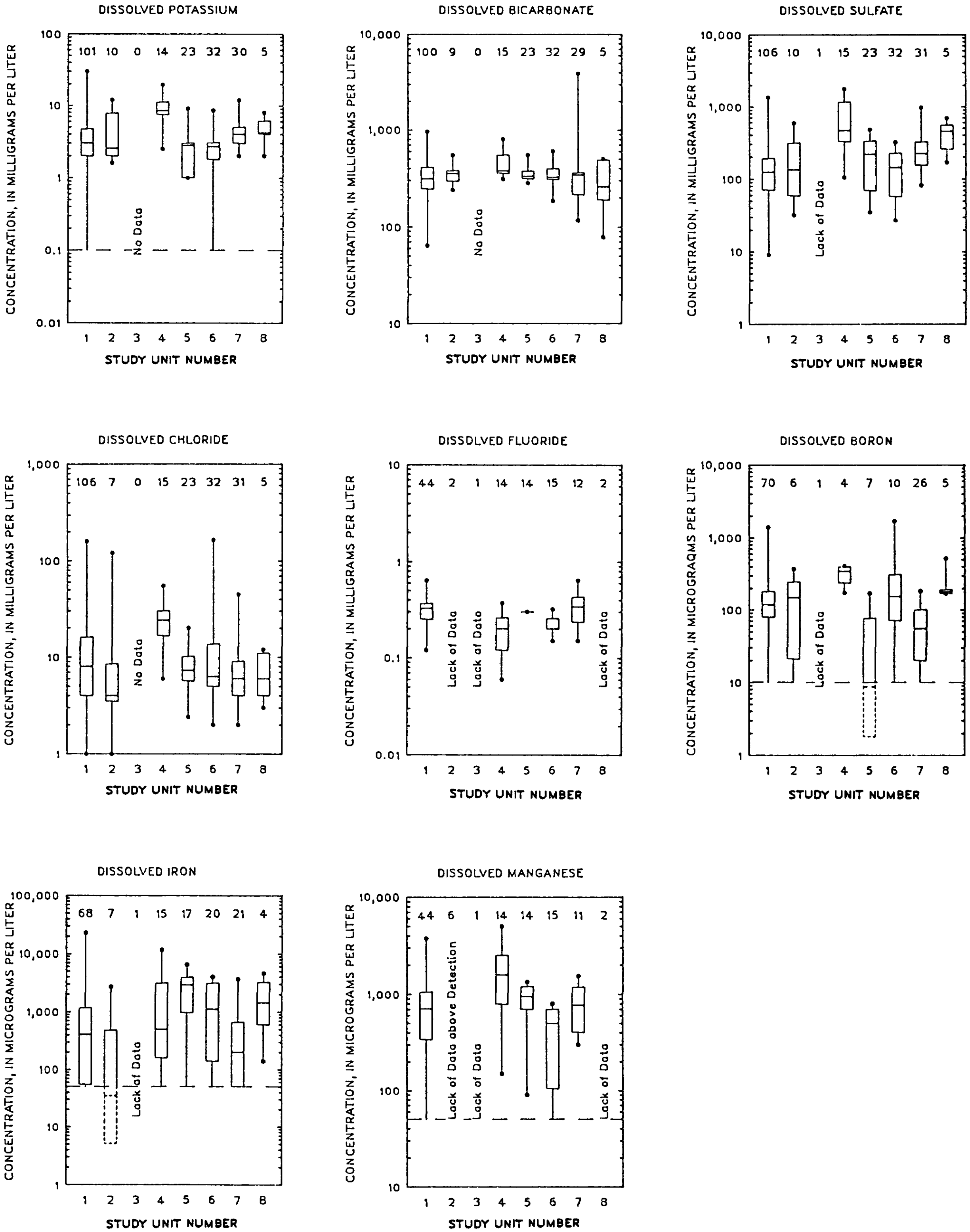

Figure 15.--Distribution of selected water-quality constituents in ground-water samples with nitrate concentrations less than 2.0 mg/L from eight study units in the Big Sioux River basin, 1978-86.--Continued

Only sulfate for the Brule Creek and Newton Hills unit had significantly different concentrations than the other units (table 12). This probably is partly attributable to small sample sizes for most constituents for this unit. Although not statistically significant, the Brule Creek and Newton Hills unit had larger median concentrations than the main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Aurora, Big Sioux-Deer Creek, and Antelope Valley units for most constituents. This may indicate that water in the Brule Creek and Newton Hills unit, like in the Big Sioux-Brookings (west) unit, has a longer residence time than water in the other five units.

Boxplots showing the distribution of depth to sand or gravel and aquifer thickness for the eight units in the Big Sioux River basin are presented in figure 16. The Kruskal-Wallis one-way analysis of variance on ranks failed to detect significant differences in depth to sand or gravel and aquifer thickness between the units. The results of this analysis do not support the hypothesis that hydrogeologic differences between the eight units can explain differences and variances in the water-quality regimes of those units.

Nitrate Nitrogen

The distribution of nitrate-nitrogen concentrations found in the eight study units is given in figure 17. All eight study units show some evidence of nitrate contamination with many samples in each study unit exceeding the assumed natural background level of less than 0.1 mg/L. The Big Sioux-Brookings (east) unit has the greatest proportion of contaminated wells. The Kruskal-Wallis one-way analysis of variance on ranks indicated significant differences in concentration of nitrate between study units (degrees of freedom = 203, P = 0.000). Dunn's multiple comparison procedure indicated nitrate concentrations in the Big Sioux-Brookings (east) unit were significantly larger than in the main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Deer Creek, Big Sioux-Brookings (west), and Antelope Valley units. A qualitative comparison of nitrate distributions (fig. 17) indicates that the Big Sioux-Aurora unit tended to have the next largest concentrations of nitrate in the Big Sioux River basin, whereas the smallest concentrations were detected in the Big Sioux-Brookings (west) unit. There may be some relation between large nitrate concentrations in the Big Sioux-Aurora unit and the shallow depth to sand or gravel seen in that area (fig. 16), although the relation is not statistically significant.

Large nitrate-nitrogen concentrations commonly have been detected in private wells near animal-confinement areas (barns and feedlots) and septic systems (South Dakota Department of Water and Natural Resources, 1986). There also is some possibility that fertilizers, both applied on fields and from leaking storage facilities, and nitrogen-fixing alfalfa fields are sources of large nitrate-nitrogen concentrations in shallow ground water in the Big Sioux River basin. This study was not designed to investigate sources of nitrate; the causes of the large nitrate concentrations in the eight study units are not known.

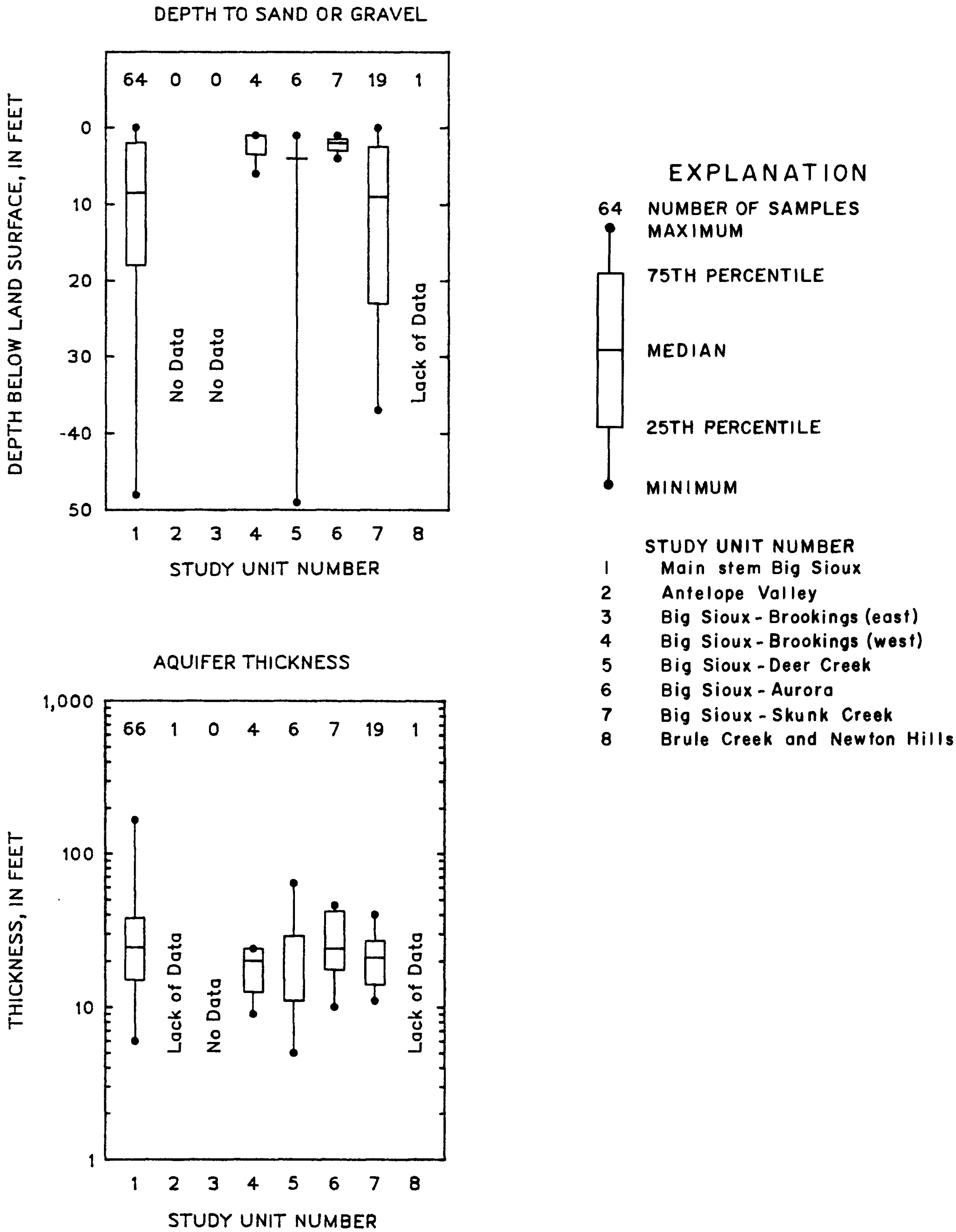

Figure 16.--Distribution of depth to sand or gravel and thickness of sand or gravel for eight study units in the Big Sioux River basin.

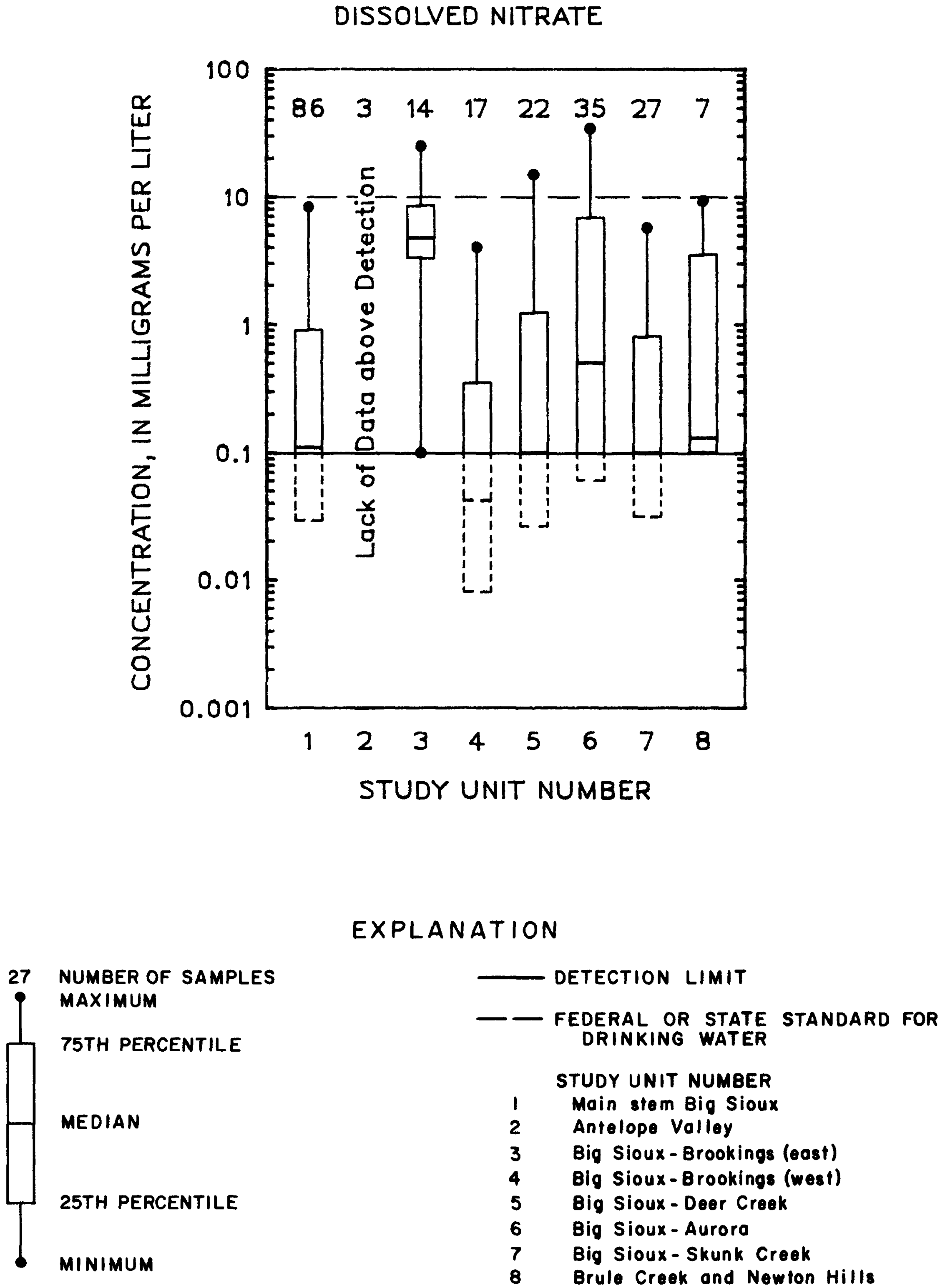

Figure 17.--Distribution of nitrate-nitrogen concentrations in ground-water samples from eight study units in the Big Sioux River basin, 1978-86.

SUMMARY AND CONCLUSIONS

The quality of ground water in the Big Sioux River basin generally is typical of glaciated areas in other parts of the upper Midwest. On a basin-wide level, the dominant cations and anions are calcium, magnesium, bicarbonate, and sulfate.

