WATER RESOURCES OF MINER COUNTY, SOUTH DAKOTA

By Neil C. Koch and Scott D. McGarvie

U.S. GEOLOGICAL SURVEY

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MINER COUNTY, EAST DAKOTA

CONSERVANCY SUB-DISTRICT, and the

LOWER JAMES CONSERVANCY SUB-DISTRICT

Huron, South Dakota
1988

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CONVERSION FACTORS

For those readers interested in converting inch-pound units to the International System of Units (SI), the following factors are used:

Multiply inch-pound unit	By	To obtain SI unit
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
gallon per minute (gal/min)	0.06308	liter per second
inch	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
square mile (mi^2)	2.590	square kilometer

Temperature can be converted to degrees Fahrenheit (°F) or degrees Celsius (°C) by the following equations:

$$°F = 9/5\ (°C) + 32$$
$$°C = 5/9\ (°F-32)$$

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

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ABSTRACT

Miner County is a rural-agricultural area of 572 square miles in east-central South Dakota. All streams in the county are intermittent and usually are recharged only from spring snowmelt and precipitation. Most ponds and sloughs may go dry in summer and during drought conditions, while larger lakes and ponds will contain water year round.

Three major confined glacial aquifers underlie Miner County. The Floyd aquifer underlies about 195 square miles of the western one-half of the county. It is buried beneath 25 to 150 feet of glacial drift and ranges from 10 to 100 feet in thickness. Water levels in the Floyd range from flowing to 56 feet below land surface. Properly constructed wells in the aquifer may produce as much as 1,200 gallons per minute. The Floyd aquifer offers the greatest potential for irrigation or other large yield development. Predominant chemical constituents in water from the Floyd aquifer are sodium, calcium, and sulfate; however, there is a wide variation in the chemical composition of the water. For the most part is is suitable for irrigation.

The Howard aquifer underlies about 165 square miles of the eastern one-half of the county. It is buried beneath 80 to 350 feet of glacial drift and ranges from 4 to 170 feet in thickness. Water levels in the Howard aquifer range from 16 to 200 feet below land surface.

The Ramona aquifer underlies about 70 square miles in northeastern Miner County. It is buried beneath 25 to 170 feet of glacial drift and ranges from 4 to 32 feet in thickness. Water levels in the Ramona range from 10 to 105 feet below land surface.

Four bedrock aquifers underlie Miner County. The uppermost aquifer is the Niobrara Formation. It is buried by 60 to 600 feet of Pierre Shale and/or glacial drift and has a thickness ranging from 10 to 120 feet. Water levels in the aquifer range from 6 feet above land surface to 200 feet below land surface. Water from the aquifer is suitable for irrigation under only the more permeable soil texture conditions.

The Codell Sandstone Member of the Carlile Shale which underlies the Niobrara Formation is at depths ranging from 120 to 720 feet below land surface. It ranges from 10 to 120 feet in thickness. Water levels in the Codell aquifer range from flowing at land surface to 235 feet below land surface. Water from the aquifer generally is not suitable for irrigation.

The Dakota Formation underlies most of northwestern and extreme southwestern Miner County. It is buried by 400 to 1,000 feet of bedrock and glacial drift and is separated from the Codell aquifer by overlying carbonate rock and shale. The Dakota aquifer ranges from 10 to 400 feet in thickness. Water levels in the aquifer range from 25 feet above land surface to 260 feet below land surface. Water from the aquifer generally is not suitable for irrigation.

The lowermost aquifer comprises the Sioux Quartzite wash and underlying fractured Sioux Quartzite. The quartzite wash may exceed 50 feet in thickness. The quartzite wash is a permeable connection between deep and shallow aquifers in Miner County.

INTRODUCTION

Purpose and Scope

In July 1976, the South Dakota Geological Survey and the U.S. Geological Survey began a 4-year study to evaluate the water resources and geology of Miner County. The purpose of this report is to provide hydrogeologic information for future water development and planning in the county. This study is part of an evaluation of the water resources and geology of eastern South Dakota (fig. 1).

Work performed included compilation and evaluation of data concerning the geology and hydrology of the area, well inventories, collection and analysis of water samples, measurement of water levels in wells, and test drilling. All wells, test sites, and data sites are numbered according to the Federal land-survey system (fig. 2).

Previous Studies

Pleistocene geology and the probable location of outwash-filled channels are discussed by Flint (1955), and a summary of the geology and ground water of South Dakota was given by Darton (1909). Reports by Barari (1972); Jorgensen (1960); and DeWild, Grant, Reckert, and Stevens Engineers and Architects (1959) discussed water availability for the town of Howard. A report by Searight and Meleen (1940) summarized the rural water supplies in Miner County, and Schroeder (1978) investigated the sand and gravel resources in Miner County.

Location and Topography

Miner County is a rural-agricultural area of 571 mi^2 in east-central South Dakota. The northeast corner of Miner County is in the Coteau des Prairies division (fig. 1) of the Central Lowlands physiographic province. The landscape here consists of wide, flat-bottomed depressions; gently sloping uplands; and flat-topped, convex-sloped hills. Land elevations range from 1,600 to 1,800 ft above sea level. The rest of the county lies in the James Basin division of the Central Lowlands. Here, the landscape consists of wide, level plains and gently undulating slopes that have surface elevations ranging from about 1,250 to 1,600 ft above sea level. North-south trending streambeds define much of the topography in Miner County.

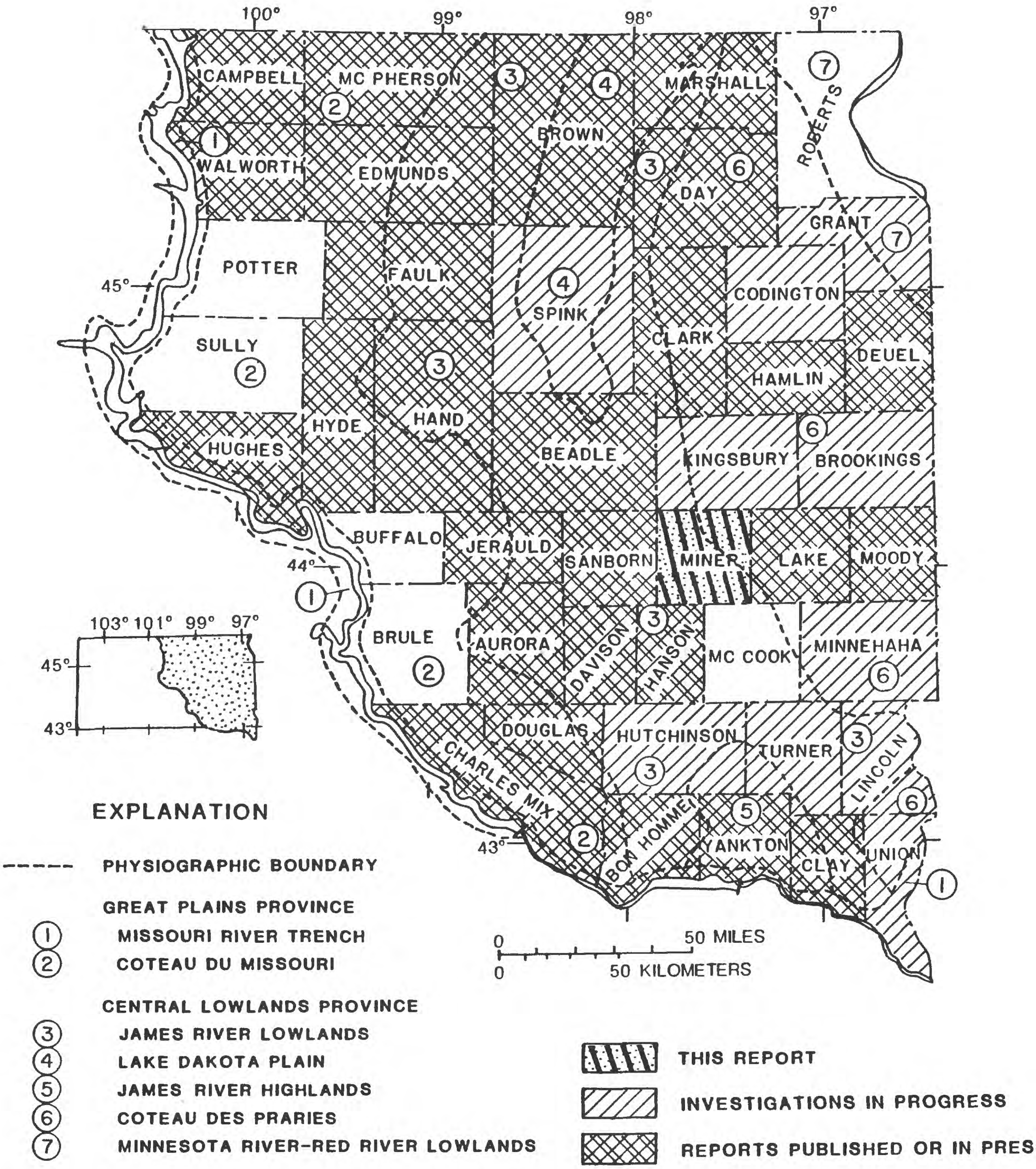


Figure 1.--Location of the study area, status of county investigations, and the major physiographic divisions.

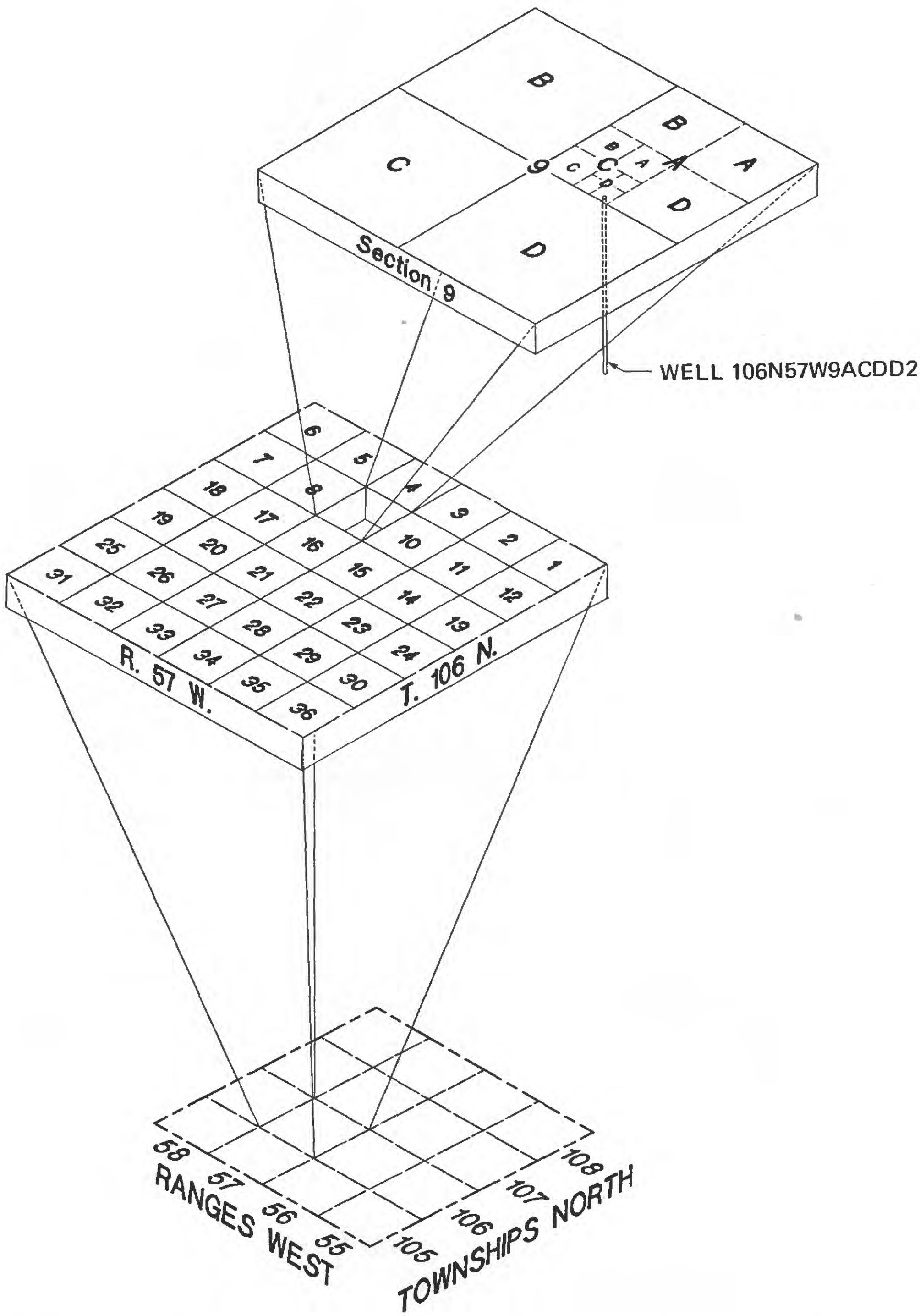


Figure 2.—Site numbering diagram. The well number consists of township followed by " N," range followed by " W," and section number, followed by a maximum of four uppercase letters that indicate, respectively, the 160-, 40-, 10-, and 2½-acre tract in which the well is located. These letters are assigned in a counterclockwise direction beginning with " A," in the northeast quarter. A serial number following the last letter is used to distinguish between wells in the same tract. Thus, well 106N57W9ACDD2 is the second well recorded in the SE¼ of the SE¼ of the NE¼ of section 9 in township 106 North and range 57 West of the 5th meridian and baseline system.

Acknowledgments

Appreciation is expressed to residents of Miner County and to municipal officials for supplying information about their wells and permitting water samples to be collected. Appreciation also is extended to local drilling companies who provided valuable well logs.