The spatial distribution of dominant ions and dissolved solids is highly variable within the basin. Dissolved solids ranged from 220 to 3,050 milligrams per liter with a median of 540 milligrams per liter. Water from wells in tributary outwash deposits tended to have larger dissolved-solids concentrations and a greater dominance of sulfate, as opposed to bicarbonate, than water from wells away from those areas. Dissolved-solids concentration and specific conductance were highly correlated with each other and with calcium, magnesium, and sulfate.

Correlation analysis indicated that well depth was not a significant factor influencing the presence of most cations or anions within the outwash deposits. This may indicate that no significant stratigraphic differences exist within the outwash deposits. However, a moderately large positive correlation exists between the major cations and bicarbonate and sulfate ions within outwash deposits in the basin. These relations and the abundance of calcium, magnesium, bicarbonate, and sulfate ions indicate possible dissolution of limestone, dolomitic limestone, and gypsum or the weathering and precipitation products of those minerals. Halite is not a significant mineral in the Big Sioux River basin as indicated by the generally low concentrations of sodium and chloride.

Chloride concentrations generally were small, but at least one sample had a chloride concentration greater than 100 milligrams per liter. Chloride concentrations were statistically correlated with sodium, magnesium, potassium, and sulfate concentrations. Chlorides in the ground water may arise from dissolution of chloride-containing minerals that are naturally a minor component of the soils, till, and sand and gravel deposits in the basin.

Dissolved-fluoride concentrations generally were much less than the U.S. Environmental Protection Agency's maximum contaminant level of 4.0 milligrams per liter. Fluoride concentrations were positively correlated to bicarbonate concentrations and negatively correlated to potassium concentrations. However, these correlations were small.

Trace-element (arsenic, cadmium, copper, chromium, mercury, lead, and selenium) concentrations were difficult to analyze statistically because of the presence of values less than a given reporting or detection limit. A log-probability regression procedure was used to estimate distributional parameters of the common trace elements. This analysis showed that on a basin-wide level, almost all elements generally were lower than the Federal or State standards for those elements in drinking water.

Iron concentrations ranged from less than 10 to 23,000 micrograms per liter, whereas manganese concentrations ranged from less than 2 to 5,000 micrograms per liter. Iron concentrations in samples from this study commonly were greater than 300 micrograms per liter, and manganese concentrations frequently were greater than 50 micrograms per liter. Slight but significant relations between the major cations and manganese indicate a common mineral source or sources. Iron was negatively correlated with depth to water. The higher the water-table elevation, the lower the iron concentration in the samples. The observed concentrations may arise from the oxidation of pyrite found within quartz fragments that make up the sand and gravel deposits in the basin or secondary minerals transported by glacial ice.

Concentrations of nitrate nitrogen in all study units commonly exceeded levels considered natural background; most study units had some samples that approached or exceeded the maximum contaminant level for drinking water of 10 milligrams per liter nitrate nitrogen established by the Environmental Protection Agency. Largest concentrations of nitrate nitrogen were found in the Big Sioux-Brookings (east) unit with about one-fourth of the samples approaching or exceeding the Environmental Protection Agency maximum contaminant level of 10 milligrams per liter for drinking water. All variables except well depth, depth to water, chloride, and fluoride were found to show a slight negative correlation with nitrate concentrations. When nitrate concentrations were large, the concentrations of most other correlated chemical variables were small. These relations indicate a dilution effect occurs when large nitrate concentrations are present. The mechanism of nitrate movement and contamination in these outwash deposits is unknown and needs additional study.

An analysis of the relation between hydrogeology and water-quality variables produced generally ambiguous results. Only potassium and chloride showed significant differences in concentrations between three depth to sand or gravel classes. Only boron and manganese showed significant differences between five classes of sand or gravel thickness. No data are available to explain the significance of these results. Undoubtedly a lack of hydrogeologic data and a lack of accuracy and resolution of the available data hampered the analysis.

Samples from the basin-wide analysis were separated into eight specific study units so that interunit comparisons could be made. Aquifers in these eight study units are the main stem Big Sioux unit, Brule Creek and Newton Hills unit, Big Sioux-Skunk Creek unit, Big Sioux-Aurora unit, Big Sioux-Deer Creek unit, Big Sioux-Brookings (west) unit, Big Sioux-Brookings (east) unit, and Antelope Valley unit. The main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Aurora, Big Sioux-Deer Creek, and Antelope Valley units contain water that is very similar for most cation and anion concentrations, although the Big Sioux-Skunk Creek generally was higher in sulfates. These relations indicate similar hydrology, hydrogeology, and mineralogy among the main stem Big Sioux, Big Sioux-Skunk Creek, Big Sioux-Aurora, Big Sioux-Deer Creek, and Antelope Valley units. The Big Sioux-Brookings (west) unit contained significantly larger concentrations than the other units, except the Brule Creek and Newton Hills, for nearly all constituents. The Big Sioux-Brookings (east) unit was not compared because nearly all samples had nitrate concentrations greater than 2.0 milligrams per liter and, thus, were dropped from comparison.

The analysis of dominant ions and the statistical analysis used in this study have directed the following conclusions concerning the probable source and controls on water quality in the basin: (1) Dominant cations and anions are similar among the eight study units; (2) hydrogeology does not appear to significantly affect the observed differences in water quality; (3) basin-wide water-table differences do not affect water quality to any significant degree; (4) the Big Sioux-Brookings (west) unit has significantly larger concentrations of most water-quality parameters than the other study units except the Brule Creek and Newton Hills unit.

Additional data would have been helpful in the interpretation of some of the relations or lack of relations observed. The analysis of the Brule Creek and Newton Hills, Big Sioux-Brookings (west), and Antelope Valley units was hampered by too few wells sampled during the study period. Data for well depth and depth to water commonly was not recorded during well sampling. Additional well logs and more accurate descriptions are needed for relating water-quality parameters to hydrogeology.

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SUPPLEMENTAL INFORMATION

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86

[*, Value exists in USGS water-quality data base as "ND" (specifically analyzed for but not detected) or "0," but was substituted with the most common detection limit for this constituent in this study; E, Estimated]

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICK-NESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
					* *	* *	* Main stem
1	424738096373301	92N49W16AAAA	07-27-81	30	22	41.50	14.40
1		--	06-18-82			41.50	10.53
2	424739096362201	92N49W15AAAA	07-27-81	18	38	53.00	--
2		--	06-18-82			53.00	10.92
3	424739096362202	92N49W15AAAA2	07-27-81	18	72	31.80	11.00
3		--	06-18-82			31.80	11.30
4	424833096354701	92N49W11BAAA	07-31-81	16	20	34.00	15.00
4		--	06-18-82			34.00	12.70
5	424833096354702	92N49W11BAAA2	07-31-81	15	44	52.00	15.00
5		--	06-18-82			52.00	12.90
6	424938096362001	93N49W35CBCB	07-31-81	9	23	32.00	9.00
7	425014096350002	93N49W25CCCB2	08-01-81	25	24	48.00	10.00
8	425016096350001	93N49W25CCCB	08-01-81	18	18	33.00	10.00
9	425027096334901	93N48W30CCAC	07-31-81	18	8	25.00	14.00
10	425059096361801	93N49W26BBBC	08-01-81	25	8	34.00	7.00
11	430354096300501	95N48W10BAD	03-09-82	-	-	33.00	--
12	430419096293901	95N48W03DDB	04-02-82	-	-	36.00	--
13	430501096293301	95N48W03ABAA	01-18-82	4	25	24.60	14.80
14	431242096284601	97N48W23ABCA	06-16-80	-	-	53.00	--
14		--	06-17-80			53.00	--
14		--	06-25-80			53.00	--
14		--	09-10-81			53.00	--
14		--	09-02-82	-	-	54.90	20.80
15	431305096285702	97N48W14CADC2	09-02-82	-	-	17.40	12.55
16	431322096285601	97N48W14BDDB	06-13-80	-	-	36.00	--
17	431322096285801	97N48W14BDBC	06-13-80	-	-	25.00	--
18	431321096294701	97N48W15ACDB	06-18-80	-	-	18.50	--
19	431527096351801	98N49W36BCBC	03-12-82	8	72	24.00	0.0
20	431527096351802	98N49W36BCBC2	03-12-82	8	72	39.00	0.0
21	431808096320302	98N48W17DDCB2	10-22-81	57	29	86.00	--
22	431917096322701	98N48W08CAAA	12-28-81	-	-	40.00	--
23	432920096351801	100N49W13BBBB	10-29-81	1	23	22.40	17.70
24	433354096454201	101N49W07CA	03-11-82	-	-	47.46	11.13
25	433418096453701	101N49W07BA	06-29-82	37	22	45.20	12.90
26	433412096410601	101N49W11BACB	09-16-80	20	12	29.00	12.80
26		--	10-22-80	20	12	29.00	12.40
27	433423096360201	101N48W04CDDC	08-27-80	3	25	23.00	--
28	433423096472402	101N50W01CCCC2	10-22-80	48	6	53.00	13.40
28		--	04-24-85	48	6	53.00	7.40
29	433538096353901	102N48W33DABA	09-08-80	-	-	42.00	--
30	433625096362101	102N48W28CACB	05-05-81	-	-	83.80	--
30		--	05-14-85		85.60	85.60	14.00
31	433634096375601	102N48W30ADDD	05-05-81	-	-	23.90	--
32	434117096434401	103N49W33BBBA	05-05-81	3	33	25.00	--
32		--	05-14-85			25.00	2.90
33	434330096431201	103N49W16ACCC	09-08-80	4	27	31.00	--
34	434330096434801	103N49W16BCCC	09-08-80	3	29	29.00	--
34		--	05-14-85			29.00	2.85
35	434340096453701	103N49W18ACBB	09-08-80	24	19	40.00	--
35		--	05-13-85			41.90	8.70
36	434446096454101	103N49W07BAAA	05-13-85	10	34	53.00	7.40
37	434446096454102	103N49W07BAAA2	05-13-85	10	24	34.00	7.40
38	434729096434801	104N49W20DDDA	09-23-80	2	40	25.00	9.30
38		--	10-20-86	2	40	25.00	2.50
39	434730096434801	104N49W20DDDA	10-29-81	10	17	24.00	13.00

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Big Sioux * * * * *									
--	710	--	--	--	--	404	96	32	20
--	704	6.7	--	10.0	--	340	92	31	20
--	722	--	--	--	--	415	110	29	18
--	711	7.1	--	9.5	--	340	98	29	22
--	624	--	--	--	--	352	94	28	7.0
--	616	--	--	--	--	340	92	26	10
--	643	--	--	--	--	363	87	26	16
--	757	--	--	--	--	330	90	27	15
--	762	--	--	--	--	340	100	30	22
--	759	7.1	--	10.0	--	320	110	34	15
--	928	--	--	--	--	425	150	45	24
--	968	--	--	--	--	480	150	44	27
--	820	--	--	--	--	400	120	34	22
--	909	--	--	--	--	470	140	45	26
--	923	--	--	--	--	460	120	44	24
--	1250	7.1	--	--	--	320	130	60	32
--	750	7.9	--	--	--	256	100	22	13
--	871	--	--	--	--	320	140	43	21
--	660	--	--	--	--	--	100	29	13
--	620	--	--	--	--	--	83	26	12
--	610	--	--	--	--	--	78	25	10
--	586	8.0	--	--	--	256	90	26	10
--	603	6.8	--	--	--	280	68	26	16
--	979	6.6	--	--	--	320	130	44	24
--	790	--	--	--	--	--	110	34	30
--	905	--	--	--	--	--	110	27	23
--	650	--	--	--	--	--	88	29	11
--	2460	--	--	9.0	--	786	450	150	100
--	2600	--	--	--	--	740	460	150	99
--	1450	7.9	--	--	--	128	150	60	86
--	1100	7.5	--	--	--	288	150	48	10
--	1180	--	--	--	--	440	190	53	46
--	1250	--	--	--	--	--	140	55	58
--	1260	7.2	--	--	--	394	130	55	77
--	650	--	8.0	--	--	132	64	43	17
650	650	--	8.0	--	--	132	64	43	17
--	930	--	--	--	--	--	120	35	45
--	450	--	8.1	--	--	158	40	24	18
--	440	--	8.0	--	--	108	37	21	12
530	530	8.3	--	--	132	132	48	19	32
470	470	--	8.0	--	--	200	52	29	22
--	500	--	8.1	--	--	188	38	30	24
600	600	--	7.9	--	--	200	64	34	20
--	800	--	7.9	--	--	249	100	22	18
--	650	--	8.0	--	--	196	57	39	20
--	510	--	8.2	--	--	152	48	29	14
--	600	--	8.3	--	--	128	52	31	27
--	700	--	8.1	--	--	136	63	40	24
--	900	--	8.2	--	--	96	100	43	30
--	750	--	8.0	--	--	124	67	47	13
--	600	--	8.0	--	--	144	57	35	15
--	500	--	8.1	--	--	160	48	28	12
--	655	--	8.0	--	--	254	75	29	32
--	700	--	7.8	--	--	312	96	29	10
--	629	--	--	--	--	330	88	28	15