WATER RESOURCES

Water in Miner County occurs in surface streams, lakes, ponds, sloughs, and in aquifers in glacial outwash and bedrock. Most of the streamflow is derived from snowmelt and spring rains.

Average annual precipitation in Miner County is about 657,000 acre-ft/yr (21.6 inches). Of this volume, 24,000 acre-ft leaves the county as surface runoff (Larimer, 1970). Stream inflow to Miner County is about 12,400 acre-ft. The remaining 645,400 acre-ft is evaporated and transpired from the county.

Surface Water

Surface water covers only about 700 acres or 0.2 percent of Miner County. It consists of many small, intermittent streams, sloughs, and ponds, and of several small lakes. Flow data was estimated using the method described by Larimer (1970).

Drainage Basins

There are two major drainage basins in Miner County (fig. 3). The eastern one-third of the county is drained by the Vermillion River system and the western two-thirds by the James River system. One large area (about 40 mi^2) of internal drainage is in southwestern Miner County around Glee Lake and smaller areas are found elsewhere in the county.

Streamflow

The East Fork of the Vermillion River receives almost its entire flow from drainages in Miner County and supplies about 1,200 acre-ft/yr of outflow to Lake County to the east. The West Fork of the Vermillion River receives about 60 acre-ft/yr of inflow from Kingsbury County from the north and supplies 5,625 acre-ft/yr of outflow to Mc Cook County to the south. The Little Vermillion River originates entirely in Miner County and supplies a yearly outflow of 2,700 acre-ft to Mc Cook County to the south.

The primary tributaries in Miner County to the James River are Wolf, Rock, Jim, Redstone, and West Redstone Creeks. Wolf Creek originates in Miner County and supplies a yearly outflow of 2,375 acre-ft to Mc Cook County. Rock Creek receives about 6,130 acre-ft/yr of inflow from Kingsbury County and supplies 7,365 acre-ft/yr of outflow to Hanson County to the south. Jim Creek originates in Miner County and supplies a yearly outflow of about 1,900 acre-ft to Sanborn County to the west. Redstone and West Redstone Creeks together receive about 6,190 acre-ft of inflow per year from Kingsbury County and

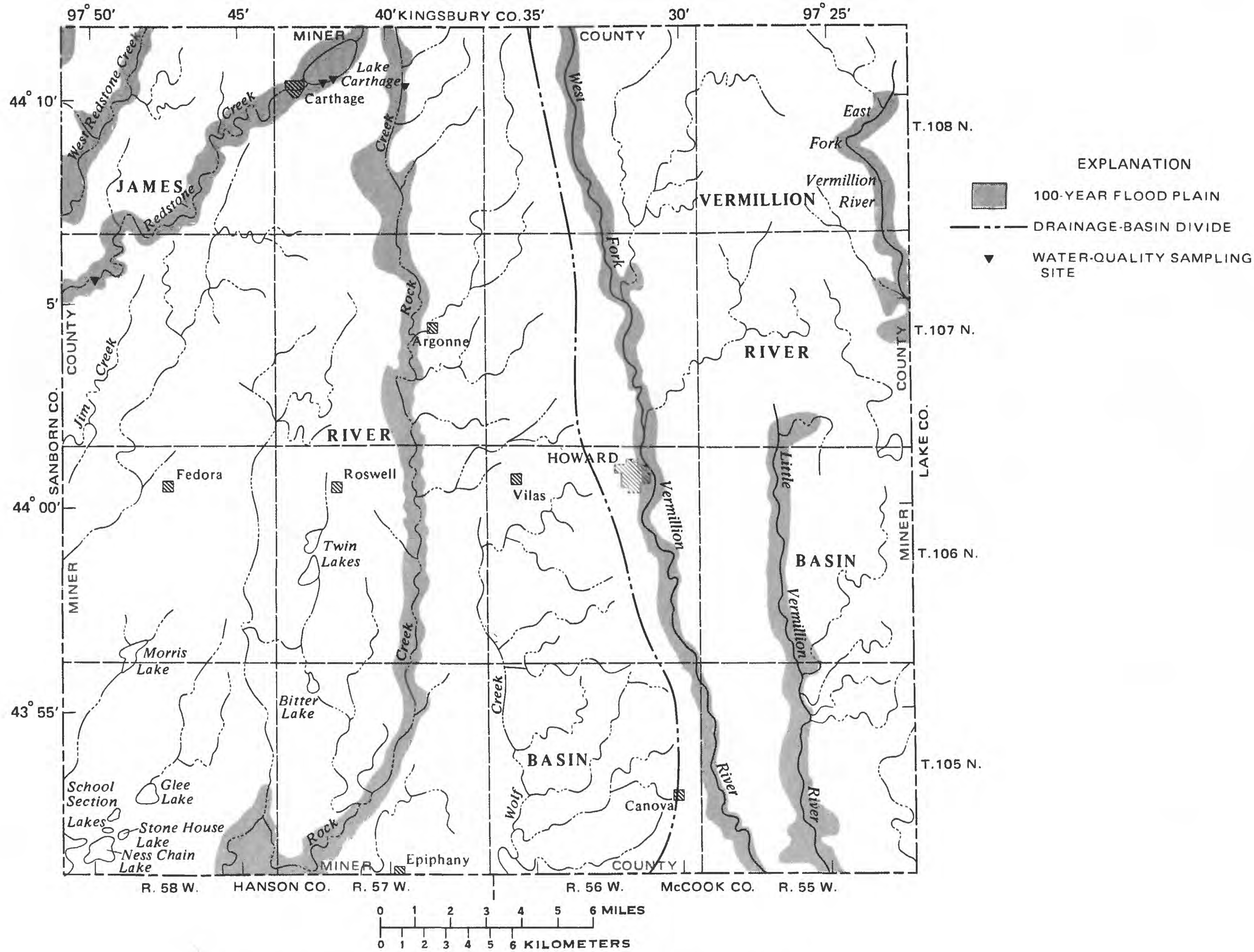


Figure 3.—Surface-water resources and areas inundated by the 100-year flood.

supply about 2,770 acre-ft of outflow per year to Sanborn County. Much of the inflow from Redstone Creek enters Lake Carthage and is evaporated. In addition to streamflow from spring snowmelt and precipitation, large stream discharges of short duration may follow intense local thunderstorms.

Lakes and Ponds

Many small lakes, ponds, and sloughs are scattered across low-lying areas of Miner County. The largest of these is Lake Carthage with an area of about 205 acres. This lake, located in the northwestern part of the county, is formed by a dam across Redstone Creek. It receives inflow mostly from spring snowmelt and precipitation via Redstone Creek. During wet periods the lake may overflow into Redstone Creek. Most of the water lost from the lake is by evaporation, which is about 33 in/yr.

The other lakes, ponds, and sloughs are concentrated primarily in an area of internal drainage in southwestern Miner County. Among these are School Section, Glee, Morris, Ness Chain, Stone House, Bitter, and Twin Lakes. Areas of these lakes are given below:

Lake	Surface area (acres)
School Section Lakes	40
Glee Lake	64
Morris Lake	55
Ness Chain Lakes	292
Stone House Lake	22
Bitter Lake	116
Twin Lakes	165

All of these lakes are natural and lie on glacial drift. They receive inflow primarily from spring snowmelt and precipitation. The lakes may or may not be connected to other small lakes and sloughs. During dry periods some of these lakes may dry up.

Chemical Quality

Chemical quality of surface water generally varies with the magnitude of streamflow and with the time of year. Dissolved-solids concentrations in water from streams and lakes in Miner County tend to vary inversely with streamflow volume. Increased streamflow in the county is caused by snowmelt runoff and precipitation which contains low dissolved-solids concentrations. Therefore, during times of high streamflow (spring and early summer) the chemical constituents in the water are diluted while during times of low streamflow (late summer, fall, and winter) the chemical constituents are concentrated. The volume of water contained in a lake likewise reflects the concentration of chemical constituents in its water. Large concentrations of dissolved solids are caused by low lake levels and evaporation of the water. Small concentrations of dissolved solids usually are the result of higher lake levels and continuous inflow and outflow of water.

Floods

Floods in Miner County usually occur only after heavy spring rains and large snowmelt runoffs. Summer thunderstorms that have large local intensities also may cause flooding. Flood-prone areas in Miner County have been delineated by the U.S. Geological Survey from past flood data and are shown in figure 3. Seven and one-half minute topographic maps of these flood-prone areas are available from the U.S. Geological Survey office in Huron. Areas indicated on these maps are expected to be inundated by a 100-year flood event. In other words, they have one chance in 100 of being flooded in any given year. The dominant factor contributing to peak runoff in small rural watersheds is overland flow rather than actual channel flow. Therefore, small watersheds are very sensitive to land use and to large-intensity rainfalls of short duration (Chow, 1964).

Use of Surface Water

Surface water in Miner County is used primarily for recreation and wildlife habitat. Lake Carthage provides access for many activities including fishing, boating, and camping. Many of the smaller lakes and sloughs provide excellent habitat for waterfowl production, as well as hunting and camping areas.

Surface water is not used for domestic and muncipal purposes because of limited supplies and the additional expense of treatment. Small dams have been constructed across some creeks to retain surface runoff for livestock watering and several permits have been granted to withdraw water from Rock Creek and the West Fork of the Vermillion River for crop irrigation.

Ground Water

Three major confined glacial aquifers, the Floyd, Howard, and Ramona aquifers, and four bedrock aquifers, the Niobrara, Codell, Dakota, and Sioux Quartzite, and Sioux Quartzite wash underlie Miner County. A summary of the hydrologic properties of these aquifers is given in table 1.

Glacial Aquifers

Glacial aquifers consist of unconsolidated sand and gravel called outwash that was deposited by glacial meltwater. The outwash deposits are buried by hundreds of feet of till in some areas. Till has a large clay content; thus it has low permeability and is a poor source of water. It also acts as a confining layer for outwash deposits.

Glacial deposits have complex hydrologic properties and the relationships between the aquifers and confining layers of such a system are likewise complex. Because of this, aquifer thicknesses given in this report generally are composite thicknesses of several layers of aquifer material. This section of the report is concerned with discussing the areal extent, thickness, and water-bearing properties of three outwash aquifers--the Floyd, Howard, and Ramona aquifers.

Table 1.--Summary of hydrologic characteristics of selected aquifers

[F, flowing wells; +, feet above land surface; --, insufficient data]

Aquifer	Areal extent (square miles)	Estimated volume of water in storage (acre-feet)	Range in depth to top of aquifer (feet)	Maximum thickness (feet)	Average thickness (feet)	Range in depth to water level below land surface (feet)	Average depth to water level below land surface (feet)	Potential well yield (gallons per minute)
Floyd	195	[1]1,250,000	25-150	100	50	F to 56	20	1,200
Howard	165	[1]530,000	80-350	170	25	16 to 200	100	300
Ramona	70	[1]134,000	25-170	32	15	10 to 105	35	300
Niobrara	550	[2]2,100,000	60-600	125	--	+6 to 200	--	--
Codell	560	[3]2,700,000	120-720	120	--	F to 235	--	--
Dakota	335	[3]6,400,000	400-1,000	400	--	+25 to 260	--	200
Sioux Quartzite and Sioux Quartzite wash	572	--	100-1,310	--	--	75 to 90	--	200

[1]Specific yield = 0.20
[2]Specific yield = 0.10
[3]Specific yield = 0.15.

Floyd aquifer

The Floyd aquifer underlies about 195 mi^2 of western Miner County (fig. 4). Hydrologic cross sections of this area are shown in figures 5 and 6. Sand and gravel deposits interfinger with till throughout the Floyd, accounting for considerable variation in aquifer thickness and depth. The top of the Floyd averages about 75 ft below land surface. Water in the Floyd aquifer is confined. Well depths range from about 50 to 160 ft and average 100 ft. A summary of hydrologic characteristics of the Floyd aquifer is presented in table 1.

The northern one-half of the Floyd aquifer is confined by overlying till and underlying Pierre Shale; the southern one-half is confined by overlying till and is underlain by the Niobrara Formation and/or the Codell Sandstone Member of the Carlile Shale (see figs. 5 and 6). Water levels in the northern part of the aquifer range from 8 to 56 ft below land surface and average about 35 ft. Water levels in the southern part of the aquifer range from above land surface to 40 ft below land surface. Water-level altitudes are given in figure 7. Some wells flow in T. 105 N., R. 58 W. and several have water levels within 10 ft of land surface in T. 105 and 106 N. The direction of movement of water generally is to the west-southwest from an altitude of 1,400 to 1,300 ft at a gradient of 6 to 20 ft/mi.

Recharge to the aquifer is by infiltration of precipitation and snowmelt through overlying drift and alluvium and by subsurface inflow from areas of higher head. In the southern part of the Floyd aquifer, in some areas where it is in contact with the underlying Niobrara or Codell aquifer, additional recharge is by upward migration of water from these aquifers. Natural discharge from the Floyd aquifer is into the Niobrara aquifer and by subsurface flow into Sanborn and Hanson Counties.

Most wells in the aquifer discharge between 5 and 100 gal/min. However, an aquifer test performed in 1962 indicated that properly constructed wells may produce as much as 1,200 gal/min.

The predominant chemical constituents in water from the Floyd aquifer are sodium, calcium, and sulfate (table 2). The chemical analyses of the major constituents in water from wells in the Floyd aquifer are presented in table 3. Water samples were collected from other wells in the aquifer, and several constituents were determined at the well site (table 4); they show that there is a wide variation in the chemical composition of the water. Total mineral content of the water increases to the west-southwest along with hardness and chloride. Hardness increases from 600 to 800 mg/L (milligrams per liter) and chloride from 50 to 200 mg/L. Water from the aquifer is used for domestic, livestock, and irrigation. Figure 8 shows under what soil texture and quality of water conditions water from the Floyd aquifer can be used for irrigation.

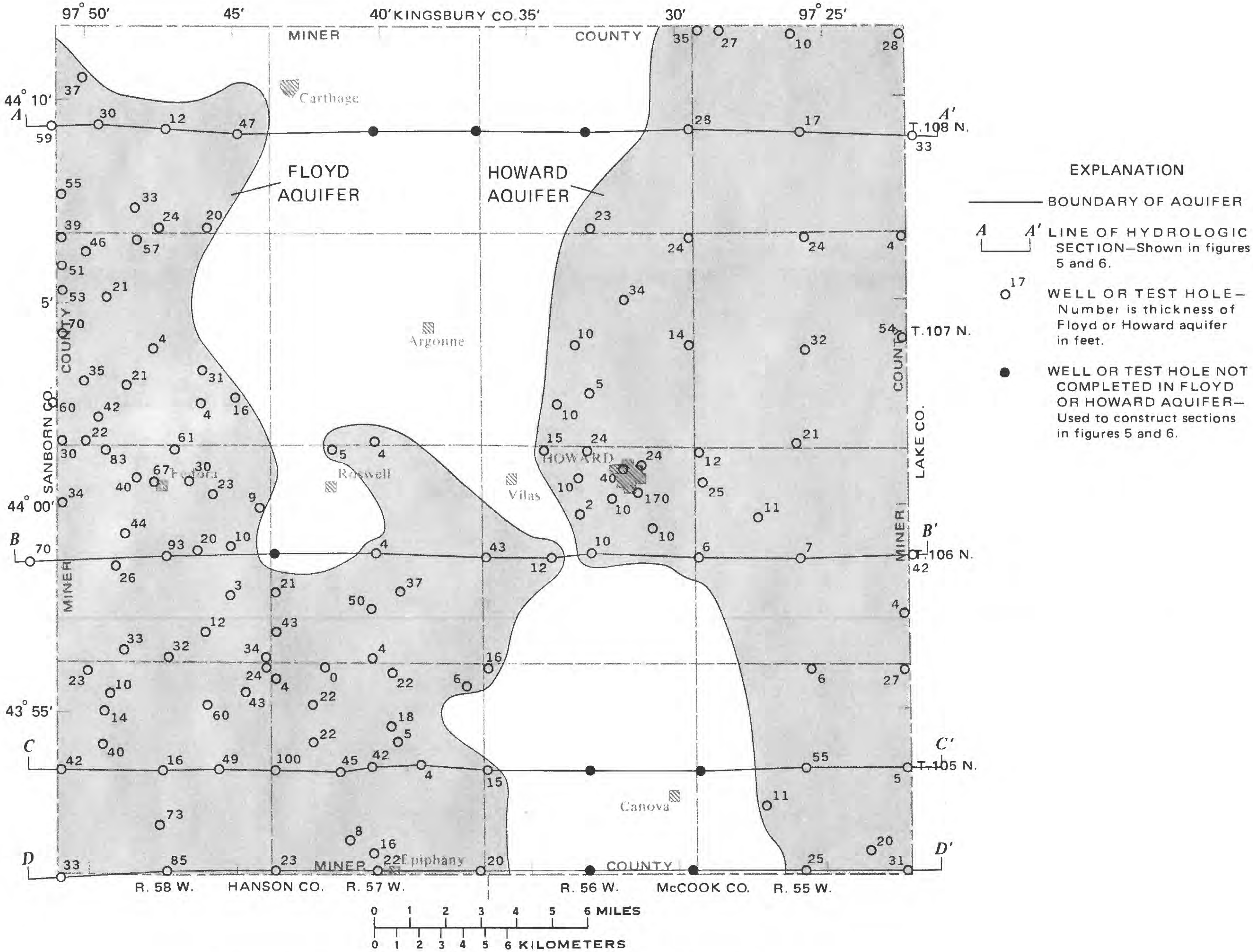


Figure 4.—Location and thickness of the Floyd and Howard aquifers.

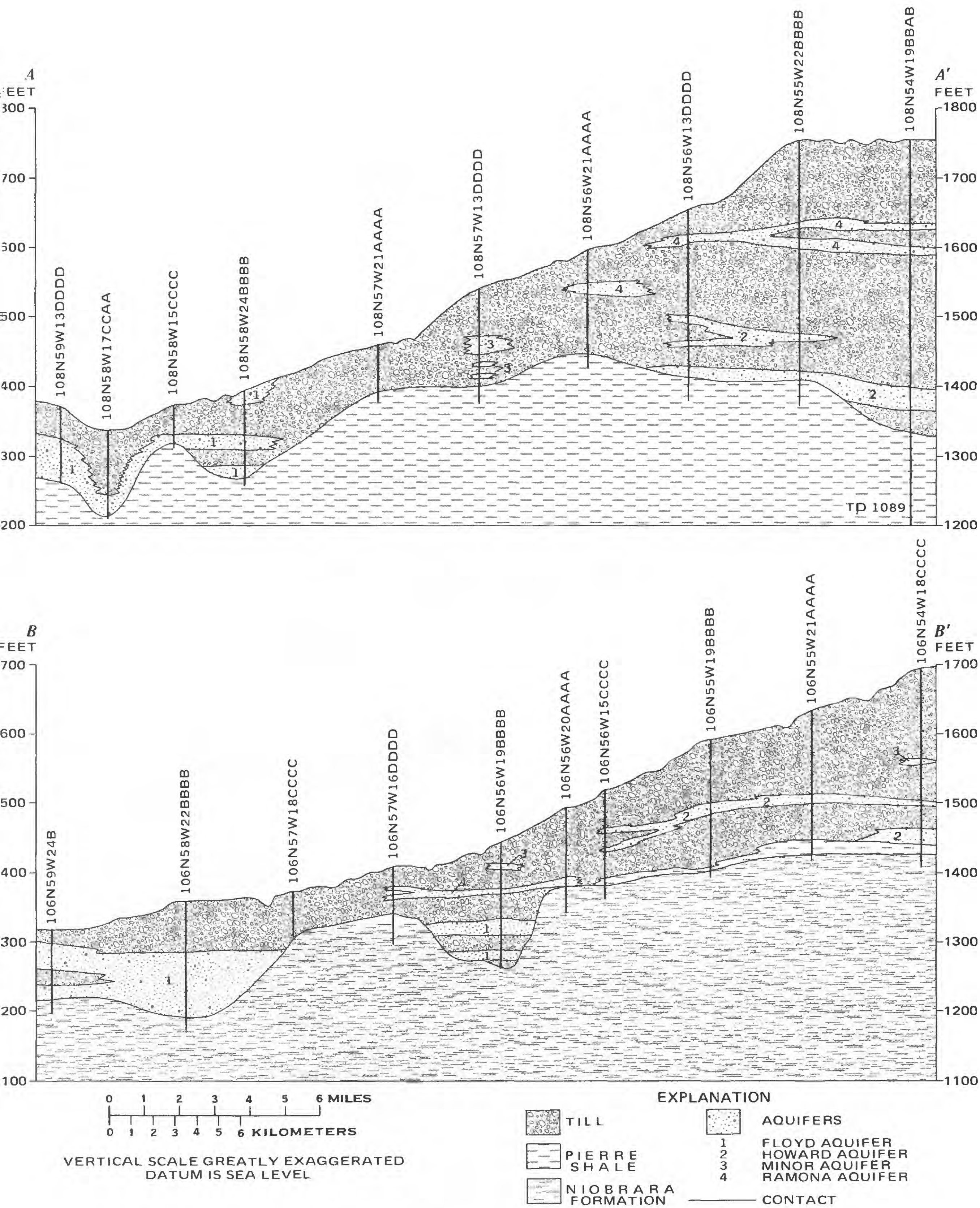


Figure 5.—Hydrologic sections A—A′ and B—B′ showing the Floyd, Ramona, and Howard aquifers. Locations are shown in figure 4.

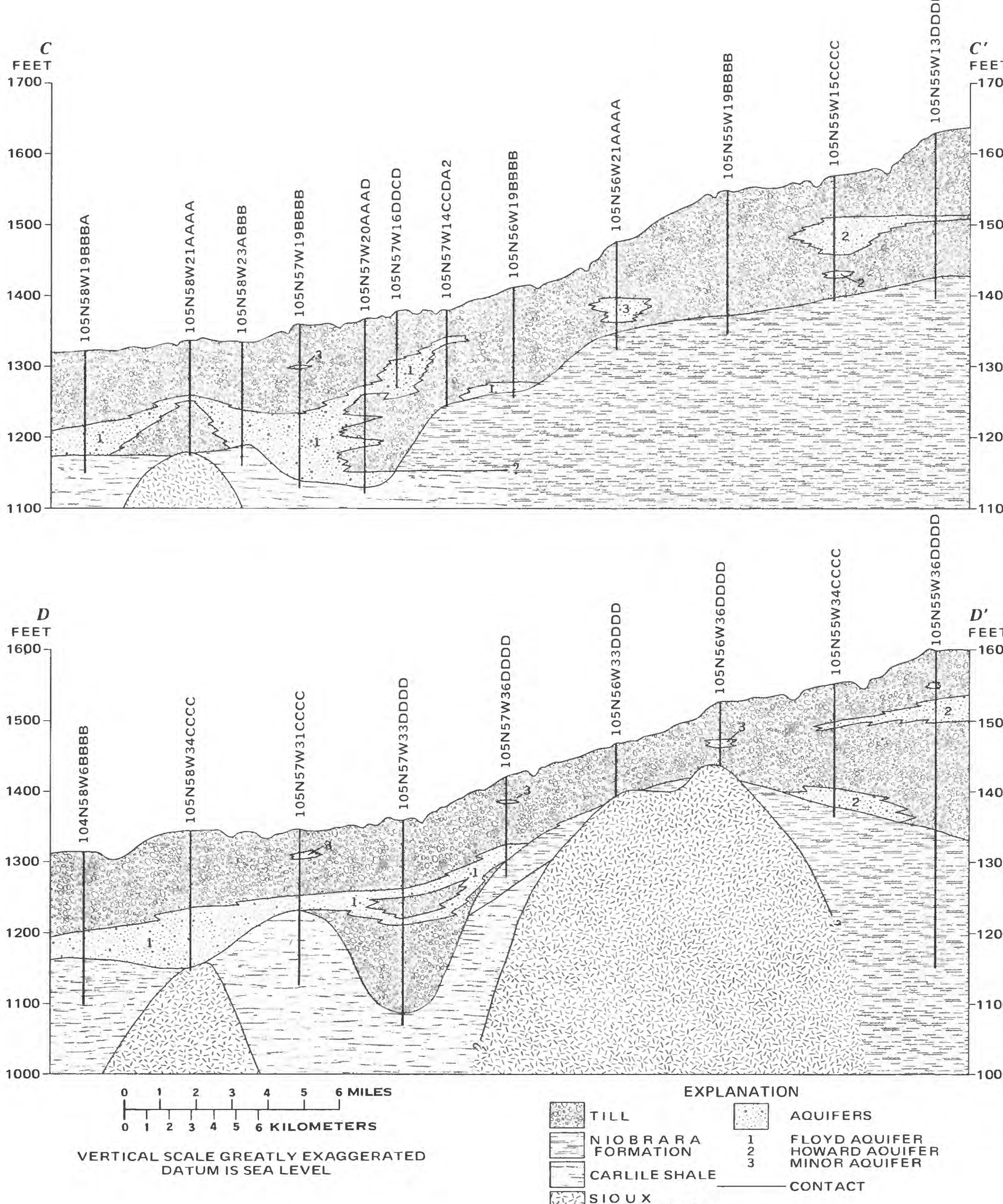
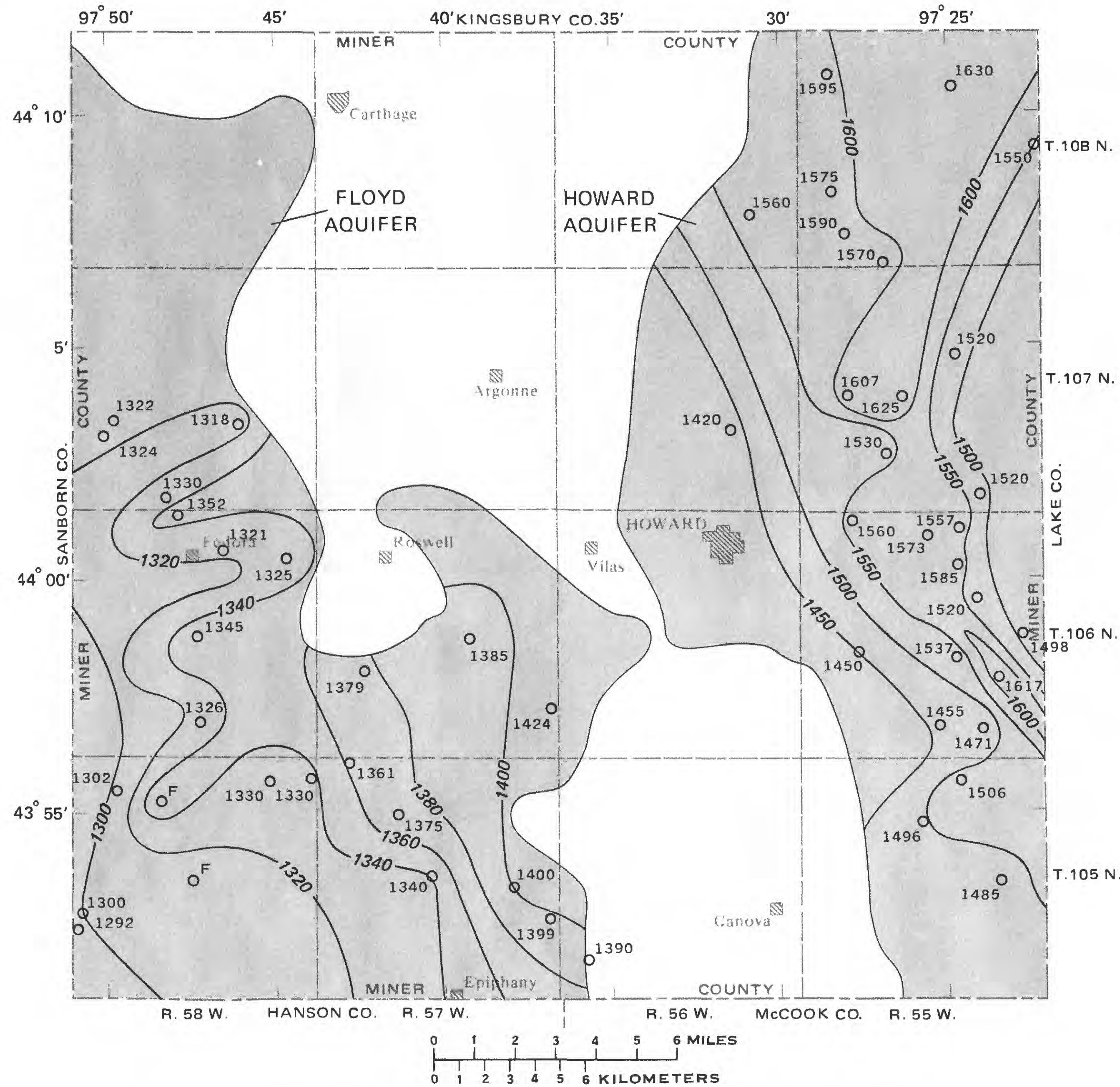


Figure 6.—Hydrologic sections C—C' and D—D' showing the Floyd and Howard aquifers. Location of sections are shown in figure 4.