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	POTAS-SIUM, TOTAL RECOV-ERABLE (MG/L AS K) (00937)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICAR-BONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)
									* * *	Main stem
1	07-27-81	4.7	--	--	493	56	5.0	0.51	438	460
1	06-18-82	4.7	--	--	414	61	2.0	0.44	396	418
2	07-27-81	4.4	--	--	506	82	5.0	0.28	455	500
2	06-18-82	4.6	--	--	413	82	6.0	0.24	482	449
3	07-27-81	1.8	--	--	429	38	4.0	0.33	380	387
3	06-18-82	1.9	--	--	414	51	7.0	0.24	414	394
4	07-31-81	2.8	--	--	442	45	5.0	0.36	385	400
4	06-18-82	2.7	--	--	402	50	4.0	0.36	456	388
5	07-31-81	3.8	--	--	421	90	13	0.37	475	472
5	06-18-82	3.8	--	--	390	150	8.0	0.29	604	512
6	07-31-81	6.4	--	--	519	130	24	0.40	612	638
7	08-01-81	4.1	--	--	615	130	16	0.26	625	681
8	08-01-81	3.1	--	--	519	65	11	0.16	512	546
9	07-31-81	0.40	--	--	573	80	31	0.36	582	617
10	08-01-81	4.8	--	--	573	98	13	0.36	582	592
11	03-09-82	9.0	--	--	390	280	14	--	--	715
12	04-02-82	8.0	--	--	312	100	11	--	--	411
13	01-18-82	2.9	--	--	390	250	20	0.32	664	681
14	06-16-80	--	--	--	--	120	20	0.34	476	--
14	06-17-80	--	--	--	--	50	8.0	0.33	396	--
14	06-25-80	--	--	--	--	65	2.0	0.33	344	--
14	09-10-81	9.4	--	--	313	56	<2.0	0.24	398	--
14	09-02-82	8.6	--	--	341	48	3.0	0.30	394	338
15	09-02-82	4.8	--	--	390	200	12	0.23	689	612
16	06-13-80	--	--	--	--	140	25	0.27	540	--
17	06-13-80	--	--	--	--	35	20	0.28	496	--
18	06-18-80	--	--	--	--	100	5.0	0.40	392	--
19	03-12-82	17	--	--	958	1000	4.0	0.20	2530	2200
20	03-12-82	17	--	--	903	1300	4.0	0.24	2440	2520
21	10-22-81	25	--	--	156	630	9.0	--	1140	1040
22	12-28-81	3.0	--	--	351	260	36	--	--	679
23	10-29-81	5.2	--	--	537	330	9.0	0.35	852	903
24	03-11-82	12	--	--	--	73	57	0.23	700	--
25	06-29-82	6.3	--	--	480	220	36	0.31	872	759
26	09-16-80	2.0	--	--	161	180	17	--	424	406
26	10-22-80	2.0	--	--	161	180	17	--	424	406
27	08-27-80	--	--	--	--	230	13	0.33	640	--
28	10-22-80	3.0	--	--	193	65	8.0	--	220	253
28	04-24-85	4.0	--	--	132	98	2.0	--	268	239
29	09-08-80	3.0	--	150	151	100	22	--	320	305
30	05-05-81	4.0	--	--	244	77	9.0	--	328	317
30	05-14-85	25	--	--	229	63	32	--	318	325
31	05-05-81	4.0	--	--	244	120	12	--	420	390
32	05-05-81	2.0	--	--	303	130	7.0	--	512	436
32	05-14-85	2.0	--	--	239	130	4.0	--	400	372
33	09-08-80	1.0	--	--	185	78	16	--	316	284
34	09-08-80	2.0	--	--	156	120	45	--	380	358
34	05-14-85	3.0	--	--	166	200	34	--	464	441
35	09-08-80	2.0	--	--	117	340	25	--	634	599
35	05-13-85	3.0	--	--	151	240	20	--	528	464
36	05-13-85	3.0	--	--	176	140	8.0	--	416	349
37	05-13-85	3.0	--	--	195	89	7.0	--	300	283
38	09-23-80	3.4	--	--	310	85	11	0.46	461	389
38	10-20-86	2.0	--	--	381	74	5.0	--	408	403
39	10-29-81	2.5	--	--	421	58	3.0	0.55	370	404

NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L) AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
Big Sioux	* * * * *								
--	--	<0.100	11	--	200	--	1.4	--	<20
--	--	<0.100	6	--	100	--	<0.2	--	<20
--	--	0.100	10	--	100	--	0.6	--	20
--	--	0.600	2	--	110	--	0.5	--	20
--	--	<0.100	<10	--	80	--	0.7	--	<20
--	--	<0.100	3	--	60	--	<0.2	--	<20
--	--	<0.100	<5	--	150	--	0.3	--	<20
--	--	0.200	<2	--	80	--	<0.2	--	<20
--	--	0.100	5	--	120	--	0.8	--	20
--	--	<0.100	<2	--	120	--	0.2	--	<20
--	--	<0.100	<10	--	190	--	0.4	--	20
--	--	0.900	<10	--	120	--	0.7	--	<20
--	--	8.30	<5	--	100	--	0.6	--	<20
--	--	3.20	<10	--	190	--	0.6	--	20
--	--	<0.100	<10	--	160	--	0.5	--	20
--	--	--	--	--	1400	--	--	--	--
--	--	--	--	--	70	--	--	--	--
--	--	1.80	<5	--	100	--	0.7	--	20
--	--	<0.050	--	--	--	--	--	--	--
--	--	<0.050	--	--	--	--	--	--	--
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	--	2	--	--	--	<1	--
--	--	<0.100	1	--	--	--	<0.2	--	<20
--	--	0.900	--	--	--	--	<0.2	--	<20
--	--	0.180	--	--	--	--	--	--	--
--	7.00	--	--	--	--	--	--	--	--
--	3.60	--	--	--	--	--	--	--	--
--	--	<0.100	<10	--	450	--	0.7	--	50
--	--	<0.100	<10	--	450	--	0.8	--	70
--	3.05	--	--	--	600	--	--	--	--
--	--	--	--	--	100	--	--	--	--
--	--	0.100	<5	--	120	--	0.4	--	<20
--	--	<0.100	1	--	340	--	<0.2	--	<20
--	--	<0.100	<0.3	--	110	--	<0.2	--	<20
0.370	--	0.370	--	--	50	--	--	--	--
0.370	--	--	--	--	50	--	--	--	--
<0.100	--	--	--	--	--	--	--	--	--
0.060	--	--	--	--	50	--	--	--	--
0.030	--	0.030	--	--	80	--	--	--	--
--	0.080	--	--	--	130	--	--	--	--
0.790	--	--	--	--	220	--	--	--	--
--	--	<0.010	--	--	210	--	--	--	--
3.68	--	--	--	--	160	--	--	--	--
0.380	--	--	--	--	90	--	--	--	--
0.020	--	--	--	--	60	--	--	--	--
1.48	--	--	--	--	30	--	--	--	--
0.120	--	--	--	--	110	--	--	--	--
--	--	--	--	--	20	--	--	--	--
0.060	--	--	--	--	90	--	--	--	--
--	--	--	--	--	100	--	--	--	--
0.060	--	--	--	--	180	--	--	--	--
--	--	--	--	--	120	--	--	--	--
<0.100	<0.100	--	--	--	--	--	--	--	--
0.010	--	--	--	--	--	--	--	--	--
--	--	<0.100	2	--	80	--	<0.4	--	<20

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-wster samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * *	* * Main stem	
1	07-27-81	--	2400	2	--	--	1200	<0.2	--	<20	--
1	06-18-82	--	2000	3	--	--	1000	--	--	<20	--
2	07-27-81	--	80	1	--	--	1000	0.2	--	20	--
2	06-18-82	--	10	13	--	--	1100	--	--	<20	--
3	07-27-81	--	1200	<1	--	--	1200	<0.2	--	<20	--
3	06-18-82	--	1200	1	--	--	820	*<0.2	--	<20	--
4	07-31-81	--	<50	<1	--	--	810	<0.2	--	<20	--
4	06-18-82	--	70	1	--	--	720	*<0.2	--	<20	--
5	07-31-81	--	50	3	--	--	--	0.2	--	20	--
5	06-18-82	--	60	1	--	--	1400	--	--	<20	--
6	07-31-81	--	2900	<1	--	--	1000	<0.2	--	<20	--
7	08-01-81	--	<50	<1	--	--	980	<0.2	--	<20	--
8	08-01-81	--	<50	<1	--	--	650	<0.2	--	<20	--
9	07-31-81	--	<50	<1	--	--	<50	<0.2	--	<20	--
10	08-01-81	--	970	<1	--	--	<50	<0.2	--	<20	--
11	03-09-82	--	--	--	--	--	--	--	--	--	--
12	04-02-82	--	--	--	--	--	--	--	--	--	--
13	01-18-82	--	20	<1	--	--	660	<0.2	--	<20	--
14	06-16-80	<50	<50	--	--	300	--	--	--	--	--
14	06-17-80	--	60	--	--	280	--	--	--	--	--
14	06-25-80	--	50	--	--	270	--	--	--	--	--
14	09-10-81	--	50	--	4	380	--	--	<0.20	--	--
14	09-02-82	--	<50	--	--	--	<50	--	--	<20	--
15	09-02-82	--	<50	1	--	--	420	--	--	<20	--
16	06-13-80	2400	2400	--	--	690	--	--	--	--	--
17	06-13-80	<30	<30	--	--	40	--	--	--	--	--
18	06-18-80	<50	<50	--	--	<50	--	--	--	--	--
19	03-12-82	--	3500	<1	--	--	1300	0.2	--	<20	--
20	03-12-82	--	3400	<1	--	--	1500	<0.2	--	<20	--
21	10-22-81	--	140	--	--	--	--	--	--	--	--
22	12-28-81	--	--	--	--	--	--	--	--	--	--
23	10-29-81	--	50	<1	--	--	3800	<0.1	--	30	--
24	03-11-82	--	6800	<1	--	--	1100	<0.2	--	<20	--
25	06-29-82	--	660	<1	--	--	1200	--	--	<20	--
26	09-16-80	--	1000	--	--	--	--	--	--	--	--
26	10-22-80	--	1000	--	--	--	--	--	--	--	--
27	08-27-80	--	1100	--	--	--	1100	--	--	--	--
28	10-22-80	--	50	--	--	--	--	--	--	--	--
28	04-24-85	--	--	--	--	--	--	--	--	--	--
29	09-08-80	*<10	*<10	--	--	--	--	--	--	--	--
30	05-05-81	--	400	--	--	--	--	--	--	--	--
30	05-14-85	--	--	--	--	--	--	--	--	--	--
31	05-05-81	--	160	--	--	--	--	--	--	--	--
32	05-05-81	--	70	--	--	--	--	--	--	--	--
32	05-14-85	--	--	--	--	--	--	--	--	--	--
33	09-08-80	--	350	--	--	--	--	--	--	--	--
34	09-08-80	--	980	--	--	--	--	--	--	--	--
34	05-14-85	--	--	--	--	--	--	--	--	--	--
35	09-08-80	--	470	--	--	--	--	--	--	--	--
35	05-13-85	--	--	--	--	--	--	--	--	--	--
36	05-13-85	--	--	--	--	--	--	--	--	--	--
37	05-13-85	--	--	--	--	--	--	--	--	--	--
38	09-23-80	--	1400	--	--	700	--	--	--	--	--
38	10-20-86	--	--	--	--	--	--	--	--	--	--
39	10-29-81	--	810	1	--	--	990	<0.1	--	<20	--

SELE- NIUM, DIS- SOLVED (UG/L AS SE) (01145)	SELE- NIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOV- ERABLE (UG/L AS ZN) (01092)
Big Sioux * * * * *			
<2	--	36	--
<0.2	--	6	--
2	--	5	--
<0.2	--	11	--
<2	--	7	--
<0.2	--	<5	--
<2	--	11	--
<2	--	<5	--
2	--	44	--
<2	--	<5	--
<2	--	<5	--
<2	--	9	--
3	--	14	--
2	--	7	--
<2	--	<5	--
--	--	--	--
--	--	--	--
<2	--	<5	--
--	--	--	--
--	--	--	--
--	--	--	--
--	*<1.0	--	10
<0.2	--	690	--
1	--	<5	--
--	--	--	--
--	--	--	--
--	--	--	--
<2	--	<5	--
<2	--	14	--
--	--	--	--
--	--	--	--
<2	--	<5	--
<0.2	--	<5	--
<0.6	--	6	--
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<2	--	20	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICK-NESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
					* *	* * *	Main stem
39	434730096434801	104N49W20DDDA	06-17-82			24.00	10.90
40	435358096411501	105N49W14BCCC	05-15-80	-	-	26.70	7.40
41	435424096411701	105N49W10DDDD	05-15-80	-	-	14.70	6.60
42	435751096412001	106N49W22DDDD	09-09-82	1	31	21.00	--
43	435922096401201	106N49W13BCBB	06-22-82	-	-	19.50	5.70
44	440543096370001	107N48W05DCCC	04-07-78	7	44	18.00	--
44		--	05-15-80			18.00	10.40
45	440908096423101	108N49W22BBBB	02-19-82	6	8	12.90	7.14
46	441043096450001	108N49W07ADDD	02-19-82	10	10	20.00	--
47	441107096435801	108N49W05DDA	11-19-80	-	-	28.00	--
48	441107096435802	108N49W05DDB2	11-19-80	-	-	27.00	--
49	441146096452501	109N49W31DCCC	02-21-80	5	14	22.00	--
50	441155096452501	109N49W31DCBB	02-21-80	-	-	23.00	--
51	441157096450901	109N49W31DDB	02-21-80	-	-	17.00	--
52	441208096452401	109N49W31DBBB	02-21-80	-	-	24.00	--
53	441220096452501	109N49W31ACBB	02-21-80	-	-	23.00	--
54	441223096450801	109N49W31AAC	02-21-80	-	-	25.00	--
55	441224096464701	109N50W36BACD	02-21-80	-	-	29.00	--
56	441257096494101	109N50W28DAAD	08-08-79	-	-	42.00	--
57	441346096540001	109N51W24CADB	03-06-79	-	-	57.00	--
58	441659096542701	110N51W36CCCC	08-22-79	4	30	37.60	--
59	441928096543001	110N51W23AAAD	08-22-79	1	14	17.10	--
60	442015096503901	110N50W16CCCC	06-16-82	1	17	13.00	4.66
61	442024096565501	110N51W16AAAA	08-22-79	25	10	35.00	--
62	442025096531101	110N50W18BBBB	08-22-79	1	23	19.20	--
62		--	06-16-82	1	23	19.20	5.20
63	442116096543101	110N51W11AAAA	08-22-79	1	13	17.90	--
64	442525096525301	111N50W18BDBB	12-15-80	-	-	121.00	--
65	442545096534901	111N51W12CDDA	05-15-80	1	24	20.80	--
66	442724096542501	112N51W35DDDD	05-15-80	0	42	35.00	--
67	442903096510301	112N50W29AAB	12-14-79	-	-	35.00	--
68	442905096531601	112N51W25AAAA	09-15-78			31.00	--
68		--	12-28-78	2	35	31.00	--
68		--	04-10-79			31.00	--
68		--	03-24-80			31.00	--
68		--	04-10-81			31.00	--
68		--	09-10-81	2	35	31.00	--
69	442934096531301	112N50W19BCCC	05-15-80	2	39	37.00	--
70	442945096515901	112N50W20BCBB	02-29-80	-	-	46.00	--
71	442956096513001	112N50W20BAAC	02-29-80	-	-	30.00	--
72	442957096531701	112N51W24AAAA	05-15-80	-	-	38.70	--
73	442957096535001	112N51W24ABBB	05-15-80	-	-	47.90	--
74	443001096522901	112N50W18CDCD	08-22-79	-	-	41.50	--
75	443107096525301	112N50W07CCAA	12-30-80	-	-	35.00	--
76	443112096525301	112N50W07CACB	12-30-80	-	-	35.00	--
77	443158096514401	112N50W05CCA	11-29-78	2	37	46.00	--
78	443239096520201	113N50W31DDDD	06-15-82	4	31	18.60	10.62
79	443328096515601	113N50W31AAAA2	06-15-82	15	25	32.20	10.63
80	443422097002001	113N51W19CCCC	07-30-81	22	13	35.00	12.00
81	443510096481601	113N50W22AADD	06-15-82	18	167	84.00	0.0
82	443514096545501	113N51W23ABBB	07-30-81	2	32	24.30	9.00
83	443522097011901	113N52W13CCAA	05-04-81	-	-	98.00	--
84	443551096583601	113N51W17BDA	11-02-81	-	-	47.00	--
85	443701096552901	113N51W02CCCC2	08-31-81	0	62	65.00	--
86	444018096575901	114N51W20AADA	04-21-82	-	-	26.00	--