EXPLANATION

—1500— POTENTIOMETRIC CONTOUR—Shows altitude at which water would have stood in tightly cased wells, 1977. Contour interval 20 feet in Floyd aquifer and 50 feet in Howard aquifer. Datum is sea level.

——— AQUIFER BOUNDARY

O 1560 WELL—Number is altitude of water level in feet. Datum is sea level. F indicates flowing well.

Figure 7.—Potentiometric contours of the Floyd and Howard aquifers.

Table 2.--Summary of chemical analyses of water from selected aquifers

Constituent or property

[Constituents are expressed as milligrams per liter except as follows: Boron, micrograms per liter; specific conductance, microsiemens per centimeter at 25 °Celsius]

	Calcium	Magnesium	Sodium	Potassium	Bicar-bonate	Sulfate	Chloride	Fluoride	Boron	Specific conductance
Floyd aquifer										
Number of analyses	13	13	13	13	11	13	13	4	10	8
Maximum	360	140	440	23	330	1,900	160	1.4	2,100	3,520
Minimum	150	46	240	14	99	900	15	.4	690	2,080
Average	250	80	340	17	260	1,300	72	1.0	1,200	2,840
Howard aquifer										
Number of analyses	4	4	4	4	4	4	4	4	4	4
Maximum	600	200	600	25	460	2,000	87	.7	2,100	3,800
Minimum	330	55	160	18	280	1,300	12	.3	320	2,900
Average	360	100	320	20	390	1,600	36	.4	1,100	3,380
Niobrara aquifer										
Number of analyses	3	3	3	3	3	3	3	3	3	3
Maximum	250	95	450	23	360	1,000	91	1.5	3,500	2,300
Minimum	33	10	97	8.7	320	740	22	1.1	960	2,050
Average	150	52	280	16	350	880	46	1.2	1,900	2,200
Codell aquifer										
Number of analyses	7	7	7	6	5	7	6	7	5	7
Maximum	220	51	800	16	620	890	480	2.5	6,000	3,750
Minimum	16	4.6	190	8.2	320	600	24	.6	760	1,460
Average	79	18	470	11	480	740	170	1.4	4,200	2,570
Dakota aquifer										
Number of analyses	9	9	9	8	9	9	9	9	7	7
Maximum	300	76	750	24	450	1,200	240	4.7	3,900	4,000
Minimum	9.7	9.1	240	9	170	1,000	130	2.0	610	2,670
Average	100	28	580	15	260	1,100	180	2.9	1,900	3,230

Table 3.--Selected chemical analyses of water

[Analyses by U.S. Geological Survey Laboratory unless otherwise noted. Reported in milligrams per liter (mg/L) except as indicated. One milligram per liter is approximately equal to one part per million. One microgram per liter (µg/L) is approximately equal to one part per billion. --, no data]

Location	Date	Well depth (feet)	Silica	Iron (µg/L)	Manganese (µg/L)	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate
Wells penetrating the Floyd aquifer											
105N57W10CDDD	7-29-77	20	--	--	--	270	140	310	11	320	1,500
105N58W21AAAA	9- 1-77	160	--	--	--	290	72	300	20	180	1,300
105N58W23ABBB	10-13-78	160	--	260	2,200	240	60	230	19	--	930
106N58W 4CBCD	8- 4-65	--	29	560	2,500	160	46	400	14	260	1,000
106N58W 7CBBB	7-28-77	75	--	--	--	150	53	240	16	99	900
106N58W17ADAA	7-28-77	122	--	--	--	230	91	310	17	280	1,200
107N58W 6DDAD	7-28-77	117	--	--	--	300	76	420	17	300	1,700
107N58W19BBBB	11-15-67	106	22	40	6,300	360	110	420	20	280	1,900
107N58W31DDDD	11-14-67	105	24	60	3,200	180	80	440	17	280	1,300
107N58W31DDDD	7-28-77	105	--	--	--	160	55	390	14	280	1,100
107N58W32BBBB	7-28-77	137	--	--	--	210	65	390	15	330	1,200
108N58W24BBBB	[1]10-13-78	140	--	500	4,500	340	86	240	14	--	1,300
108N58W33DDDD	[2]4- 7-78	83	--	700	--	340	120	290	23	280	1,700
Wells penetrating the Howard aquifer											
105N55W26DCDD	8-16-79	41	28	230	9,600	600	200	160	19	280	2,000
107N55W35CADD	8-17-79	225	30	4,000	1,200	290	67	280	19	460	1,300
107N56W26ABAA	8-17-79	185	28	360	720	200	55	600	25	430	1,600
108N55W31BBCC	8-17-79	225	28	90	1,200	330	88	230	18	380	1,300
Wells penetrating the Niobrara aquifer											
105N56W24CDBA2	9- 1-77	203	23	30	240	180	50	300	16	360	1,000
106N55W27DDD	8-17-79	300	11	6,700	160	250	95	97	23	320	910
107N58W23CCCA	8-16-79	220	11	120	30	33	10	450	8.7	360	740
Wells penetrating the Codell aquifer											
105N57W20AAAD	[1]10-13-78	277	--	170	1,400	98	22	220	13	--	600
105N58W 2AAAD	8-16-79	264	8.6	2,600	140	220	51	190	16	320	890
107N55W 3BBCD	8-17-79	750	8.5	80	20	28	9.1	450	13	330	770
107N57W23A	11- 7-67	365	--	5,200	--	160	28	260	--	--	730
108N55W22ADBA	9-19-61	743	9.1	1,600	--	16	4.6	670	8.3	560	750
108N55W22ADBA	5-21-68	743	8.5	110	10	17	5.2	690	10	570	760
108N57W32CDBA	8-16-79	399	7.5	130	10	19	5	800	8.2	620	660
Wells penetrating the Dakota aquifer											
105N58W19BBAB	4-13-65	365	9.2	4,500	140	300	74	260	23	170	1,200
105N58W31BACC	[2]7-26-79	630	8	1,500	130	300	76	240	24	180	1,200
106N57W 5D	[1]11- -60	611	--	--	--	140	36	520	18	220	1,200
107N57W20CCBB	8-16-79	790	8.4	250	40	40	11	700	12	320	1,100
107N58W25DDAB	9-19-61	768	7.9	1,800	--	36	12	660	9	270	1,000
107N58W25DDAB	4-29-65	768	6.9	1,700	100	39	12	670	10	290	1,100
108N56W21DDAD	8-17-79	1,020	8.6	20	20	9.7	9.1	750	13	450	1,000
108N57W 7DDBB	[2]8-15-79	1,050	9.3	20	30	30	9.3	650	10	220	1,000
108N57W 8C	[1]11- -54	1,140	--	500	--	36	10	740	--	190	1,200
Wells penetrating the Sioux Quartzite wash aquifer											
105N56W24CDBA	[1]1- -57	406	--	3,200	200	210	60	210	13	360	880
105N56W24CDBA	10- -77	406	23	180	170	220	59	190	13	340	860
105N56W24CDBA	[2]8-15-79	406	--	550	190	170	45	310	15	370	990
106N56W 2CDCC	[2]8-15-79	405	9.4	1,100	70	180	47	360	18	270	1,100
Wells penetrating the Sioux Quartzite aquifer											
105N58W22AAAB	8-16-79	210	7.8	1,300	140	260	56	280	21	170	1,100

[1]South Dakota Geological Survey.
[2]Water Resources Institute, Brookings, South Dakota.

Chloride	Fluoride	Nitrate plus nitrite (dissolved as nitrogen)	Boron (µg/L)	Dissolved solids: Residue at 180 °C	Dissolved solids: Calculated	Total hardness	Sodium-adsorption ratio	Specific conductance (micro-siemens per centimter at 25 °Celsius)	pH (units)
32	--	--	690	2,730	--	1,300	3.8	3,010	--
160	--	--	770	2,230	--	1,000	4.1	2,750	--
87	1.4	--	--	--	1,780	--	--	2,080	--
120	1.4	5.2	2,100	2,030	1,950	580	7.1	2,660	--
72	--	--	680	1,540	--	590	4.3	--	--
90	--	--	770	2,320	--	950	4.4	--	--
36	--	--	1,400	2,850	--	1,100	5.6	--	--
42	.4	6.8	1,150	3,210	3,010	1,300	5	3,520	7.8
100	.9	7.9	1,500	--	2,320	770	6.8	3,090	7.8
98	--	--	1,500	1,950	--	630	6.8	--	--
50	--	--	1,500	2,230	--	790	6	--	--
15	--	--	--	--	2,340	--	--	2,450	--
30	--	3.0	--	--	--	--	3.5	3,170	8.2
87	.7	8.5	320	--	3,140	2,300	1.4	3,650	7.2
12	.3	.14	1,100	--	2,230	1,000	3.9	2,900	7.2
33	.4	2.8	2,100	--	2,770	730	9.7	3,800	7.4
13	.4	.8	810	--	2,200	1,200	2.9	3,160	7.4
22	1.1	--	960	--	1,770	660	5.1	2,240	--
25	1.5	.01	1,200	--	1,580	1,000	1.3	2,050	--
91	1.1	.14	3,500	--	1,780	120	27	2,300	8.0
--	.6	--	--	--	1,140	--	--	1,460	--
40	1.8	4.3	760	--	1,380	760	13	2,080	7.2
24	.6	.6	2,700	--	1,470	110	19	2,350	7.8
45	2.5	--	--	--	--	510	--	2,310	7.7
210	1.6	.3	6,000	2,020	1,950	59	38	3,030	7.9
200	1.5	6.3	5,900	2,030	1,980	64	38	3,040	8.1
480	1.6	.03	5,800	--	2,290	68	42	3,750	8.0
130	2.0	.0	610	2,200	2,080	1,000	3.5	2,670	7.3
130	2.4	2.6	500	2,180	--	1,100	3.2	2,700	7.3
150	2.8	2	--	--	2,170	490	10	--	8.0
190	3.2	.07	2,400	--	2,230	150	25	3,430	8.5
180	3.1	6.2	2,100	2,150	2,080	140	25	3,160	7.8
180	2.6	8.5	2,200	2,190	2,160	150	24	3,220	7.6
200	4.7	.05	3,900	--	2,230	62	42	4,000	8.6
230	2.6	.96	1,700	2,130	--	110	27	3,400	7.5
240	3.0	4.0	--	--	2,170	130	--	--	7.3
24	.8	.6	--	--	1,660	780	--	--	7.7
22	.7	--	570	--	1,560	790	--	1,990	--
4.3	1.2	.04	1,000	1,780	1,750	610	5.5	2,000	6.7
11	2.9	.04	1,600	2,010	--	650	6.2	2,770	6.9
130	2.2	.03	830	--	2,110	880	6.6	2,710	7.3

Table 4.--Field tests of specific conductance, hardness, chloride, and bicarbonate of water from major aquifers

[To help determine variations in the chemical quality of water within an aquifer, field tests were made to determine chemical properties of ground water. The results of the field tests for hardness, chloride, and bicarbonate are not as accurate as laboratory analyses, but are useful in that they give a general indication of water quality. mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 °Celsius]

	Constituent or property			
	Bicarbonate (mg/L)	Chloride (mg/L)	Hardness (mg/L)	Specific conductance (µS/cm)
Floyd aquifer				
Number of analyses	23	53	53	52
Maximum	420	290	920	2,750
Minimum	170	23	270	1,110
Average	290	100	660	2,100
Howard aquifer				
Number of analyses	66	67	67	67
Maximum	670	50	1,500	3,900
Minimum	230	15	320	1,600
Average	370	30	860	2,600
Ramona aquifer				
Number of analyses	17	16	17	17
Maximum	700	45	1,800	3,700
Minimum	150	15	550	1,140
Average	430	20	1,100	2,300
Niobrara aquifer				
Number of analyses	75	115	115	114
Maximum	880	420	1,000	3,600
Minimum	190	15	50	800
Average	380	90	600	2,160
Codell aquifer				
Number of analyses	69	101	101	100
Maximum	920	730	940	3,450
Minimum	170	22	17	1,250
Average	350	120	460	2,270
Dakota aquifer				
Number of analyses	53	78	79	79
Maximum	690	730	1,000	4,200
Minimum	190	60	15	2,200
Average	350	200	200	3,100

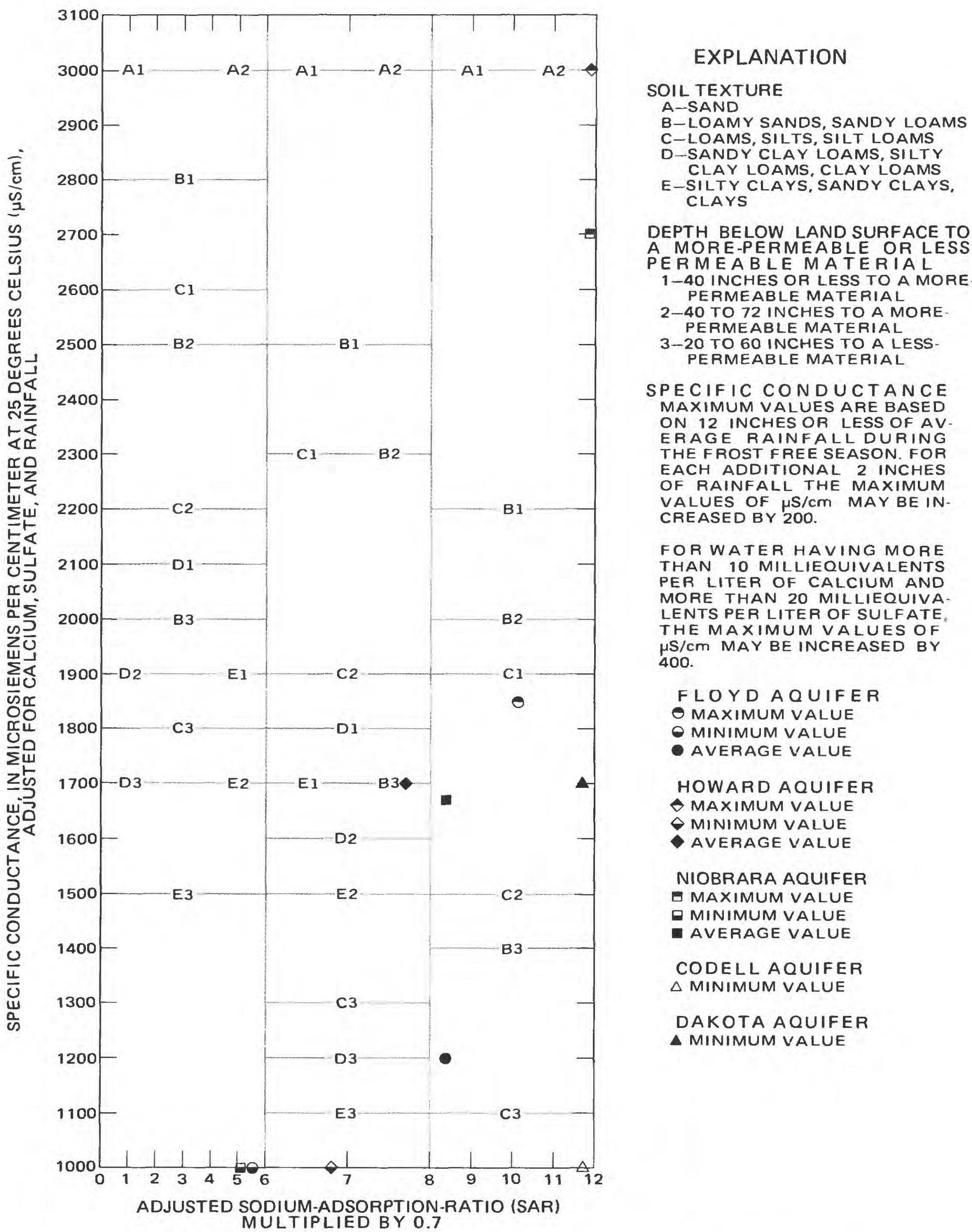


Figure 8.—South Dakota irrigation-water classification diagram (based on South Dakota standards, revised January 7, 1982) for maximum allowable specific conductance and adjusted sodium-adsorption-ratio values for which an irrigation permit can be issued for applying water under various soil texture conditions. Water can be applied under all conditions at or above the plotted point but not below it provided other conditions as defined by the State Conservation Commission are met. (From Koch, 1983.)

Howard aquifer

The Howard aquifer underlies about 165 mi^2 of eastern Miner County at an altitude from about 1,300 to 1,500 ft above sea level (fig. 4). Well depths range from 90 to 375 ft. The southern and western parts of the aquifer have well depths less than 200 ft and in the east-central part of the aquifer depths range from 180 to 220 ft. In the northeast, well depths are greater than 300 ft. The sand and gravel interfinger with the till throughout the Howard aquifer, accounting for considerable variation in aquifer thickness (figs. 5 and 6).

In some areas, the aquifer is in contact with the bedrock and where the bedrock is the Niobrara aquifer (T. 105 N.), the two aquifers are hydraulically connected (figs. 5 and 6). Water in the Howard aquifer is confined and generally is 80 or more feet below land surface in wells. The potentiometric surface ranges from over 1,600 to 1,450 ft above sea level and slopes to the southwest and to the east in Miner County (fig. 7). See table 1 for a summary of hydrologic characteristics of the Howard aquifer.

Recharge to the Howard aquifer in Miner County is by subsurface inflow from Kingsbury County, by infiltration of precipitation and snowmelt through overlying drift, and by discharge from the underlying Niobrara aquifer in T. 105 N. where it is in hydraulic connection with the Niobrara aquifer. Discharge is to the Niobrara aquifer where the head in the Howard aquifer is higher than that in the Niobrara, and as subsurface outflow to Lake County.

The predominant chemical constituents in water from the Howard aquifer are calcium, sodium, and sulfate (table 2). See tables 3 and 4 for additional chemical analyses data. Hardness generally is greater than 1,000 mg/L in T. 107 and 108 N. because water recharging the aquifer from the overlying glacial drift is hard whereas in T. 105 and 106 N. hardness is less than 1,000 mg/L because water recharging to the aquifer from the underlying Niobrara aquifer has a hardness generally less than 1,000 mg/L. Water from the aquifer is used for domestic and livestock purposes but may be adequate for irrigation use (fig. 8).

Ramona aquifer

The Ramona aquifer underlies about 70 mi^2 of northeastern Miner County (fig. 9) at an altitude ranging from about 1,650 to 1,550 ft above sea level. The aquifer interfingers with the till and varies considerably in thickness (fig. 5). Well depths generally range from 40 to 140 ft; however, most wells are more than 100 ft. The limited water-level data suggest that the direction of water movement is from east to west at an altitude from 1,695 to 1,580 ft. Water in the Ramona aquifer is confined and generally is less than 50 ft below land surface in wells.

Several chemical constituents in the water were determined at the well site (table 4) and show that there is a wide variation in the chemical composition of the water. Water from the aquifer is used for domestic and livestock purposes and may be suitable for irrigation under certain soil texture conditions.

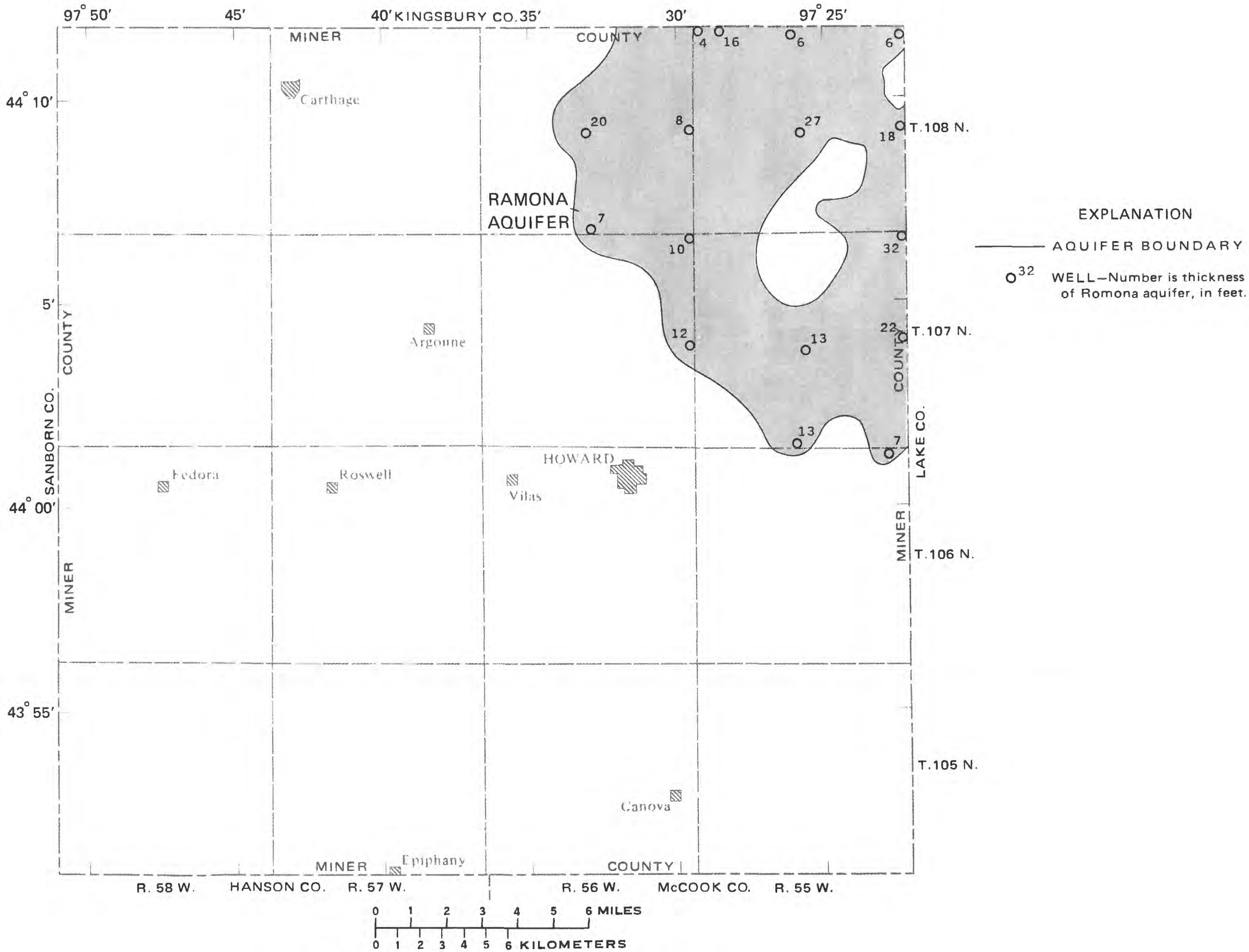


Figure 9.—Location and thickness of the Ramona aquifer.

Minor aquifers

Stream-deposited sand and gravel is present along the flood plains of the East Fork Vermillion River, Little Vermillion River, West Fork Vermillion River, and Rock Creek (fig. 3). Sand and gravel thicknesses generally are less than 20 ft, however, some test holes showed over 30 ft of sand and gravel (Schroeder, 1978). The upper portion of the sand and gravel may be dry, limiting well yield. Where there is sufficient saturated sand and gravel, quantities of water could supply domestic and stock needs. These minor aquifers are recharged directly by precipitation and are discharged by evapotranspiration and discharged to streams.

Bedrock Aquifers

Four major bedrock aquifers underlie Miner County. They are in descending order the Niobrara Formation, the Codell Sandstone Member of the Carlile Shale, the Dakota Formation, and the Sioux Quartzite and overlying Sioux Quartzite wash. See table 1 for the hydrologic characteristics of these aquifers. The structure contours of the bedrock surface are shown in figure 10. The Pierre Shale hydrologically separates the bedrock aquifers from the glacial aquifers in the northern one-half and most of the eastern part of Miner County. In the southern one-half of the county, both the Niobrara and Codell aquifers may be in contact with overlying glacial aquifers. The Niobrara Formation and the underlying Codell Sandstone Member of the Carlile Shale were deposited in ocean environments during Late Cretaceous time. The Dakota Sandstone was deposited in deltaic to near-shore marine environments during Lake Cretaceous time and the Sioux Quartzite formed when marine sandstone was metamorphosed in Precambrian time.

Niobrara aquifer

The Niobrara aquifer is the uppermost bedrock aquifer in Miner County. It varies in composition from chalk to chalky shale and looks like a gray calcareous shale in drill cuttings. The Niobrara is buried by as much as 600 ft of glacial drift and Pierre Shale in the northern part of the county and by as little as 60 ft of drift in the southern part (fig. 5). It is thickest in the northern part of the county where it averages 125 ft. It thins to the south and pinches out on the Sioux Quartzite. Figure 11 shows the structure contours on the top of the Niobrara Formation. The top of the Niobrara slopes to the north and west.

The aquifer is confined and wells may flow at the land surface in low-lying areas of central Miner County. In the northern part of the county, the aquifer generally is confined by overlying till and Pierre Shale and underlying Carlile Shale. The Niobrara seems to be hydrologically connected with overlying outwash and the underlying Codell aquifer in southern Miner County. Water levels in the Niobrara aquifer are over 100 ft below land surface in southeastern Miner County and generally are less than 40 ft below land surface in western Miner County (fig. 12). Wells flow in the south-central part of the county. The direction of water movement in the Niobrara aquifer is from east to west at a gradient of about 10 ft/mi.