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Big Sioux * * * * *									
--	641	--	--	--	--	333	92	30	8.0
--	430	8.3	--	--	--	164	40	24	5.0
--	460	8.0	--	--	--	150	40	29	11
--	894	--	--	--	--	--	120	42	18
--	1050	7.2	--	--	--	290	150	50	28
--	712	8.3	--	--	--	224	90	32	10
--	460	8.2	--	--	--	160	56	29	11
--	882	--	--	--	--	306	130	42	19
--	442	--	--	--	--	53	35	11	37
--	534	8.2	--	--	--	164	84	13	4.0
--	537	7.2	--	--	--	217	80	24	4.0
--	819	7.7	--	--	--	252	89	47	17
--	744	8.3	--	--	--	253	100	38	14
--	922	7.5	--	--	--	268	120	52	18
--	997	8.3	--	--	--	277	120	45	19
--	806	7.4	--	--	--	252	100	44	17
--	737	8.4	--	--	--	254	100	47	18
669	--	7.6	--	--	110	--	59	34	10
--	945	7.0	--	--	--	294	160	29	24
--	1660	7.1	--	--	--	388	230	85	34
--	980	7.6	--	--	--	188	110	53	16
--	690	7.9	--	--	--	256	96	29	12
--	1060	--	--	9.0	--	560	130	54	29
--	920	7.9	--	--	--	292	120	31	33
--	545	8.2	--	--	--	212	88	19	7.0
--	594	--	--	--	--	220	80	27	8.0
--	798	8.0	--	--	--	272	110	34	18
795	795	7.5	--	--	349	349	96	36	17
650	650	8.1	--	--	232	232	80	24	17
400	400	8.0	--	--	144	144	48	34	5.0
537	537	8.2	--	--	233	233	72	7.0	28
--	--	--	--	--	--	--	--	--	--
675	675	7.6	--	--	244	244	100	38	7.0
607	607	7.4	--	--	214	214	87	26	8.0
584	584	7.4	--	--	228	228	88	24	8.0
651	651	7.6	--	--	228	228	100	17	8.0
607	607	7.6	--	--	224	224	100	19	10
510	510	7.9	--	--	144	144	48	24	9.0
646	646	--	--	--	264	264	86	27	9.0
650	--	7.4	--	--	272	--	100	14	10
480	480	7.7	--	--	116	116	48	29	10
700	700	7.5	--	--	123	123	40	38	18
609	609	7.6	--	--	232	232	96	24	14
666	666	7.7	--	--	281	281	88	38	21
603	603	7.6	--	--	234	234	92	22	20
--	1480	7.2	--	--	--	360	160	71	97
--	712	7.8	--	8.0	--	268	87	33	20
--	871	7.8	--	8.0	--	249	100	41	28
--	674	--	--	--	--	345	95	32	8.0
--	1410	--	--	10.0	--	350	120	50	59
--	598	--	--	--	--	270	86	27	11
--	860	7.6	--	--	--	326	120	43	44
--	1100	7.0	--	--	--	332	140	43	20
--	950	8.0	--	--	--	236	110	36	18
580	580	7.5	--	--	252	252	96	20	10

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	POTASSIUM, TOTAL RECOVERABLE (MG/L AS K) (00937)	BICARBONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICARBONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)
									* * *	Main stem
39	06-17-82	1.5	--	--	399	46	3.0	0.57	412	379
40	05-15-80	2.0	--	--	190	46	12	--	252	228
41	05-15-80	2.0	--	--	183	87	10	--	378	270
42	09-09-82	4.2	--	--	256	260	14	0.12	650	583
43	06-22-82	2.9	--	--	353	330	4.0	0.35	758	734
44	04-07-78	4.0	--	--	273	140	9.0	--	500	418
44	05-15-80	3.0	--	--	195	94	12	--	316	306
45	02-19-82	<0.10	--	--	375	240	2.0	0.32	610	--
46	02-19-82	7.8	--	--	64	110	45	0.64	244	280
47	11-19-80	2.0	--	--	200	47	6.0	--	--	254
48	11-19-80	2.0	--	--	264	49	6.0	--	--	295
49	02-21-80	1.0	--	--	307	170	4.0	--	--	479
50	02-21-80	1.0	--	--	249	130	5.0	--	--	443
51	02-21-80	5.0	--	--	327	180	56	--	--	593
52	02-21-80	5.0	--	--	251	160	47	--	--	562
53	02-21-80	1.0	--	--	307	160	2.0	--	--	479
54	02-21-80	1.0	--	--	261	180	2.0	--	--	502
55	02-21-80	1.0	--	130	--	95	2.0	--	--	265
56	08-08-79	10	--	--	359	220	4.0	--	--	626
57	03-06-79	11	--	--	473	440	10	--	--	1050
58	08-22-79	4.0	--	--	229	380	4.0	--	780	683
59	08-22-79	3.0	--	--	312	120	2.5	--	528	421
60	06-16-82	1.3	--	--	682	66	21	0.47	562	642
61	08-22-79	11	--	--	356	180	6.0	--	676	561
62	08-22-79	2.0	--	--	259	81	2.0	--	384	328
62	06-16-82	2.7	--	--	268	73	5.0	0.25	312	331
63	08-22-79	11	--	--	332	190	2.0	--	580	531
64	12-15-80	1.0	--	430	425	38	6.0	--	--	403
65	05-15-80	1.0	--	250	254	76	11	--	450	350
66	05-15-80	2.0	--	180	176	96	11	--	366	285
67	12-14-79	5.0	--	260	256	26	21	--	--	299
68	09-15-78	--	--	--	--	--	--	--	--	--
68	12-28-78	3.0	--	300	298	96	5.0	--	420	400
68	04-10-79	1.0	--	260	261	110	8.0	--	--	367
68	03-24-80	1.0	--	280	278	93	4.0	--	--	355
68	04-10-81	2.0	--	280	278	88	8.0	--	--	362
68	09-10-81	1.0	--	280	278	98	13	--	--	380
69	05-15-80	1.0	--	180	176	71	8.0	--	294	248
70	02-29-80	*<0.1	--	320	322	29	5.0	--	--	--
71	02-29-80	*<0.1	--	330	--	9.0	6.0	--	--	--
72	05-15-80	1.0	--	140	142	110	10	--	296	280
73	05-15-80	1.0	--	150	150	160	12	--	468	345
74	08-22-79	2.0	--	280	283	110	5.0	--	456	413
75	12-30-80	4.0	--	340	342	130	18	--	--	467
76	12-30-80	4.0	--	290	285	110	16	--	--	406
77	11-29-78	17	--	--	439	130	160	--	--	849
78	06-15-82	2.6	--	--	327	120	4.0	0.24	366	441
79	06-15-82	2.3	--	--	304	240	4.0	0.26	492	568
80	07-30-81	3.1	--	--	421	69	1.0	0.33	414	417
81	06-15-82	2.8	--	--	427	260	2.0	0.42	696	706
82	07-30-81	2.9	--	--	329	79	6.0	0.26	394	387
83	05-04-81	3.0	--	--	398	200	8.0	--	--	616
84	11-02-81	30	--	--	405	200	16	--	--	644
85	08-31-81	2.0	--	--	288	190	17	--	--	515
86	04-21-82	1.0	--	310	307	81	1.0	--	--	360

NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L) AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
Big Sioux * * * * *									
--	--	<0.100	<2	--	80	--	<0.2	--	<20
--	0.010	--	--	--	50	--	--	--	--
--	4.02	--	--	--	50	--	--	--	--
--	--	1.90	--	--	40	--	--	--	--
--	--	0.600	--	--	300	--	--	--	--
--	1.58	--	--	--	30	--	--	--	--
--	1.75	--	--	--	120	--	--	--	--
--	--	<0.100	<10	--	90	--	1.2	--	<20
--	--	<0.100	5	--	230	--	0.5	--	<20
--	--	--	--	--	--	--	--	--	--
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--	0.060	--	--	--	*<10	--	--	--	--
--	0.900	--	--	--	160	--	--	--	--
--	--	<0.100	<2	--	160	--	<0.2	--	<20
--	1.40	--	--	--	480	--	--	--	--
--	0.200	--	--	--	*<10	--	--	--	--
--	--	0.400	<2	--	150	--	<0.2	--	<20
--	0.140	--	--	--	*<10	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	0.300	--	--	--	270	--	--	--	--
--	0.160	--	--	--	160	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	<1	--	--	--	2	--
--	2.10	--	--	--	--	--	--	--	--
--	0.200	--	--	--	--	--	--	--	--
--	2.60	--	--	--	--	--	--	--	--
--	2.70	--	--	--	--	--	--	--	--
--	4.50	--	--	--	--	--	--	--	--
--	0.090	--	--	--	150	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	0.070	--	--	--	90	--	--	--	--
--	0.160	--	--	--	180	--	--	--	--
--	0.220	--	--	--	400	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	1.90	<2	--	120	--	0.3	--	<20
--	--	<0.100	4	--	140	--	<0.2	--	<20
--	--	<0.100	<5	--	60	--	0.5	--	<20
--	--	<0.100	21	--	350	--	0.2	--	<20
--	--	2.90	<10	--	60	--	0.9	--	<20
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Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * *	* *	Main stem
39	06-17-82	--	650	1	--	--	540	*<0.2	--	<20	--
40	05-15-80	--	200	--	--	--	--	--	--	--	--
41	05-15-80	--	1200	--	--	--	--	--	--	--	--
42	09-09-82	--	460	--	--	--	120	--	--	--	--
43	06-22-82	--	120	--	--	--	240	--	--	--	--
44	04-07-78	--	410	--	--	--	--	--	--	--	--
44	05-15-80	--	4700	--	--	--	--	--	--	--	--
45	02-19-82	--	120	<1	--	--	680	<0.2	--	<20	--
46	02-19-82	--	20	<1	--	--	120	<0.2	--	<20	--
47	11-19-80	--	--	--	--	--	--	--	--	--	--
48	11-19-80	--	--	--	--	--	--	--	--	--	--
49	02-21-80	--	--	--	--	--	--	--	--	--	--
50	02-21-80	--	--	--	--	--	--	--	--	--	--
51	02-21-80	--	--	--	--	--	--	--	--	--	--
52	02-21-80	--	--	--	--	--	--	--	--	--	--
53	02-21-80	--	--	--	--	--	--	--	--	--	--
54	02-21-80	--	--	--	--	--	--	--	--	--	--
55	02-21-80	--	--	--	--	--	--	--	--	--	--
56	08-08-79	--	--	--	--	--	--	--	--	--	--
57	03-06-79	--	--	--	--	--	--	--	--	--	--
58	08-22-79	--	1200	--	--	--	--	--	--	--	--
59	08-22-79	--	80	--	--	--	--	--	--	--	--
60	06-16-82	--	450	1	--	--	910	--	--	<20	--
61	08-22-79	--	590	--	--	--	--	--	--	--	--
62	08-22-79	--	1400	--	--	--	--	--	--	--	--
62	06-16-82	--	560	1	--	--	430	*<0.2	--	<20	--
63	08-22-79	--	440	--	--	--	--	--	--	--	--
64	12-15-80	--	--	--	--	--	--	--	--	--	--
65	05-15-80	1400	1400	--	--	--	--	--	--	--	--
66	05-15-80	2500	2500	--	--	--	--	--	--	--	--
67	12-14-79	--	--	--	--	--	--	--	--	--	--
68	09-15-78	--	--	--	3	--	--	--	<0.20	--	--
68	12-28-78	200	200	--	--	500	--	--	--	--	--
68	04-10-79	110	110	--	--	300	--	--	--	--	--
68	03-24-80	*<50	*<50	--	--	100	--	--	--	--	--
68	04-10-81	90	90	--	--	*<50	--	--	--	--	--
68	09-10-81	60	60	--	--	*<50	--	--	--	--	--
69	05-15-80	--	--	--	--	--	--	--	--	--	--
70	02-29-80	--	--	--	--	--	--	--	--	--	--
71	02-29-80	--	--	--	--	--	--	--	--	--	--
72	05-15-80	180	180	--	--	--	--	--	--	--	--
73	05-15-80	60	60	--	--	--	--	--	--	--	--
74	08-22-79	23000	23000	--	--	--	--	--	--	--	--
75	12-30-80	--	--	--	--	--	--	--	--	--	--
76	12-30-80	--	--	--	--	--	--	--	--	--	--
77	11-29-78	--	--	--	--	--	--	--	--	--	--
78	06-15-82	--	60	1	--	--	20	--	--	<20	--
79	06-15-82	--	1000	1	--	--	790	--	--	<20	--
80	07-30-81	--	<50	<1	--	--	1000	<0.2	--	<20	--
81	06-15-82	--	2300	<1	--	--	460	--	--	<20	--
82	07-30-81	--	<50	<1	--	--	<50	<0.2	--	<20	--
83	05-04-81	--	--	--	--	--	--	--	--	--	--
84	11-02-81	--	--	--	--	--	--	--	--	--	--
85	08-31-81	--	--	--	--	--	--	--	--	--	--
86	04-21-82	--	--	--	--	--	--	--	--	--	--