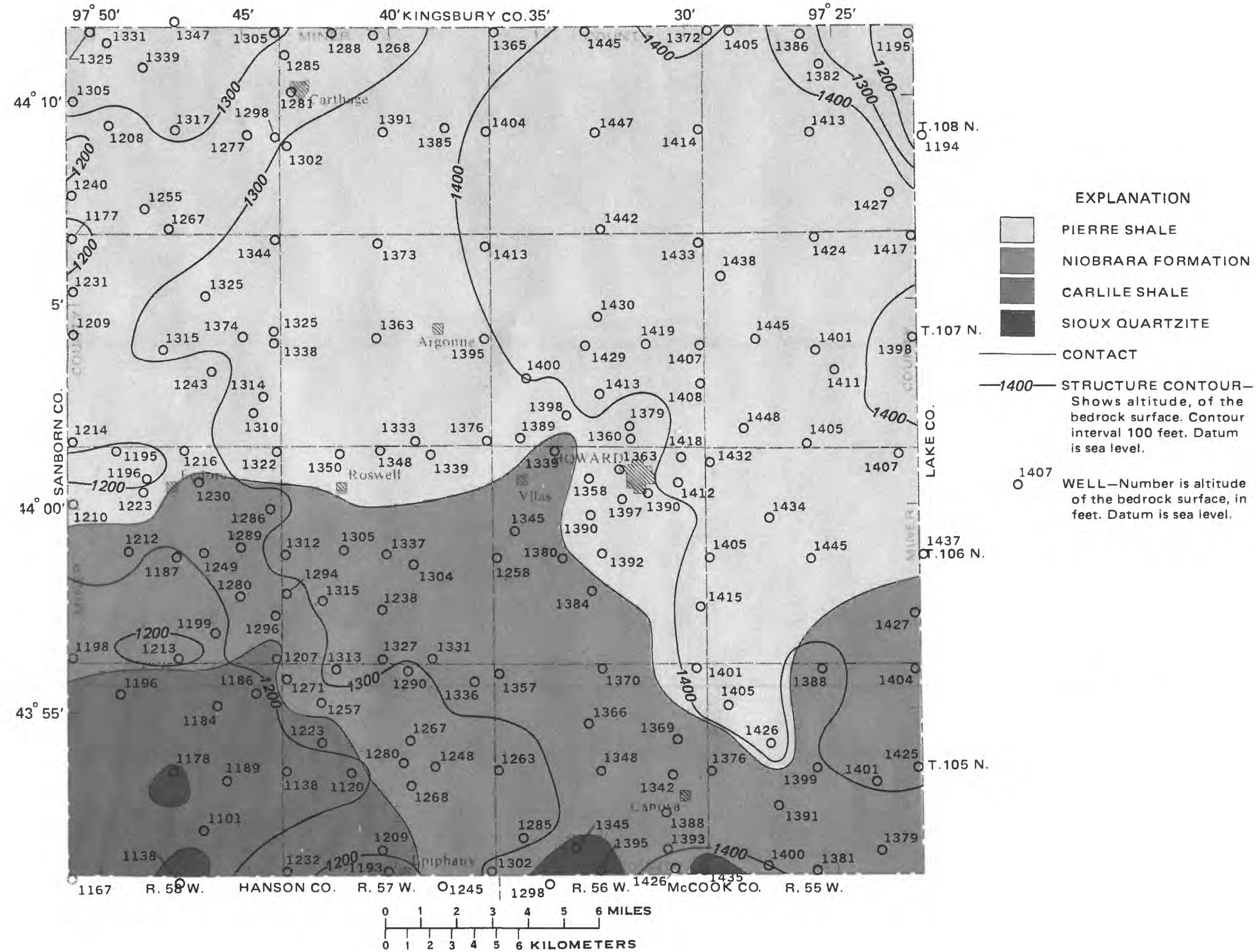


Figure 10.—Structure contours of the bedrock surface.

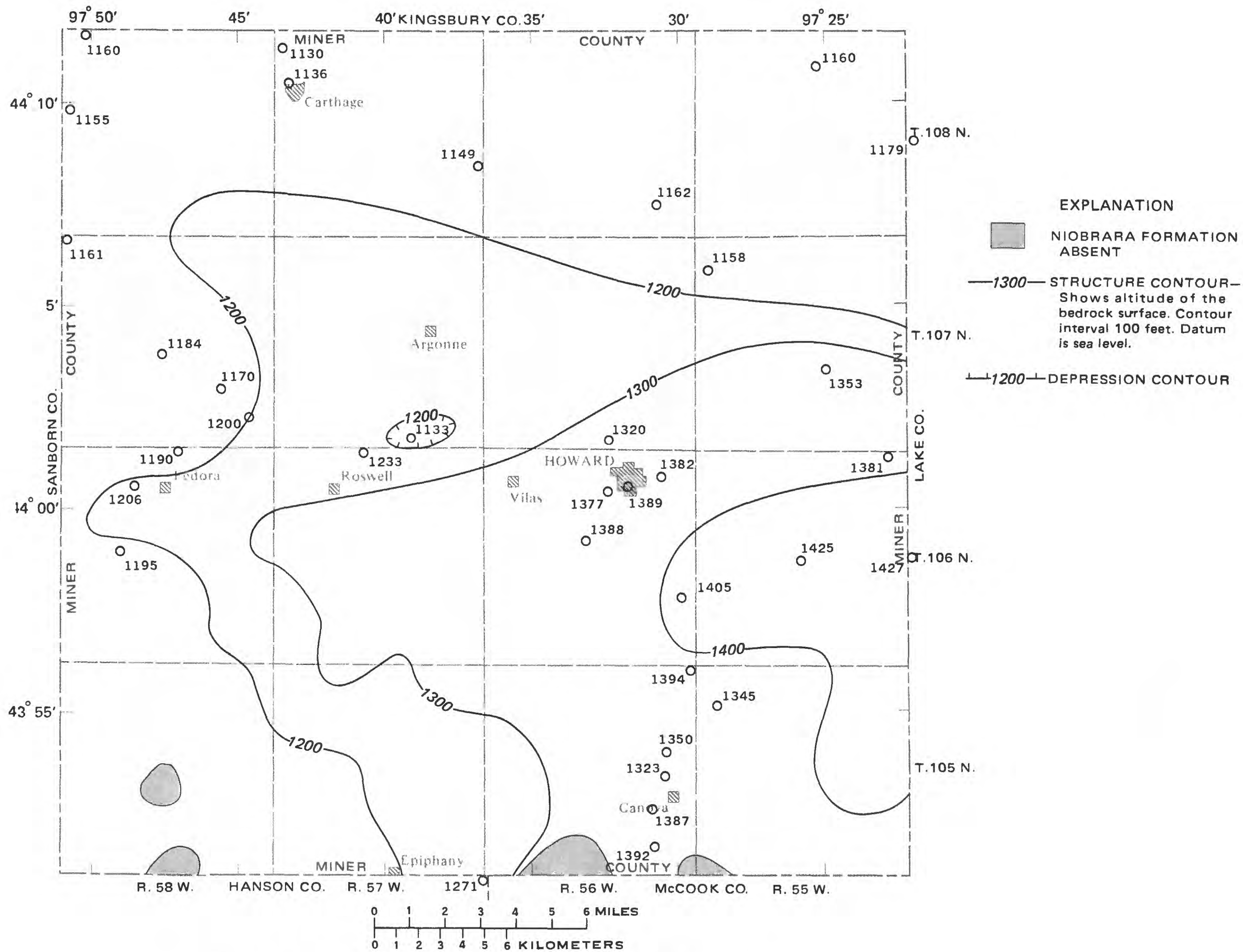


Figure 11.—Structure contours on the top of the Niobrara Formation.

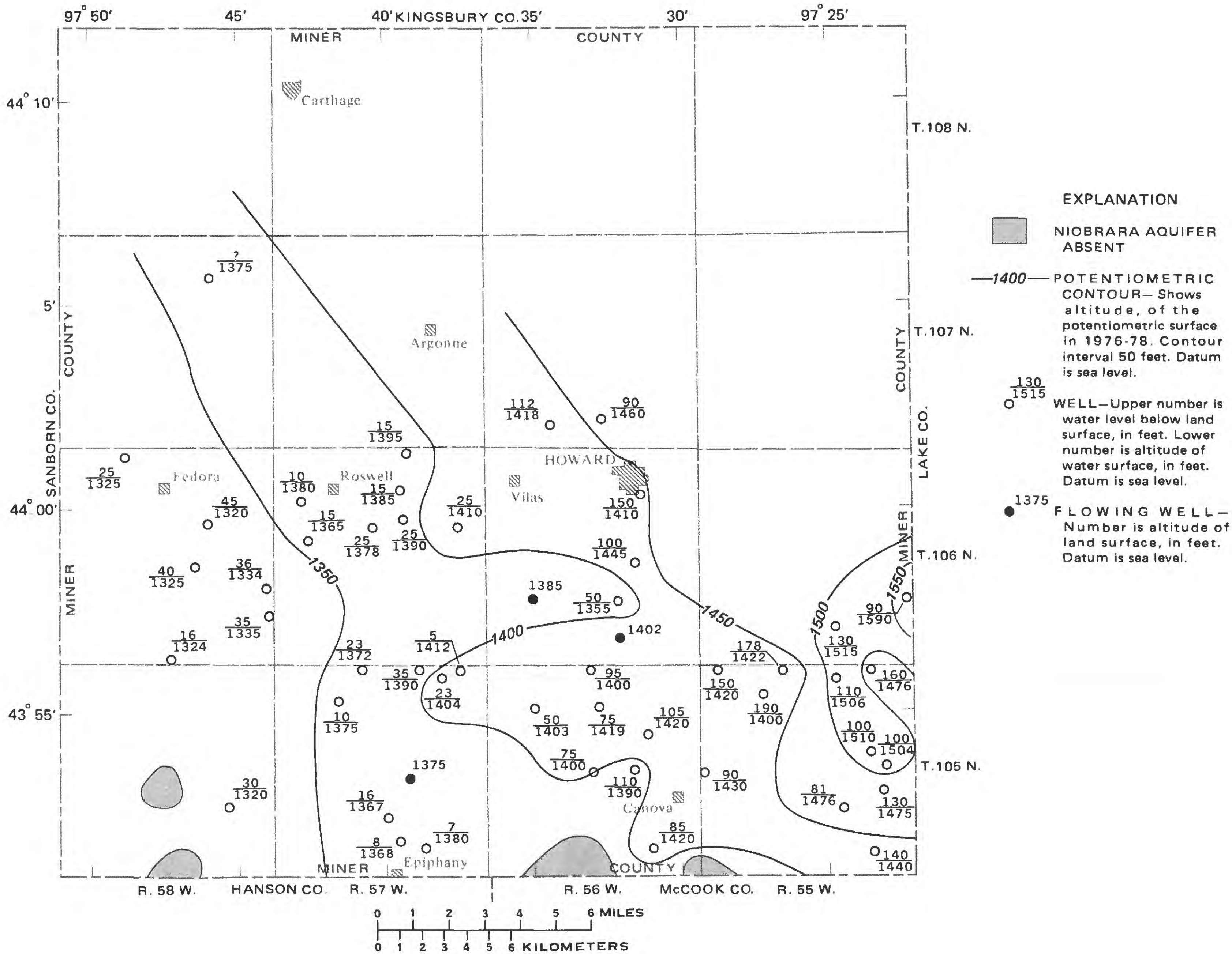


Figure 12.—Potentiometric contours of the Niobrara aquifer.

The Niobrara aquifer is recharged by subsurface inflow from Lake County, and by the upward movement of water from deeper aquifers. The aquifer may discharge naturally to overlying outwash, to underlying bedrock aquifers, and as subsurface outflow into Sanborn County. The Niobrara also discharges water through flowing and pumping wells.

The predominant ions in water from the aquifer are sodium and sulfate (table 2). Hardness was less than 200 mg/L in the northwest part of Miner County and generally more than 500 mg/L elsewhere in the county. See tables 2, 3, and 4 for chemical quality of water from the Niobrara aquifer. Water from the Niobrara aquifer is suitable for domestic, livestock, and municipal use. It also is suitable for irrigation under more permeable soil texture conditions (fig. 8).

Codell aquifer

The Codell aquifer in the Codell Sandstone Member of the Carlile Shale underlies the Niobrara Formation. The Codell Sandstone Member is a fine- to medium-grained sandstone interbedded in places with Carlile Shale. Structure contours on the top of the Carlile Shale are shown in figure 13. The Codell aquifer in the southern part of the county is in contact with the overlying Niobrara aquifer and in the southwestern corner it is in contact with the overlying glacial aquifer (fig. 10). Elsewhere in the county a shale zone of the Carlile separates the Codell from the Niobrara.

The direction of water movement in the Codell aquifer in Miner County generally is from east to west (fig. 14). Water levels in wells are as much as 200 ft below land surface in eastern Miner County and less than 100 ft in western Miner County. Wells flow in southwestern Miner County.

Recharge to the Codell aquifer is from deeper bedrock aquifers and from overlying glacial drift and the Niobrara aquifer. Natural discharge from the Codell aquifer is to overlying glacial outwash and the Niobrara aquifer. Pumping and flowing wells also discharge water from the aquifer.

Predominant chemical constituents in water from the Codell aquifer are sodium and sulfate. Hardness is less than 100 mg/L in the northern part of Miner County and over 400 mg/L in the southern part of the county (fig. 15). The high hardness is the result of recharge of high-hardness water from the glacial and Niobrara aquifers.

Water from the aquifer is suitable for domestic, livestock, and municipal use. It generally is not suitable for irrigation except for water having a minimum adjusted sodium-adsorption ratio which can be used for irrigation under certain soil texture conditions (fig. 7).

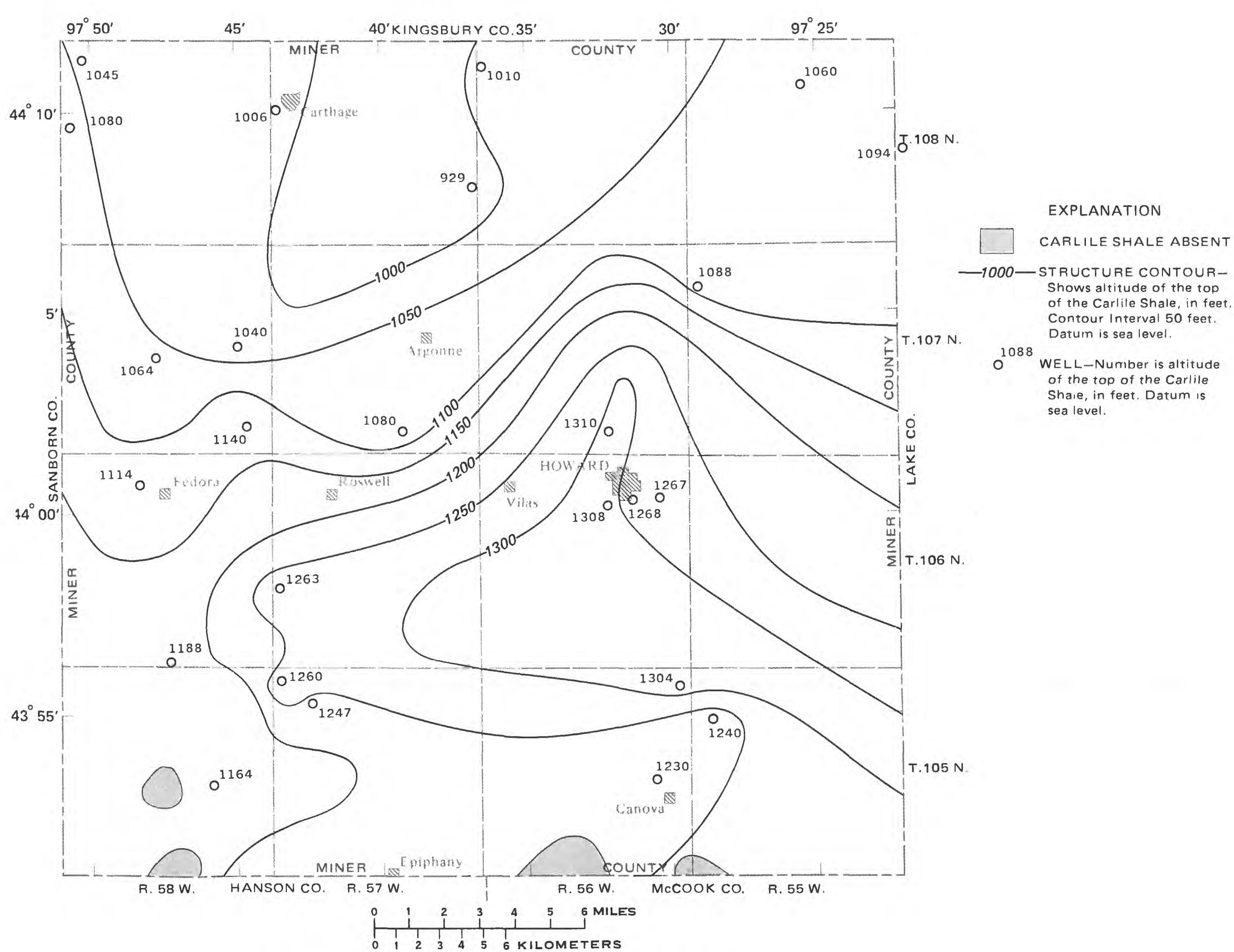


Figure 13.—Structure contours on the top of the Carlile Shale.

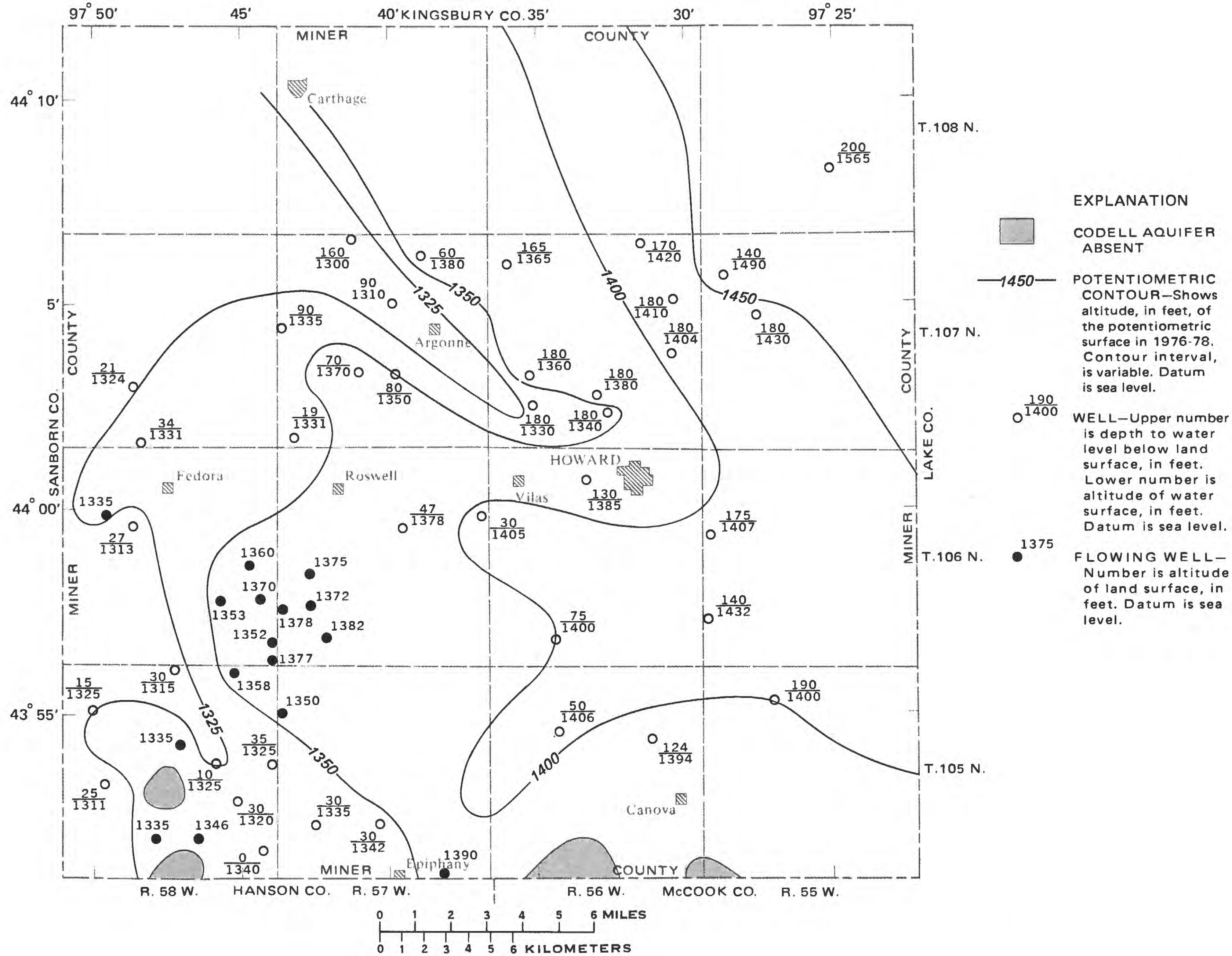


Figure 14.—Potentiometric contours of the Codell aquifer.

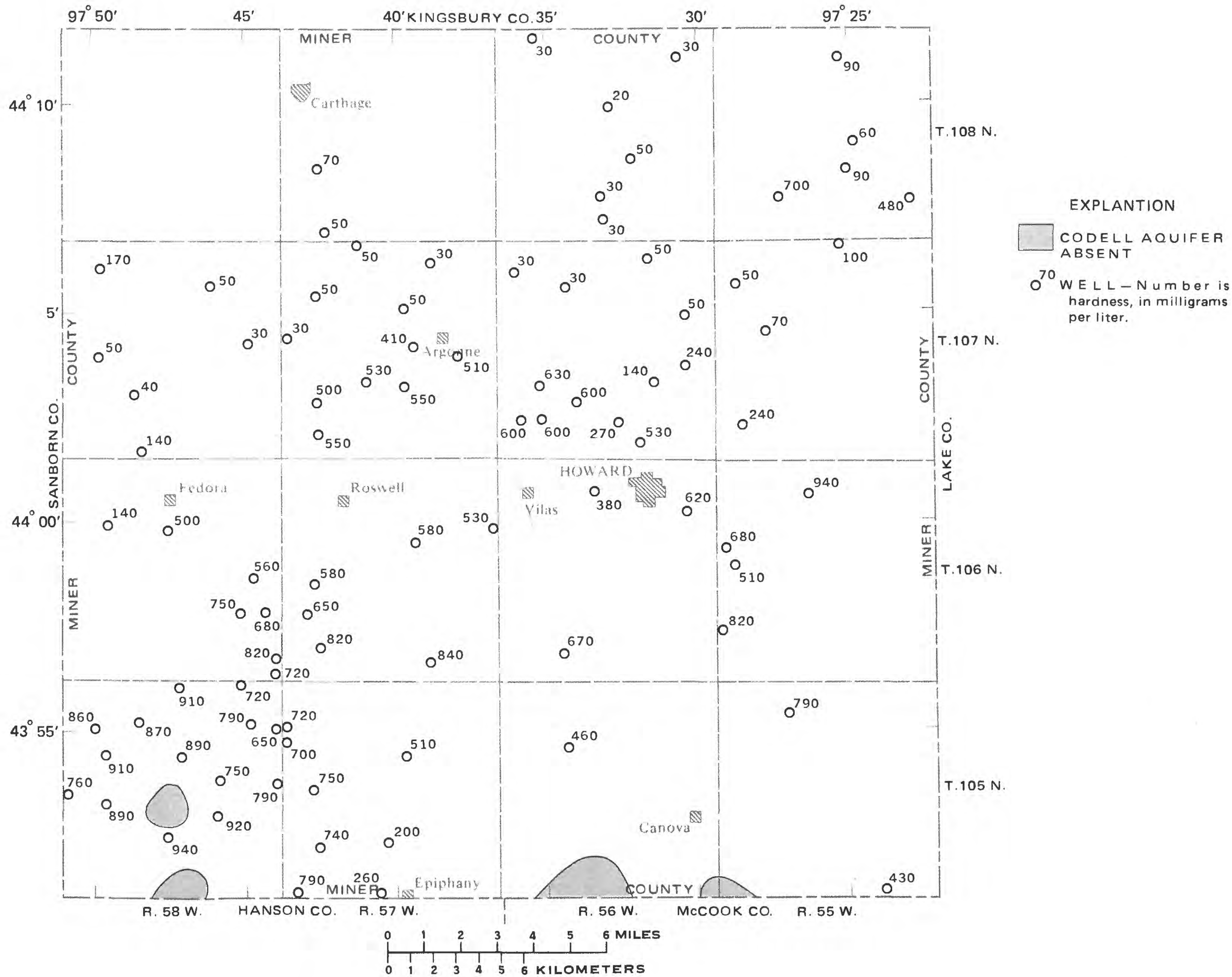


Figure 15.—Hardness of water from the Codell aquifer.

Dakota aquifer

The Dakota aquifer is a soft, fine-grained, porous sandstone that is interbedded with siltstone and shale. It is not uniformly permeable and contains from two to seven zones of large permeability. The top of the aquifer is 400 to 1,000 ft below land surface and the formation may reach 400 ft in thickness along the northern edge of Miner County. Structure contours (fig. 16) show that the aquifer slopes to the north and west. It thins to the southeast and pinches out on the quartzite ridge in southern Miner County. See table 1 for the hydrologic characteristics of the aquifer. The aquifer is artesian and wells in low-lying parts of western Miner County flow.

Recharge to the Dakota aquifer in South Dakota is by subsurface inflow that probably originates in western South Dakota and eastern Wyoming where water enters rock outcrops of the Mississippian Madison Limestone. The water moves easterly and migrates up into the Dakota where the Madison pinches out in central South Dakota (Swenson, 1968). The Dakota may be receiving some recharge from overlying aquifers in eastern Miner County and from the underlying Sioux Quartzite and Sioux Quartzite wash. However, in some areas the Dakota aquifer discharges naturally by upward movement of water through the Sioux Quartzite wash into the overlying Codell, Niobrara, and glacial aquifers. Water also flows and is pumped from wells penetrating the Dakota aquifer. Since 1900, the number of flowing wells has dropped considerably because of unrestricted discharge that flows to waste. The subsequent loss of artesian pressure also has been observed in Brown County (Koch and Bradford, 1976). Although wells in Miner County completed in the Dakota may yield as much as 200 gal/min and flows of 1,500 gal/min have been measured in other parts of South Dakota, smaller discharges are more common.

The direction of water movement in the Dakota aquifer is from east to west (fig. 17). Water levels are as much as 200 ft below land surface in eastern Miner County and wells flow in western Miner County.

Predominant chemical constituents in water from the Dakota aquifer are sodium and sulfate (tables 2, 3, and 4). Hardness is less than 100 mg/L in north-central and eastern Miner County but is over 700 mg/L in western Miner County (fig. 18). The high hardness is the result of recharge of water with a hardness generally greater than 800 mg/L from the Sioux Quartzite and Sioux Quartzite wash. Water from the aquifer is used for domestic and stock purposes. It generally is not suitable for irrigation except for water having a minimum adjusted sodium-adsorption ratio which can be used for irrigation under certain soil texture conditions (fig. 8).