SELE- NIUM, DIS- SOLVED (UG/L AS SE) (01145)	SELE- NIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOV- ERABLE (UG/L AS ZN) (01092)
Big Sioux * * * * *			
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<2	--	7	--
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3	--	<5	--
<2	--	8	--
<2	--	22	--
<0.2	--	8	--
<2	--	7	--
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Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICK-NESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
					* * * * * Main stem		
87	444257097013101	114N52W01BBBB3	04-14-82	1	15	17.20	11.20
88	445345097020701	117N52W35ABBB	07-29-81	10	10	17.80	8.20
89	445522097075201	117N53W24D	10-06-80	-	-	20.00	--
90	445747097062401	117N52W06DDDD	06-25-81	35	12	44.30	4.60
90		--	07-30-81			44.30	6.00
91	445813097031901	117N52W03	12-10-80	-	-	90.00	--
92	451740097100302	121N52W03CCCC2-RR	06-15-82	1	15	15.90	9.82
93	451827097104501	122N52W33BDB	09-04-79	-	-	60.00	--
94	452109097085001	122N52W15AA-R	10-17-78	-	-	55.00	--
					* * * * * Brule Creek and		
95	425858096433701	94N50W03DDDD	04-21-82	21	57	62.80	7.30
96	425933096341301	94N49W01ADA	10-27-81	-	-	22.90	--
97	425933096340701	94N49W01ADAA	10-27-81	18	7	22.90	9.38
98	425943096422101	94N50W01BBBB	06-19-80	5	61	43.00	--
99	430054096433101	95N50W26CCCC	03-17-81	-	-	64.00	--
100	430311096373801	95N49W15BBBC	06-19-80	-	-	44.40	--
101	430315096430501	95N50W14BAAB	06-19-80	-	-	61.80	--
102	430502096415401	96N50W36CDDC	06-19-80	-	-	28.50	--
					* * * * * Big Sioux-		
103	433235096483101	101N50W23BBBA	05-20-85	-	-	57.00	8.00
103		--	09-08-80	-	-	53.00	--
104	433237096461701	101N50W24AAAA	07-28-81	-	-	24.00	15.00
105	433330096502701	101N50W16BAAA	03-10-82	0	14	17.30	12.89
105		--	04-24-85			17.30	7.10
106	433421096523601	101N50W07ABAB	07-28-81	4	11	14.10	7.00
107	433726096525101	102N50W19BCCD	08-14-78	1	21	22.90	--
107		--	04-24-85	1	21	25.40	9.70
108	434239096532201	103N50W19BCCC	08-14-78	3	25	29.10	--
108		--	04-23-85	3	25	31.60	2.60
109	434344096525201	103N50W18BDAD	11-28-78	-	-	46.00	--
110	434355096521601	103N50W18AAAA	08-14-78	9	26	30.90	--
110		--	04-23-85	9	26	34.30	3.20
111	434541096524001	104N50W31DCCD	08-14-78	-	-	31.90	--
112	434542096524101	--	06-16-82	20	12	32.20	--
113	435005096501902	104N50W04DCCC2	06-16-82	2	34	29.10	11.09
114	435005096502201	104N50W04DCCC	08-14-78	-	-	45.70	--
114		--	06-16-82	-	-	45.70	8.10
114		--	04-23-85	-	-	49.30	5.10
115	435237096520401	105N50W29BBBB	08-14-78	-	-	43.80	--
115		--	09-10-82	-	-	43.80	--
116	435316096582601	105N51W20ABD	11-18-78	-	-	52.00	--
117	435350096580401	105N51W16CBBC	07-31-79	37	14	52.20	--
117		--	02-19-82	37	14	52.20	--
118	435333096580602	105N51W16CCCC2	07-31-79	-	-	28.70	--
119	435354097004901	105N52W13DBA	11-18-78	-	-	27.00	--
120	435424096552601	105N51W11CCCD	07-31-79	32	16	42.40	--
120		--	02-19-82	32	16	42.40	20.16
121	435513096580401	105N51W09BBBB	07-31-79	23	28	43.40	--
121		--	02-19-82	23	28	43.40	12.81
122	440000097052501	106N52W08DAAA	03-01-82	10	40	50.00	--
122		--	08-31-82			50.00	12.90

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Big Sioux * * * * *									
848	848	--	--	6.0	--	309	100	47	13
--	970	--	--	--	--	440	120	57	20
944	944	7.0	--	--	252	252	120	50	10
--	850	--	7.8	--	--	224	84	41	53
--	1120	--	--	--	--	510	140	54	42
1070	1070	6.8	--	--	352	352	160	64	47
--	478	--	7.7	10.0	--	220	63	24	11
--	562	--	7.4	--	--	296	72	43	6.0
--	663	--	7.2	--	--	246	64	46	7.0
Newton Hills * * * * *									
--	938	--	--	7.5	--	400	150	46	29
--	1230	--	--	--	--	420	200	61	22
--	968	--	--	10.0	--	395	140	44	20
700	--	8.3	--	--	--	128	64	43	16
1300	--	7.8	--	--	--	156	210	67	45
1150	--	8.0	--	--	--	80	160	53	26
1200	--	8.0	--	--	--	64	160	53	24
550	--	8.1	--	--	--	212	60	53	10
Skunk Creek * * * * *									
--	900	--	7.9	--	--	134	110	38	16
850	850	8.1	--	--	96	96	84	50	16
--	1040	--	--	--	--	290	160	49	21
767	767	--	--	--	505	505	120	37	19
--	500	--	8.0	--	--	144	43	29	12
--	1070	--	--	--	--	290	100	38	13
--	946	--	7.7	--	--	212	110	52	25
--	700	--	8.1	--	--	116	62	46	13
--	1020	--	7.4	--	--	288	120	48	24
--	800	--	8.1	--	--	140	54	50	40
1060	1060	7.2	--	--	331	331	170	57	19
--	682	--	7.7	--	--	174	67	35	12
--	480	--	8.0	--	--	132	40	25	12
--	850	--	7.7	--	--	260	120	42	14
858	858	--	--	--	340	340	120	35	45
588	588	--	--	10.0	--	219	33	14	75
--	850	--	8.0	--	--	317	97	47	18
--	825	--	--	--	--	337	100	44	20
--	570	--	8.1	--	--	176	48	38	16
--	1130	8.0	--	--	--	264	150	53	32
--	1160	--	--	--	--	--	150	58	34
--	1850	7.1	--	--	--	320	320	65	44
--	922	7.6	--	--	--	284	160	29	30
--	650	--	--	9.0	--	295	96	27	21
--	592	8.1	--	--	--	204	80	29	19
--	2070	7.2	--	--	--	414	390	62	78
--	986	7.7	--	--	--	282	110	49	39
--	1010	--	--	9.0	--	290	140	52	22
--	660	7.9	--	--	--	228	100	24	14
--	719	--	--	9.0	--	270	96	35	15
--	1780	--	--	--	--	--	230	98	94
--	1850	7.5	7.5	13.0	--	568	230	89	79

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	POTAS-SIUM, TOTAL RECOV-ERABLE (MG/L AS K) (00937)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICAR-BONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)
									* * *	Main stem
87	04-14-82	1.4	--	--	377	130	22	0.25	550	503
88	07-29-81	2.1	--	--	537	180	6.0	0.31	650	652
89	10-06-80	20	--	310	307	240	10	--	--	601
90	06-25-81	4.0	--	--	273	220	12	--	620	548
90	07-30-81	3.2	--	--	622	200	2.0	0.38	680	747
91	12-10-80	4.0	--	430	429	320	9.0	--	--	810
92	06-15-82	2.1	--	--	268	37	6.0	0.14	281	277
93	09-04-79	3.0	--	--	361	28	2.0	--	--	332
94	10-17-78	3.0	--	--	300	28	4.0	--	--	300
							*	* * * *	Brule Creek	and
95	04-21-82	4.2	--	--	488	260	3.0	0.32	730	730
96	10-27-81	6.1	--	--	500	450	4.0	1.0	1010	996
97	10-27-81	2.3	--	--	482	170	7.0	1.0	664	669
98	06-19-80	6.0	--	--	146	210	4.0	*<0.1	516	431
99	03-17-81	8.0	--	--	190	690	11	--	--	1130
100	06-19-80	6.0	--	--	98	570	8.0	--	1050	881
101	06-19-80	4.0	--	--	78	550	6.0	--	996	836
102	06-19-80	2.0	--	--	259	170	12	--	480	433
								* *	* * *	Big Sioux-
103	05-20-85	4.0	--	--	164	310	9.0	--	654	572
103	09-08-80	3.0	--	120	117	330	10	--	612	546
104	07-28-81	3.6	--	--	354	340	5.0	0.15	795	759
105	03-10-82	2.9	--	620	616	82	5.0	0.35	511	571
105	04-24-85	4.0	--	--	176	110	6.0	--	316	293
106	07-28-81	2.3	--	--	354	160	35	0.36	545	529
107	08-14-78	5.0	--	--	259	320	4.0	--	700	641
107	04-24-85	4.0	--	--	142	220	7.0	--	484	427
108	08-14-78	3.0	--	350	351	240	7.0	--	692	619
108	04-23-85	4.0	--	--	171	230	34	--	604	497
109	11-28-78	2.0	--	400	403	220	45	--	--	708
110	08-14-78	2.0	--	210	212	99	4.0	--	388	323
110	04-23-85	2.0	--	--	161	94	6.0	--	304	258
111	08-14-78	5.0	--	320	317	170	9.0	--	536	524
112	06-16-82	4.1	--	--	414	190	4.0	0.33	646	612
113	06-16-82	10	--	--	267	98	11	0.54	306	377
114	08-14-78	5.0	--	390	386	170	3.0	--	584	525
114	06-16-82	3.4	--	--	411	160	6.0	0.36	476	537
114	04-23-85	3.0	--	--	215	120	9.0	--	392	342
115	08-14-78	5.0	--	--	322	330	2.0	--	812	730
115	09-10-82	3.6	--	--	342	390	4.0	0.25	850	814
116	11-18-78	4.0	--	--	390	760	2.0	--	--	1390
117	07-31-79	8.0	--	--	346	270	2.0	--	424	672
117	02-19-82	4.7	--	--	360	120	5.0	0.22	378	455
118	07-31-79	4.0	--	--	239	120	8.0	--	--	382
119	11-18-78	12	--	--	505	970	2.0	--	--	1770
120	07-31-79	7.0	--	--	344	320	6.0	--	736	696
120	02-19-82	5.2	--	--	354	300	2.0	0.26	696	701
121	07-31-79	4.0	--	--	278	150	4.0	--	500	441
121	02-19-82	3.6	--	--	329	150	2.0	0.20	456	470
122	03-01-82	--	--	--	--	580	14	0.64	1320	--
122	08-31-82	12	--	--	--	550	12	0.50	1430	1340

NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L) AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
Big Sioux * * * * *									
--	--	1.00	<5	--	170	--	0.7	--	<20
--	--	0.200	<10	--	200	--	0.5	--	20
--	--	--	--	--	--	--	--	--	--
0.380	--	--	--	--	220	--	--	--	--
<0.100	--	--	<10	--	170	--	0.5	--	<20
--	--	--	--	--	--	--	--	--	--
0.300	--	--	<2	--	80	--	<0.2	--	<20
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
Newton Hills * * * * *									
--	--	0.100	5	--	190	--	0.3	--	20
--	--	<0.100	<5	--	180	--	0.2	--	30
--	--	9.30	5	--	120	--	0.7	--	20
3.50	--	--	--	--	140	--	--	--	--
--	--	--	--	--	70	--	--	--	--
2.28	--	--	--	--	140	--	--	--	--
0.120	--	--	--	--	170	--	--	--	--
0.130	--	--	--	--	520	--	--	--	--
Skunk Creek * * * * *									
--	--	<0.010	--	--	100	--	--	--	--
--	0.940	--	--	--	30	--	--	--	--
--	--	0.800	<10	--	40	--	0.4	--	<20
--	--	0.100	5	--	120	--	0.9	--	20
--	--	<0.010	--	--	110	--	--	--	--
--	--	<0.100	<5	--	40	--	0.2	--	<20
0.270	--	--	--	--	20	--	--	--	--
0.610	--	--	--	--	60	--	--	--	--
0.140	--	--	--	--	50	--	--	--	--
0.060	--	--	--	--	180	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	*<10	--	--	--	--
0.040	--	--	--	--	10	--	--	--	--
0.300	--	--	--	--	50	--	--	--	--
--	--	<0.100	12	--	90	--	0.3	--	--
--	--	0.800	<2	--	70	--	<0.2	--	<20
0.070	--	--	--	--	*<10	--	--	--	--
--	--	<0.100	<2	--	120	--	0.2	--	<20
--	--	--	--	--	100	--	--	--	--
--	1.53	--	--	--	40	--	--	--	--
--	--	1.84	--	--	180	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	1.80	--	--	--	20	--	--	--	--
--	--	0.300	<5	--	180	--	1.1	--	<20
--	5.75	--	--	--	*<10	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	0.010	--	--	--	*<10	--	--	--	--
--	--	<0.100	<10	--	100	--	1.4	--	20
--	0.350	--	--	--	*<10	--	--	--	--
--	--	<0.100	5	--	80	--	1.1	--	<20
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	--	--	--	--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * * * * Main stem		
87	04-14-82	--	10	<1	--	--	80	<0.2	--	<20	--
88	07-29-81	--	170	<1	--	--	410	<0.2	--	<20	--
89	10-06-80	--	--	--	--	--	--	--	--	--	--
90	06-25-81	--	2600	--	--	--	--	--	--	--	--
90	07-30-81	--	300	<1	--	--	960	<0.2	--	<20	--
91	12-10-80	--	--	--	--	--	--	--	--	--	--
92	06-15-82	--	40	1	--	--	520	--	--	<20	--
93	09-04-79	--	--	--	--	--	--	--	--	--	--
94	10-17-78	--	--	--	--	--	--	--	--	--	--
								* * * * * Brule Creek and			
95	04-21-82	--	4600	1	--	--	960	0.2	--	20	--
96	10-27-81	--	1100	<1	--	--	460	<0.1	--	<20	--
97	10-27-81	--	70	1	--	--	10	0.1	--	20	--
98	06-19-80	2400	--	--	--	--	--	--	--	--	--
99	03-17-81	--	--	--	--	--	--	--	--	--	--
100	06-19-80	400	--	--	--	--	--	--	--	--	--
101	06-19-80	1800	--	--	--	--	--	--	--	--	--
102	06-19-80	140	--	--	--	--	--	--	--	--	--
									* * * * * Big Sioux-		
103	05-20-85	--	--	--	--	--	--	--	--	--	--
103	09-08-80	140	140	--	--	--	--	--	--	--	--
104	07-28-81	--	<50	<1	--	--	1200	E0.4	--	<20	--
105	03-10-82	--	50	1	--	--	900	0.2	--	20	--
105	04-24-85	--	--	--	--	--	--	--	--	--	--
106	07-28-81	--	3700	<1	--	--	1200	<0.2	--	<20	--
107	08-14-78	200	200	--	--	--	--	--	--	--	--
107	04-24-85	--	--	--	--	--	--	--	--	--	--
108	08-14-78	80	80	--	--	--	--	--	--	--	--
108	04-23-85	--	--	--	--	--	--	--	--	--	--
109	11-28-78	--	--	--	--	--	--	--	--	--	--
110	08-14-78	170	170	--	--	--	--	--	--	--	--
110	04-23-85	--	--	--	--	--	--	--	--	--	--
111	08-14-78	1500	1500	--	--	--	--	--	--	--	--
112	06-16-82	--	3400	1	--	--	1300	--	--	<20	--
113	06-16-82	--	270	1	--	--	530	--	--	<20	--
114	08-14-78	120	120	--	--	--	--	--	--	--	--
114	06-16-82	--	210	1	--	--	410	--	--	<20	--
114	04-23-85	--	--	--	--	--	--	--	--	--	--
115	08-14-78	--	50	--	--	--	--	--	--	--	--
115	09-10-82	--	30	--	--	--	310	--	--	--	--
116	11-18-78	--	--	--	--	--	--	--	--	--	--
117	07-31-79	--	660	--	--	--	--	--	--	--	--
117	02-19-82	--	290	<1	--	--	300	<0.2	--	<20	--
118	07-31-79	--	1200	--	--	--	--	--	--	--	--
119	11-18-78	--	--	--	--	--	--	--	--	--	--
120	07-31-79	--	660	--	--	--	--	--	--	--	--
120	02-19-82	--	50	<1	--	--	1500	<0.2	--	<20	--
121	07-31-79	--	330	--	--	--	--	--	--	--	--
121	02-18-82	--	870	<1	--	--	770	<0.2	--	<20	--
122	03-01-82	--	20	--	--	--	400	--	--	--	--
122	08-31-82	--	--	--	--	--	--	--	--	--	--

SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SELENIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN) (01092)
Big Sioux * * * * *			
<2	--	12	--
<2	--	<5	--
--	--	--	--
--	--	--	--
<2	--	71	--
--	--	--	--
<2	--	<5	--
--	--	--	--
--	--	--	--
Newton Hills * * * * *			
2	--	7	--
<2	--	84	--
7	--	5	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
Skunk Creek * * * * *			
--	--	--	--
--	--	--	--
9	--	34	--
2	--	10	--
--	--	--	--
<2	--	8	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
<0.3	--	<5	--
<2	--	17	--
--	--	--	--
<2	--	<5	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
<2	--	53	--
--	--	--	--
--	--	--	--
--	--	--	--
<2	--	14	--
--	--	--	--
<2	--	26	--
--	--	--	--
--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICKNESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
						* * * * *	Big Sioux-
123	441124096294301	109N47W32BDD	07-15-80	-	-	90.00	--
124	441217096294601	--	07-15-80	-	-	0.0	--
125	441259096284801	109N47W21CBD	05-02-79	-	-	25.00	--
126	441313096283001	109N47W21BDD	05-02-79	-	-	44.00	--
126		--	04-08-80	-	-	44.00	--
126		--	10-21-80	-	-	44.00	--
127	441423096404001	109N49W14BCDD	12-14-78	-	-	68.00	--
128	441526096454501	109N49W07CCA	06-02-80	-	-	63.00	--
129	441602096285101	109N47W09BAB	07-15-80	-	-	16.00	--
130	441610096463004	109N50W01DC4	02-13-82	-	-	24.89	9.56
131	441612096463306	109N50W01DC6	10-05-81	-	-	21.15	3.88
131		--	04-20-82			21.15	3.74
131		--	06-30-82			21.15	2.93
132	441645096454901	109N49W06BBDD	05-15-79	-	-	30.00	--
132		--	06-30-81	-	-	30.00	--
132		--	08-06-81	-	-	30.00	--
133	441657096433801	110N49W33CCCC	08-22-79	1	19	18.00	--
134	441707096413201	110N49W34DDBB	01-16-80	-	-	60.00	--
134		--	04-07-81	-	-	60.00	--
134		--	01-27-82	-	-	60.00	--
135	441712096392301	110N49W36DBCB	03-07-79	-	-	55.00	--
136	441737096423402	110N49W33AAC2	03-12-80	-	-	57.00	--
137	441747096440301	110N49W32ABAB	06-20-79	-	-	64.00	--
137		--	05-05-80	-	-	64.00	--
137		--	04-27-81	-	-	64.00	--
138	441747096440801	110N49W32ABBA	06-20-79	-	-	64.00	--
138		--	05-05-80	-	-	64.00	--
138		--	04-27-81	-	-	64.00	--
139	441747096441301	110N49W32ABBB	06-20-79	-	-	64.00	--
139		--	05-05-80	-	-	64.00	--
139		--	10-08-80	-	-	64.00	--
139		--	05-05-82	-	-	64.00	--
140	441802096345201	110N48W27CCA	07-11-79	2	43	44.00	--
141	441825096371601	110N48W29BBD	04-27-79	-	-	56.00	--
142	441827096401601	110N49W26ADB	07-11-79	-	-	63.00	--
143	441839096434201	110N49W29AAAA	10-22-80	1	41	33.00	--
144	441914096390901	110N49W24ACAC	01-18-80	-	-	50.00	--
145	441932096411001	110N49W22AAAA	10-28-81	-	-	29.00	16.53
146	441933096411501	110N49W22AAAA	10-22-80	-	-	23.00	--
147	441932096434101	110N49W20AAAA	08-22-79	-	-	17.90	--
148	441932096434301	--	10-28-81	2	16	17.90	7.80
149	442005096393601	110N49W13BDBC	12-10-80	-	-	50.00	--
150	442011096371401	110N48W17BACC	11-26-80	2	46	58.00	--
151	442012096393801	110N49W13BBDD	12-10-80	-	-	60.00	--
152	442018096371601	110N48W17BBAD	11-26-80	-	-	55.00	--
153	442024096422501	110N49W15BBBB	08-22-79	4	10	17.80	--
154	442021096421801	--	10-28-81	-	-	19.03	7.22
155	442026096411301	110N49W11CCCC	10-22-80	4	24	20.00	--
						* * * * *	Big Sioux-
156	441959096470001	110N50W13CBAA	06-27-79	-	-	60.00	--
156		--	05-05-82	-	-	60.00	--
157	442000096470601	110N50W13CBAB	06-11-80	-	-	60.00	--
157		--	04-27-81	-	-	60.00	--
158	442000096470902	110N50W13CBBD2	06-11-80	-	-	66.00	--

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Aurora * * * * *									
810	--	7.4	--	15.0	271	--	92	36	27
--	810	--	--	--	--	330	92	36	27
--	820	7.4	--	--	--	293	110	45	15
--	820	7.4	--	--	--	261	110	43	15
--	--	--	--	--	--	--	--	--	--
--	1020	7.4	--	--	--	271	130	46	15
--	576	8.3	--	--	--	285	48	35	22
--	626	7.5	--	--	--	272	96	19	43
--	610	--	--	11.0	--	194	65	29	6.0
--	857	--	--	--	--	364	56	29	96
--	960	--	--	--	--	446	120	52	33
--	1030	--	--	--	--	495	110	55	38
--	813	7.4	--	--	--	345	55	50	40
--	660	7.7	--	--	--	219	79	36	17
--	645	7.8	--	--	--	208	72	32	14
--	--	--	--	--	--	--	--	--	--
--	668	7.8	--	--	--	249	120	29	7.0
--	680	7.4	--	--	--	260	80	31	14
--	--	--	--	--	--	--	--	--	--
--	707	--	--	--	--	252	86	39	15
--	1390	7.4	--	--	--	481	150	67	26
--	550	8.2	--	--	--	261	80	34	7.0
--	840	7.4	--	--	--	247	130	42	17
--	926	7.3	--	--	--	260	130	43	15
--	915	--	--	--	--	256	130	41	14
--	900	7.3	--	--	--	263	140	44	19
--	936	7.3	--	--	--	262	130	45	16
--	884	--	--	--	262	262	120	41	15
--	750	7.3	--	--	--	262	110	38	12
--	749	7.3	--	--	--	261	98	36	11
--	--	--	--	--	--	--	--	--	--
--	765	--	--	--	--	269	94	36	9.4
--	1620	7.4	--	--	--	464	170	110	47
--	595	7.3	--	--	--	260	83	32	7.0
--	1290	7.1	--	--	--	484	230	53	29
--	750	8.2	--	--	--	140	80	48	22
--	745	7.9	--	--	--	320	80	43	20
--	814	--	--	9.0	--	280	110	40	17
650	--	8.1	--	--	100	--	72	34	12
--	515	8.0	--	--	--	246	72	29	7.0
--	562	--	--	--	--	330	82	33	12
--	1000	7.0	--	--	--	296	120	43	15
--	988	7.4	--	--	--	288	160	48	16
--	1050	7.1	--	--	--	292	140	36	16
--	1030	7.5	--	--	--	292	140	46	17
--	508	8.0	--	--	--	268	64	31	7.0
--	828	--	--	11.5	--	460	99	50	13
--	460	8.2	--	--	--	152	48	26	12
Deer Creek * * * * *									
--	915	7.3	--	--	--	265	120	46	20
--	1050	--	--	--	--	272	140	49	21
--	1070	7.6	--	--	--	286	150	50	21
--	1140	--	--	--	--	297	160	55	22
--	1370	7.0	--	--	--	336	210	65	20

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	POTAS-SIUM, TOTAL RECOV-ERABLE (MG/L AS K) (00937)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICAR-BONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)
								*	* *	Big Sioux-
123	07-15-80	2.2	--	330	--	25	11	0.80	408	374
124	07-15-80	2.2	--	--	403	25	11	0.76	408	410
125	05-02-79	2.8	--	--	358	87	25	0.20	615	461
126	05-02-79	2.6	--	--	318	88	26	0.20	615	438
126	04-08-80	--	--	--	--	--	--	0.20	--	--
126	10-21-80	2.8	--	--	331	87	34	0.70	710	475
127	12-14-78	6.0	--	--	288	28	2.0	--	--	312
128	06-02-80	4.0	--	--	332	98	6.0	--	--	429
129	07-15-80	0.30	--	--	237	25	15	0.28	380	302
130	02-13-82	4.5	--	--	443	70	52	0.24	546	527
131	10-05-81	3.3	--	--	543	54	72	0.15	300	600
131	04-20-82	3.1	--	--	603	72	83	0.27	547	654
131	06-30-82	8.6	--	--	420	50	43	0.24	502	454
132	05-15-79	1.5	--	--	267	130	19	0.36	494	411
132	06-30-81	1.6	--	--	254	100	13	0.32	501	358
132	08-06-81	--	--	--	--	--	--	--	--	--
133	08-22-79	2.0	--	--	303	150	6.0	--	464	465
134	01-16-80	2.1	--	--	317	80	7.4	0.70	449	371
134	04-07-81	--	--	--	--	--	--	0.30	--	--
134	01-27-82	1.8	--	--	307	82	7.7	1.3	453	382
135	03-07-79	4.0	--	--	586	82	75	--	--	692
136	03-12-80	*<0.1	--	--	298	49	8.0	--	--	--
137	06-20-79	2.9	--	--	301	250	3.2	0.20	710	588
137	05-05-80	2.9	--	--	317	250	4.5	0.30	713	604
137	04-27-81	3.0	--	--	312	250	5.3	0.20	683	600
138	06-20-79	3.1	--	--	321	290	3.4	0.20	772	654
138	05-05-80	3.0	--	--	320	260	5.1	0.20	726	612
138	04-27-81	2.9	--	320	320	220	6.3	0.20	646	570
139	06-20-79	2.8	--	--	320	180	4.2	0.20	604	502
139	05-05-80	2.8	--	--	318	150	5.5	0.20	545	463
139	10-08-80	--	--	--	--	--	--	--	--	--
139	05-05-82	2.6	--	--	328	140	6.3	0.20	542	448
140	07-11-79	1.0	--	--	566	170	170	--	--	947
141	04-27-79	1.0	--	--	317	38	5.0	--	--	322
142	07-11-79	3.0	--	--	590	320	14	--	--	938
143	10-22-80	2.0	--	--	171	270	9.0	--	640	511
144	01-18-80	1.0	--	--	390	37	18	--	--	391
145	10-28-81	2.7	--	--	341	200	5.0	0.22	586	568
146	10-22-80	2.0	--	120	--	200	10	--	460	389
147	08-22-79	2.0	--	--	300	51	3.0	--	376	312
148	10-28-81	2.4	--	--	403	61	5.0	0.29	406	394
149	12-10-80	2.0	--	--	361	150	11	--	--	523
150	11-26-80	1.0	--	--	351	220	6.0	--	--	619
151	12-10-80	2.0	--	--	356	160	10	--	--	543
152	11-26-80	1.0	--	--	356	230	8.0	--	--	616
153	08-22-79	1.0	--	--	327	27	3.0	--	320	298
154	10-28-81	1.3	--	--	561	60	4.0	0.51	546	541
155	10-22-80	2.0	--	--	185	94	10	--	340	283
								* *	* * *	Big Sioux-
156	06-27-79	2.6	--	--	323	240	2.4	0.30	811	599
156	05-05-82	2.9	--	--	332	300	4.5	0.30	769	684
157	06-11-80	2.7	--	--	349	310	5.4	0.30	903	710
157	04-27-81	3.0	--	--	362	350	7.3	0.30	882	785
158	06-11-80	2.8	--	--	410	480	7.5	0.30	1230	991

NITRO- GEN, NITRATE DIS- SOLVED (MG/L AS N) (00618)	NITRO- GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N) (00631)	ARSENIC DIS- SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS- SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV- ERABLE (UG/L) AS B) (01022)	CADMIUM DIS- SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV- ERABLE (UG/L AS CD) (01027)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR) (01030)
Aurora * * * * *									
--	--	3.80	--	--	--	--	--	--	--
--	--	3.80	--	--	210	--	0.1	--	--
--	19.1	--	--	--	--	--	--	--	--
--	25.0	--	--	--	--	--	--	--	--
--	26.5	--	--	<1	--	--	--	<1	--
--	34.3	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	10.2	--	--	--	--	0.1	--	--
--	--	0.300	1	--	130	--	<0.2	--	<20
--	--	<0.100	--	--	170	--	<0.2	--	<20
--	--	<0.100	<1	--	210	--	<0.2	--	<20
--	--	<0.100	1	--	310	--	<0.2	--	<20
--	2.50	--	--	--	--	--	--	--	--
--	1.30	--	--	--	--	--	--	--	--
--	1.60	--	--	<1	--	--	--	1	--
--	0.130	--	--	--	800	--	--	--	--
--	6.50	--	--	--	--	--	--	--	--
--	7.50	--	--	2	--	--	--	<1	--
--	7.70	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	--	--	--	3	--	--	--	<1	--
--	<0.100	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
0.220	--	--	--	--	140	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	6.83	<5	--	110	--	0.9	--	20
--	5.30	--	--	--	*<10	--	--	--	--
--	0.240	--	--	--	*<10	--	--	--	--
--	--	<0.100	<5	--	70	--	1.0	--	<20
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	1.45	--	--	--	1700	--	--	--	--
--	--	8.46	<5	--	80	--	<1.0	--	<20
--	0.500	--	--	--	60	--	--	--	--
Deer Creek * * * * *									
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * * * *	Big Sioux-	
123	07-15-80	--	50	--	--	--	580	--	--	--	--
124	07-15-80	--	<50	--	--	--	580	--	--	--	--
125	05-02-79	--	60	--	--	<20	--	--	--	--	--
126	05-02-79	--	<20	--	--	<20	--	--	--	--	--
126	04-08-80	--	--	--	<1	--	--	--	0.72	--	--
126	10-21-80	--	20	--	--	30	--	--	--	--	--
127	12-14-78	--	--	--	--	--	--	--	--	--	--
128	06-02-80	--	--	--	--	--	--	--	--	--	--
129	07-15-80	--	<50	--	--	--	50	--	--	--	--
130	02-13-82	--	<50	<2	--	--	110	<0.2	--	<20	--
131	10-05-81	--	<50	<1	--	--	<50	<0.1	--	<20	--
131	04-20-82	--	<50	<1	--	--	<50	<0.2	--	<20	--
131	06-30-82	--	<50	<1	--	--	370	--	--	<20	--
132	05-15-79	--	<20	--	--	<20	--	--	--	--	--
132	06-30-81	--	80	--	--	<20	--	--	--	--	--
132	08-06-81	--	--	--	<1	--	--	--	<0.20	--	--
133	08-22-79	--	520	--	--	--	--	--	--	--	--
134	01-16-80	--	<20	--	--	<20	--	--	--	--	--
134	04-07-81	--	--	--	<1	--	--	--	<0.20	--	--
134	01-27-82	--	<20	--	--	<20	--	--	--	--	--
135	03-07-79	--	--	--	--	--	--	--	--	--	--
136	03-12-80	--	--	--	--	--	--	--	--	--	--
137	06-20-79	--	3000	--	--	600	--	--	--	--	--
137	05-05-80	--	4000	--	--	700	--	--	--	--	--
137	04-27-81	--	3600	--	--	700	--	--	--	--	--
138	06-20-79	--	3200	--	--	700	--	--	--	--	--
138	05-05-80	--	3700	--	--	800	--	--	--	--	--
138	04-27-81	3600	3600	--	--	700	--	--	--	--	--
139	06-20-79	--	2900	--	--	500	--	--	--	--	--
139	05-05-80	--	2900	--	--	500	--	--	--	--	--
139	10-08-80	--	--	--	<1	--	--	--	<0.20	--	--
139	05-05-82	--	1700	--	--	100	--	--	--	--	--
140	07-11-79	--	--	--	--	--	--	--	--	--	--
141	04-27-79	--	--	--	--	--	--	--	--	--	--
142	07-11-79	--	--	--	--	--	--	--	--	--	--
143	10-22-80	--	200	--	--	--	--	--	--	--	--
144	01-18-80	--	--	--	--	--	--	--	--	--	--
145	10-28-81	--	80	<1	--	--	<10	<0.1	--	<20	--
146	10-22-80	760	--	--	--	--	--	--	--	--	--
147	08-22-79	--	390	--	--	--	--	--	--	--	--
148	10-28-81	--	240	<1	--	--	240	<0.1	--	<20	--
149	12-10-80	--	--	--	--	--	--	--	--	--	--
150	11-26-80	--	--	--	--	--	--	--	--	--	--
151	12-10-80	--	--	--	--	--	--	--	--	--	--
152	11-26-80	--	--	--	--	--	--	--	--	--	--
153	08-22-79	--	2800	--	--	--	--	--	--	--	--
154	10-28-81	--	120	<1	--	--	<10	<0.1	--	<20	--
155	10-22-80	--	430	--	--	--	--	--	--	--	--
									* * * * *	Big Sioux-	
156	06-27-79	--	3000	--	--	600	--	--	--	--	--
156	05-05-82	--	1800	--	--	700	--	--	--	--	--
157	06-11-80	--	3100	--	--	900	--	--	--	--	--
157	04-27-81	--	4800	--	--	900	--	--	--	--	--
158	06-11-80	--	6500	--	--	1300	--	--	--	--	--

SELE- NIUM, DIS- SOLVED (UG/L AS SE) (01145)	SELE- NIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOV- ERABLE (UG/L AS ZN) (01092)
Aurora * * * * *			
--	--	39	--
--	--	14	--
--	--	--	--
--	--	--	--
--	1	--	30
--	--	--	--
--	--	--	--
--	--	--	--
--	--	68	--
<0.2	--	<5	--
<0.2	--	89	--
<0.2	--	<5	--
<0.4	--	5	--
--	--	--	--
--	--	--	--
--	<1	--	10
--	--	--	--
--	--	--	--
--	6	--	--
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<2	--	29	--
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<2	--	8	--
--	--	--	--
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--	--	--	--
--	--	--	--
--	--	--	--
<2	--	<5	--
--	--	--	--
Deer Creek * * * * *			
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Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICKNESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
					* * * * *	Big Sioux-	
158	442000096470902	110N50W13CBBD2	04-27-81	-	-	66.00	--
159	442000096471402	110N50W13CBBA2	06-27-79	-	-	65.00	--
159		--	06-11-80	-	-	65.00	--
159		--	04-27-81	-	-	65.00	--
160	442001096470701	110N50W13CBBA	06-27-79	-	-	65.00	--
161	442117096445301	110N49W07AAAA	10-22-80	6	46	18.00	--
162	442207096441201	110N49W05ABBB	10-22-80	4	64	42.00	--
163	442137096520301	110N50W05CBCB	08-22-79	1	29	23.80	4.40
164	442208096520401	110N50W05BBBB	06-16-82	1	13	14.00	5.20
165	442301096420801	111N49W27CCDD	10-22-80	-	-	64.70	--
166	442303096411501	111N49W27DDD	07-16-80	-	-	50.00	--
167	442304096520701	111N50W30DDDD	08-22-79	-	-	17.20	--
168	442305096520401	--	04-14-82	4	11	19.00	6.34
169	442355096411501	111N49W22DDD	07-16-80	-	-	75.00	--
170	442450096505101	111N50W17DDDD	09-27-84	49	5	53.90	4.10
171	442450096505102	111N50W17DDDD2	04-14-82	4	11	16.80	4.15
171		--	09-27-84	4	11	16.80	5.70
172	442458096453801	111N49W18CCA	11-19-80	-	-	57.00	--
173	442510096452101	111N49W18DBBB	02-25-81	-	-	63.00	--
174	441947096473001	111N50W14DDB	07-11-79	-	-	30.00	--
175	442603096444701	111N49W08CBBB	02-25-81	-	-	54.00	--
176	442606096435201	111N49W08ADCC	02-25-81	-	-	31.00	--
177	442609096441001	111N49W08ACCB	02-25-81	-	-	17.00	--
					* * * * *	Big Sioux-	
178	443333097100501	113N53W26CCCB	10-28-81	1	24	18.20	9.50
179	443347097084801	113N53W25CBBC	10-28-81	1	9	12.90	7.70
180	443543097124801	113N53W17ADCB	05-14-79	-	-	60.00	--
180		--	10-07-80	-	-	60.00	--
181	443606097130801	113N53W08DCCC	10-28-81	6	16	21.00	9.00
182	443718097134301	114N53W32CCCC	06-15-82	-	-	26.10	13.94
183	443845097113201	114N53W27CCCC	06-15-82	1	24	21.00	4.77
184	443915097121001	114N53W28BDCB	07-22-82	-	-	22.90	7.38
185	443926097122501	114N53W28BBCA	10-19-82	-	-	46.70	22.25
186	443927097123201	114N53W29AADA	07-22-82	-	-	23.70	12.74
187	443927097123202	114N53W29AADA2	07-22-82	-	-	44.40	12.76
188	443922097123201	114N53W20DDAA	07-22-82	-	-	42.10	4.41
189	443935097122601	114N53W21CCCA2	04-06-81	-	-	48.00	--
189		--	01-25-82	-	-	48.00	--
189		--	05-28-82	-	-	48.00	--
190	443936097122302	114N53W21CCCA3	11-20-78	-	-	59.00	--
191	443812097123301	114N53W17DDAA	07-22-82	-	-	44.80	5.11
191		--	03-09-83	-	-	44.80	5.55
192	443812097123302	114N53W17DAAA2	07-22-82	-	-	24.50	5.29
					* * * * *	Big Sioux-	
193	443938096504401	114N50W20DDD	04-29-81	-	-	48.00	--
193		--	07-16-80	-	-	48.00	--
194	444045096493501	114N50W16DAA	07-16-80	-	-	37.00	--
195	444123096492601	114N50W10CCC	07-16-80	-	-	7.00	--
196	444527096401301	115N49W23ACCD	12-15-81	-	-	31.00	--
197	444615096372501	115N48W18ADAD	04-11-79	-	-	55.00	--
197	444615096372501	--	03-24-80	-	-	55.00	--
197		--	04-10-81	-	-	55.00	--
197		--	04-28-81	-	-	55.00	--
197		--	07-20-81	-	-	55.00	--

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Deer Creek * * * * *									
--	998	--	--	--	--	264	130	46	21
--	1140	7.1	--	--	--	338	170	59	23
--	1290	7.0	--	--	--	342	190	64	24
--	1210	--	--	--	--	313	170	63	21
--	--	7.2	--	--	--	300	170	57	23
--	320	8.3	--	--	--	132	40	14	6.0
--	750	8.3	--	--	--	108	76	48	23
--	793	7.8	--	--	--	244	120	43	18
--	844	--	--	--	--	360	78	36	62
--	550	8.3	--	--	--	128	44	38	18
--	720	7.7	--	13.0	--	200	84	33	8.0
--	637	8.0	--	--	--	288	72	34	15
--	781	--	--	5.0	--	450	110	38	17
--	720	7.5	--	13.0	--	258	84	39	10
--	625	--	--	--	--	298	76	30	17
--	565	--	--	4.0	--	341	76	26	14
--	532	--	--	--	--	254	69	22	9.0
646	646	7.6	--	--	260	260	110	19	7.0
660	660	7.9	--	--	249	249	88	24	7.0
--	652	7.4	--	--	--	260	110	18	13
700	700	7.6	--	--	264	264	96	19	8.0
700	700	8.3	--	--	284	284	110	24	8.0
620	620	8.2	--	--	235	235	92	17	7.0
Brookings (west) * * * * *									
--	1770	--	--	--	--	660	200	96	100
--	1480	--	--	--	--	470	230	77	62
--	--	--	--	--	--	--	--	--	--
--	1270	7.3	--	--	--	306	170	61	38
1160	--	--	--	12.0	305	--	180	58	48
--	399	7.2	--	8.0	--	194	48	20	4.0
2470	2470	7.4	--	7.0	--	494	300	160	110
--	1020	7.5	--	--	--	284	140	45	23
--	3100	--	--	--	--	430	460	130	160
--	2890	7.0	--	--	--	420	400	150	150
--	2900	7.4	--	--	--	510	480	150	160
--	652	7.5	--	--	--	280	84	31	9.0
--	--	--	--	--	--	--	--	--	--
--	1040	--	--	--	274	274	150	47	14
--	1040	--	--	--	254	254	150	--	17
--	--	--	--	--	--	--	--	--	--
--	2290	6.3	--	--	--	337	310	98	140
--	2180	--	--	--	--	300	310	96	140
--	2130	6.9	--	--	--	310	300	95	110
Brookings (east) * * * * *									
--	--	--	--	11.0	458	458	--	--	--
--	--	7.2	--	17.0	--	--	--	--	--
--	--	7.3	--	21.0	279	279	--	--	--
--	800	7.4	--	17.0	--	394	100	39	7.0
--	3540	--	--	--	276	76	290	93	310
491	491	7.6	--	--	230	230	77	24	5.0
511	511	8.0	--	--	228	228	72	29	7.0
531	531	--	--	--	228	228	97	14	4.0
430	430	7.1	--	--	180	180	94	13	3.0
550	550	7.5	--	--	220	220	80	24	3.0

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTAS- SIUM, DIS- SOLVED (MG/L AS K) (00935)	POTAS- SIUM, TOTAL RECOV- ERABLE (MG/L AS K) (00937)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICAR- BONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DIS- SOLVED (MG/L AS SO4) (00945)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL) (00940)	FLUO- RIDE, DIS- SOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L) (70301)
									* * *	Big Sioux-
158	04-27-81	3.3	--	--	322	280	6.5	0.30	734	646
159	06-27-79	2.8	--	--	412	360	10	0.30	1020	829
159	06-11-80	2.8	--	--	417	390	12	0.30	1120	893
159	04-27-81	3.0	--	--	382	370	7.3	0.30	953	830
160	06-27-79	2.6	--	--	367	390	3.8	0.30	1030	829
161	10-22-80	2.0	--	--	161	23	11	--	260	175
162	10-22-80	3.0	--	--	132	290	20	--	636	522
163	08-22-79	4.0	--	--	298	220	10	--	596	559
164	06-16-82	5.4	--	--	438	130	7.0	0.33	458	550
165	10-22-80	2.0	--	--	156	130	17	--	382	326
166	07-16-80	2.2	--	--	244	120	10	0.25	448	390
167	08-22-79	1.0	--	--	351	81	4.0	--	440	380
168	04-14-82	1.2	--	--	549	85	6.0	0.30	490	532
169	07-16-80	1.1	--	--	315	30	11	0.28	480	397
170	09-27-84	3.4	--	--	363	55	4.0	0.28	383	367
171	04-14-82	9.1	--	--	416	54	7.0	0.16	385	398
171	09-27-84	7.7	--	--	310	35	6.0	0.20	328	305
172	11-19-80	1.0	--	320	317	64	8.0	--	--	367
173	02-25-81	1.0	--	300	303	69	12	--	--	350
174	07-11-79	1.0	--	--	317	100	7.0	--	--	411
175	02-25-81	1.0	--	320	322	43	14	--	--	339
176	02-25-81	1.0	--	290	293	70	16	--	--	397
177	02-25-81	1.0	--	280	283	76	10	--	--	344
								* *	* * *	Big Sioux-
178	10-28-81	7.8	--	--	805	440	16	0.20	1300	1260
179	10-28-81	11	--	--	573	380	55	0.22	1170	1100
180	05-14-79	--	--	--	--	--	--	--	--	--
180	10-07-80	8.3	--	--	373	460	9.6	0.20	--	942
181	10-28-81	7.5	--	370	--	440	7.0	0.31	1140	926
182	06-15-82	3.1	--	--	236	18	2.0	0.10	252	229
183	06-15-82	10	--	--	602	1200	44	0.26	2050	2160
184	07-22-82	5.0	--	--	346	270	32	0.15	776	688
185	10-19-82	20	--	--	524	1700	33	0.07	3050	2820
186	07-22-82	16	--	--	511	1500	28	0.12	2640	2500
187	07-22-82	18	--	--	621	1800	24	0.06	2940	2930
188	07-22-82	2.5	--	--	341	100	6.0	0.13	440	406
189	04-06-81	--	--	--	--	--	--	--	--	--
189	01-25-82	6.5	--	330	334	260	21	0.10	729	658
189	05-28-82	--	--	310	310	260	17	--	741	--
190	11-20-78	--	--	--	--	--	--	--	--	--
191	07-22-82	9.6	--	--	410	1100	21	0.36	1940	1880
191	03-09-83	8.7	--	--	366	1100	24	0.22	2030	1860
192	07-22-82	8.1	--	--	377	1000	24	0.37	1840	1750
								* *	* * *	Big Sioux-
193	04-29-81	--	--	--	--	980	--	0.30	--	--
193	07-16-80	--	--	--	--	660	--	0.31	--	--
194	07-16-80	--	--	--	--	190	--	0.20	--	--
195	07-16-80	--	--	--	481	30	3.0	0.26	400	--
196	12-15-81	9.8	--	340	337	150	930	0.20	2230	1950
197	04-11-79	1.0	--	280	281	34	4.0	--	--	283
197	03-24-80	1.0	--	280	278	40	4.0	--	--	295
197	04-10-81	--	--	280	278	46	10	--	--	--
197	04-28-81	1.0	--	220	220	47	10	--	--	276
197	07-20-81	2.0	--	270	268	50	11	--	--	302

NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L) AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
Deer Creek * * * * *									
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	<0.100	--	--	--	--	--	--	--	--
--	2.38	--	--	--	60	--	--	--	--
--	0.570	--	--	--	170	--	--	--	--
--	0.480	--	--	--	*<10	--	--	--	--
--	--	2.20	<2	--	100	--	0.2	--	<20
--	3.80	--	--	--	160	--	--	--	--
--	--	2.90	--	--	130	--	0.1	--	--
--	0.090	--	--	--	*<10	--	--	--	--
--	--	0.300	<10	--	80	--	0.3	--	<20
--	--	15.0	--	--	160	--	0.2	--	--
--	--	0.200	*<5	--	*<10	--	*<0.2	--	*<20
--	--	0.900	<10	--	60	--	0.3	--	<20
--	--	<0.200	*<5	--	*<10	--	*<0.2	--	*<20
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
Brookings (west) * * * * *									
--	--	<0.100	<5	--	410	--	0.5	--	50
--	--	<0.100	<5	--	170	--	0.6	--	30
--	--	--	--	4	--	--	--	4	--
--	0.800	--	--	--	--	--	--	--	--
--	--	0.100	5	--	300	--	0.3	--	20
--	--	4.00	<2	--	50	--	<0.2	--	<20
--	--	<0.100	1	--	390	--	<0.2	--	40
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	1	--	--	--	<0.2	--	<20
--	--	<0.100	13	--	--	--	0.6	--	<20
--	--	<0.100	--	--	--	--	--	--	--
--	0.200	--	--	2	--	--	--	<1	--
--	0.500	--	--	--	--	--	--	--	--
--	0.900	--	--	--	--	--	--	--	--
--	--	--	--	2	--	--	--	3	--
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	--	--	--	--	--	--	--
Brookings (east) * * * * *									
--	--	0.100	<10	--	260	--	0.8	--	20
--	--	25.0	--	--	1200	--	1.5	--	--
--	--	3.30	--	--	210	--	0.1	--	--
--	--	4.40	--	--	220	--	0.1	--	--
--	3.90	--	--	--	--	--	--	--	--
--	2.50	--	--	--	--	--	--	--	--
--	5.10	--	--	--	*<10	*<10	--	--	--
--	16.0	--	--	--	--	--	--	--	--
--	13.0	--	--	--	--	--	--	--	--
--	5.80	--	--	--	--	--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * * * * Big Sioux-		
158	04-27-81	--	3100	--	--	800	--	--	--	--	--
159	06-27-79	--	3900	--	--	1100	--	--	--	--	--
159	06-11-80	--	5000	--	--	1200	--	--	--	--	--
159	04-27-81	--	5200	--	--	1200	--	--	--	--	--
160	06-27-79	--	2900	--	--	1000	--	--	--	--	--
161	10-22-80	--	50	--	--	--	--	--	--	--	--
162	10-22-80	--	300	--	--	--	--	--	--	--	--
163	08-22-79	--	600	--	--	--	--	--	--	--	--
164	06-16-82	--	50	1	--	--	680	*<0.2	--	<20	--
165	10-22-80	--	70	--	--	--	--	--	--	--	--
166	07-16-80	--	<50	--	--	--	<50	--	--	--	--
167	08-22-79	--	720	--	--	--	--	--	--	--	--
168	04-14-82	--	20	<1	--	--	90	<0.2	--	<20	--
169	07-16-80	--	50	--	--	--	<50	--	--	--	--
170	09-27-84	--	970	*<1	--	--	660	*<0.2	--	*<20	--
171	04-14-82	--	2600	<1	--	--	1000	<0.2	--	<20	--
171	09-27-84	--	2000	*<1	--	--	1300	*<0.2	--	*<20	--
172	11-19-80	--	--	--	--	--	--	--	--	--	--
173	02-25-81	--	--	--	--	--	--	--	--	--	--
174	07-11-79	--	--	--	--	--	--	--	--	--	--
175	02-25-81	--	--	--	--	--	--	--	--	--	--
176	02-25-81	--	--	--	--	--	--	--	--	--	--
177	02-25-81	--	--	--	--	--	--	--	--	--	--
									* * * * * Big Sioux-		
178	10-28-81	--	150	<1	--	--	2500	<0.1	--	<20	--
179	10-28-81	--	40	<1	--	--	2500	<0.1	--	<20	--
180	05-14-79	--	--	--	1	--	--	--	<0.20	--	--
180	10-07-80	--	4300	--	--	--	1200	--	--	--	--
181	10-28-81	--	4600	1	--	--	1300	0.1	--	20	--
182	06-15-82	--	10	1	--	--	10	--	--	<20	--
183	06-15-82	--	1800	<1	--	--	5000	--	--	<20	--
184	07-22-82	--	90	--	--	--	1200	--	--	--	--
185	10-19-82	--	170	--	--	--	3400	--	--	--	--
186	07-22-82	--	<50	2	--	--	150	--	--	<20	--
187	07-22-82	--	12000	1	--	--	3000	--	--	<20	--
188	07-22-82	--	380	--	--	--	690	--	--	--	--
189	04-06-81	--	--	--	2	--	--	--	<0.20	--	--
189	01-25-82	400	400	--	--	790	--	--	--	--	--
189	05-28-82	500	500	--	--	780	--	--	--	--	--
190	11-20-78	--	--	--	2	--	--	--	<0.20	--	--
191	07-22-82	--	3200	--	--	--	1900	--	--	--	--
191	03-09-83	--	2400	--	--	--	--	--	--	--	--
192	07-22-82	--	3000	--	--	--	1900	--	--	--	--
									* * * * * Big Sioux-		
193	04-29-81	--	50	--	--	--	1100	<0.2	--	20	--
193	07-16-80	--	60	--	--	--	70	--	--	--	--
194	07-16-80	--	550	--	--	--	960	--	--	--	--
195	07-16-80	--	70	--	--	--	<50	--	--	--	--
196	12-15-81	<20	<20	--	--	<20	--	--	--	--	--
197	04-11-79	10	10	--	--	*<50	--	--	--	--	--
197	03-24-80	10	10	--	--	--	--	--	--	--	--
197	04-10-81	30	30	--	--	*<50	--	--	--	--	--
197	04-28-81	--	--	--	--	*<50	--	--	--	--	--
197	07-20-81	60	60	--	--	*<50	--	--	--	--	--

SELE- NIUM, DIS- SOLVED (UG/L AS SE) (01145)	SELE- NIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOV- ERABLE (UG/L AS ZN) (01092)
Deer Creek * * * * *			
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
<2	--	5	--
--	--	--	--
--	--	45	--
--	--	--	--
<2	--	<5	--
--	--	7	--
*<2	--	*<5	--
<2	--	<5	--
*<2	--	*<5	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
Brookings (west) * * * * *			
<2	--	10	--
<2	--	7	--
--	2	--	380
--	--	--	--
2	--	180	--
<2	--	<5	--
<0.2	--	<10	--
--	--	<5	--
--	--	3	--
*<2	--	<5	--
<0.2	--	<5	--
--	--	<5	--
--	<1	--	<90
--	--	--	--
--	--	--	--
--	<1	--	20
--	--	<5	--
--	--	2	--
--	--	<5	--
Brookings (east) * * * * *			
<2	--	280	--
--	--	680	--
--	--	62	--
--	--	57	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	STATION NUMBER	LOCAL NUMBER	DATE	DEPTH BELOW LAND TO FIRST WATER-BEARING STRATA (FEET)	THICK-NESS OF WATER-BEARING STRATA (FEET)	DEPTH OF WELL, TOTAL (FEET) (72008)	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)
					* * * * *	Big Sioux-	
198	444625096372501	115N48W18AADA	04-11-79	-	-	55.00	--
198		--	03-24-80	-	-	55.00	--
198		--	04-10-81	-	-	55.00	--
198		--	07-20-81	-	-	55.00	--
					* * * * *	Antelope	
199	445956096493701	118N50W28ACDD	06-20-78	-	-	39.40	--
200	450137096540701	118N51W14DAAA	06-30-78	-	13.10	13.10	--
201	450252096493701	118N50W09ABAA	06-29-78	-	-	65.60	--
201		--	08-27-86	-	-	65.60	--
202	450443096541401	119N51W26DDDD	04-14-82	-	-	27.50	8.00
203	450902096563901	120N51W34CCCC	08-10-78	-	-	33.40	--
204	451033096573401	120N51W28BBDD	09-12-78	-	-	60.00	--
205	451044096564501	120N51W21DDCD	06-30-78	-	-	49.20	--
206	451100096573701	120N51W21CCAA	09-12-78	-	-	60.00	--
207	451106096580001	120N51W20DAA	09-12-78	-	-	90.00	--

SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	PH (STAND- ARD UNITS) (00400)	PH LAB (STAND- ARD UNITS) (00403)	TEMPER- ATURE WATER (DEG C) (00010)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)
Brookings (east) * * * * *									
575	575	7.8	--	--	244	244	91	28	4.0
572	572	7.9	--	--	232	232	80	24	6.0
556	556	8.1	--	--	244	244	94	24	3.0
579	579	7.4	--	--	244	244	96	19	3.0
Valley * * * * *									
1970	--	6.9	--	8.0	300	--	190	130	37
1500	--	7.0	--	11.0	310	--	120	95	36
1010	--	7.6	--	11.0	300	--	120	46	22
980	1050	6.9	7.2	--	--	340	160	46	20
519	519	--	--	7.0	--	290	70	28	9.0
486	--	8.0	--	--	196	--	80	19	6.0
--	1270	--	7.0	--	--	449	220	7.0	19
840	--	7.4	--	20.5	242	--	77	28	2.6
--	705	--	7.4	--	--	290	120	20	3.0
--	615	--	6.9	--	--	224	100	13	4.0

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	POTASSIUM, TOTAL RECOVERABLE (MG/L AS K) (00937)	BICARBONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	BICARBONATE IT-LAB (MG-L - HCO3) (90440)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)
								*	*	* Big Sioux-
198	04-11-79	1.0	--	300	298	64	3.0	--	--	338
198	03-24-80	1.0	--	280	283	59	6.0	--	--	315
198	04-10-81	1.0	--	300	298	61	10	--	--	340
198	07-20-81	2.0	--	300	298	61	10	--	--	338
								* *	* *	* Antelope
199	06-20-78	--	12	380	--	200	120	--	--	--
200	06-30-78	--	2.7	350	--	310	<10	--	--	--
201	06-29-78	--	9.0	380	--	590	<10	--	--	--
201	08-27-86	7.8	--	--	--	300	1.7	0.30	--	772
202	04-14-82	1.6	--	--	353	59	3.0	0.25	346	346
203	08-10-78	2.0	--	240	--	68	4.0	--	352	297
204	09-12-78	7.0	--	--	547	70	4.0	--	--	600
205	06-30-78	--	2.4	300	--	380	<10	--	--	--
206	09-12-78	2.0	--	--	354	32	12	--	--	363
207	09-12-78	2.0	--	--	273	35	5.0	--	--	297

NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L) AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
Brookings (east) * * * * *									
--	3.00	--	--	--	--	--	--	--	--
--	3.40	--	--	--	--	--	--	--	--
--	8.50	--	--	--	--	--	--	--	--
--	5.80	--	--	--	--	--	--	--	--
Valley * * * * *									
--	--	--	--	<1	--	110	--	--	--
--	--	--	--	<1	--	180	--	--	--
--	--	--	--	5	--	250	--	--	--
--	--	<0.100	--	--	--	--	--	--	--
--	--	<0.100	<5	--	370	--	<0.2	--	<20
--	0.060	--	--	--	*<10	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	<1	--	20	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--

Table 13.--Hydrogeologic characteristics of wells, physical properties of ground-water samples, and concentrations of water-quality constituents in ground-water samples from the Big Sioux River basin, 1978-86--Continued

SITE NUMBER (FIG. 5 AND FIG. 6)	DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	NICKEL, TOTAL RECOV-ERABLE (UG/L) AS NI) (01067)
									* * * * * Big Sioux-		
198	04-11-79	10	10	--	--	*<50	--	--	--	--	--
198	03-24-80	10	10	--	--	*<50	--	--	--	--	--
198	04-10-81	20	20	--	--	*<50	--	--	--	--	--
198	07-20-81	10	10	--	--	*<50	--	--	--	--	--
									* * * * * Antelope		
199	06-20-78	20	--	--	--	3	--	--	--	--	<4
200	06-30-78	<10	--	--	--	3	--	--	--	--	<4
201	06-29-78	<10	--	--	--	3	--	--	--	--	4
201	08-27-86	--	2700	--	--	--	560	--	--	--	--
202	04-14-82	--	480	<1	--	--	360	<0.2	--	<20	--
203	08-10-78	110	--	--	--	--	--	--	--	--	--
204	09-12-78	--	--	--	--	--	--	--	--	--	--
205	06-30-78	<10	--	--	--	<2	--	--	--	--	<4
206	09-12-78	--	--	--	--	--	--	--	--	--	--
207	09-12-78	--	--	--	--	--	--	--	--	--	--

SELE- NIUM, DIS- SOLVED (UG/L AS SE) (01145)	SELE- NIUM, TOTAL (UG/L AS SE) (01147)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOV- ERABLE (UG/L AS ZN) (01092)
Brookings (east) * * * * *			
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
Valley * * * * *			
--	<0.2	--	5
--	0.2	--	8
--	<0.2	--	8
--	--	--	--
<2	--	<5	--
--	--	--	--
--	--	--	--
--	0.4	--	30
--	--	--	--
--	--	--	--

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