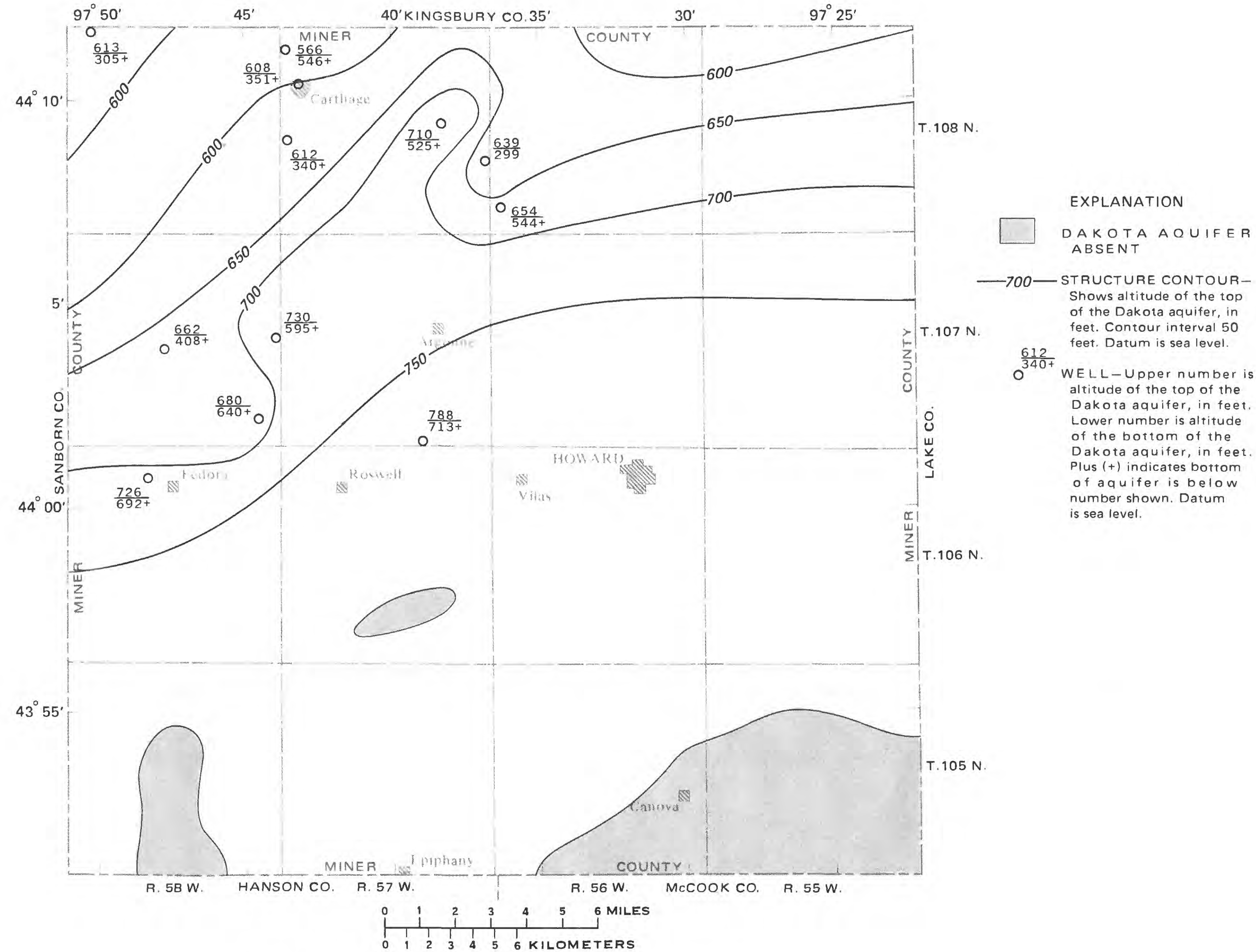


Figure 16.—Structure contours on the top of the Dakota aquifer.

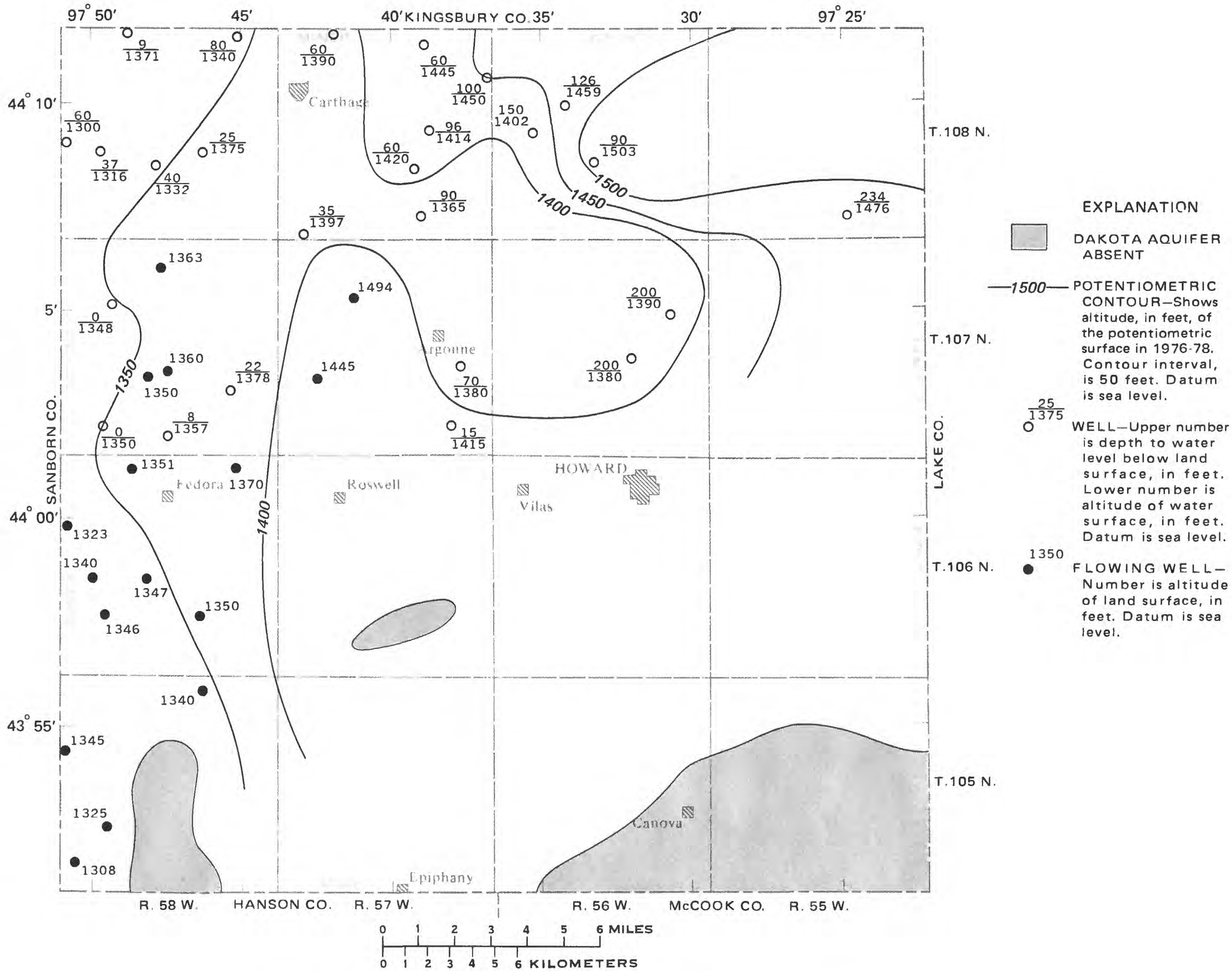


Figure 17.—Potentiometric contours of the Dakota aquifer.

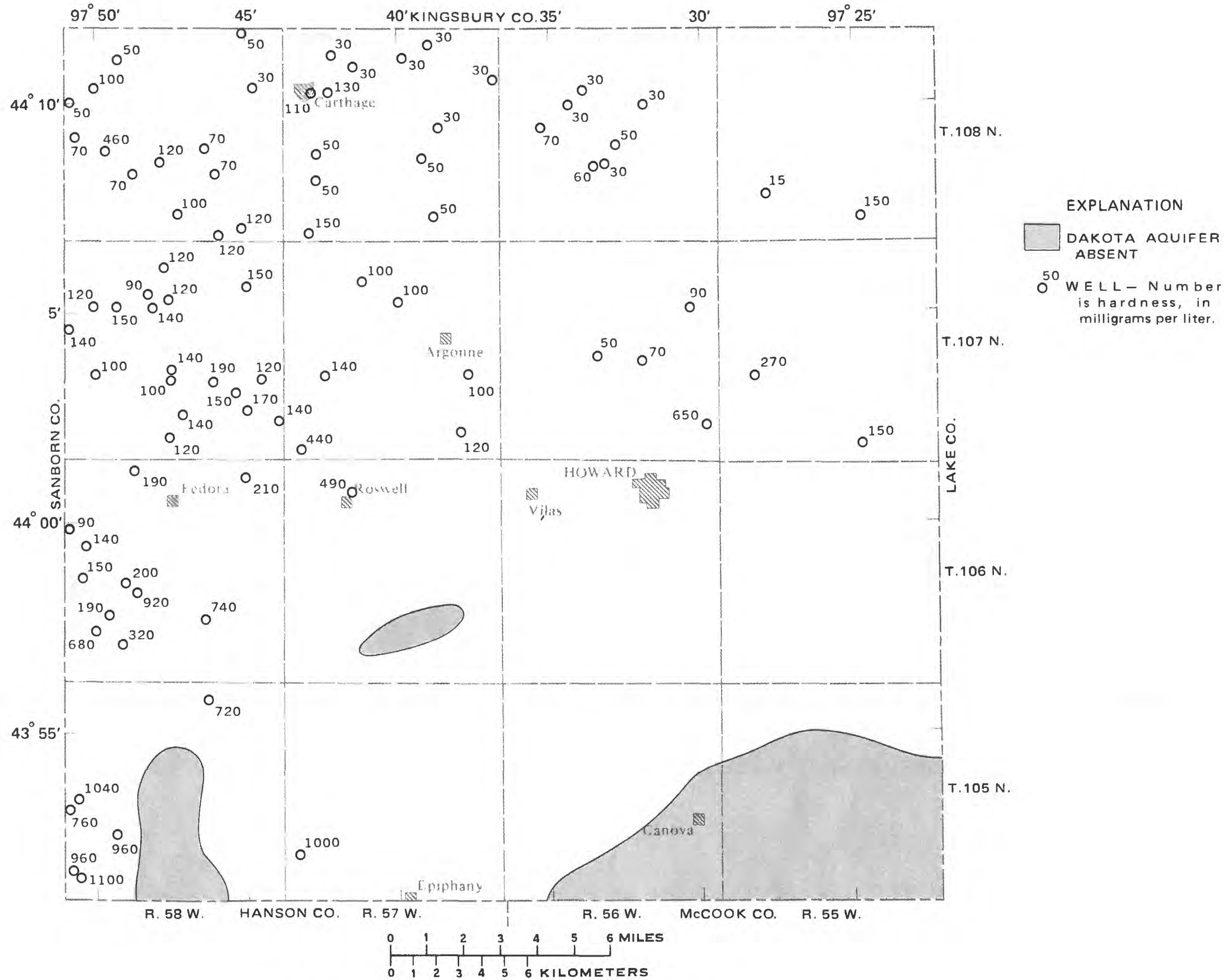


Figure 18.—Hardness of water from the Dakota aquifer.

Sioux Quartzite and Sioux Quartzite wash aquifer

The Sioux Quartzite of Precambrian age forms a large ridge in the surface of the basement rock in southern Miner County. The quartzite may be as thick as 5,000 ft. In several places an erosional zone of quartzite "wash" overlies the Sioux Quartzite and underlies the Dakota Formation. This material is a mixture of weathered quartzite and sandstone. The wash was most likely formed when the main body of the Sioux Quartzite was exposed to erosion during Precambrian or later time and subsequently buried by Createaceous sediments. Sioux Quartzite wash may attain a thickness of more than 50 ft in Miner County. Water in both the Sioux Quartzite and the quartzite wash is confined.

Poorly cemented and fractured zones of the Sioux Quartzite may yield small quantities of water while the Sioux Quartzite wash may supply yields sufficient for municipal use. The Sioux Quartzite and the Sioux Quartzite wash are hydraulically connected.

The aquifer is recharged by subsurface inflow and discharges to overlying bedrock and glacial aquifers. Properly constructed wells in the aquifer may yield as much as 200 gal/min. Predominant chemical constituents in water from the Sioux Quartzite and Sioux Quartzite wash are calcium, sodium, and sulfate (table 3). Water from the aquifer is suitable for domestic, stock, and muncipal use.

WATER USE AND POTENTIAL FOR LARGE-CAPACITY WELL PRODUCTION

Domestic, Stock, and Municipal Use

Most of the ground water in Miner County is of satisfactory quality for domestic, stock, and municipal use. Some of the water may contain chemical concentrations that exceed U.S. Environmental Protection Agency (1977) standards. Bedrock and glacial aquifers capable of producing 200 gal/min can supply water for municipal use while even the smaller glacial aquifers can meet domestic and stock needs.

Irrigation

The aquifer in Miner County most favorable for the development of large-yield wells necessary for crop irrigation is the Floyd. Well yields of 1,200 gal/min may be available and water quality may be suitable for plant growth.

Prior to well construction, test holes commonly are drilled at and around the selected site to determine aquifer thickness, depth to the top of the aquifer, depth to water, and grain size of the aquifer material. This information can be used to properly design the production well including selection of the proper pump and slot size and placement of the screen. Controlled pumping of a test well for at least several hours can indicate the yield of the aquifer at that locality and provides a representative water sample for chemical analysis.

SUMMARY AND CONCLUSIONS

Miner County has a rather large potential for ground-water development but the potential for surface-water development is small. Neither water resource has yet been intensely developed.

Several lakes and many sloughs, ponds, and streams make up the county's surface-water resources. Lake Carthage has an area of about 205 acres and is filled by spring snowmelt and precipitation. Water quality is acceptable for fish and waterfowl, as well as for swimming; the area has good potential for both recreation and wildlife management. Ponds and sloughs in the county are filled by spring snowmelt and precipitation and many are potential wildlife reserves as well as potential hunting, fishing, and camping areas.

Small intermittent streams in Miner County include Rock, Redstone, West Redstone, Wolf, and Jim Creeks; the West and East Forks of the Vermillion River and the Little Vermillion River. They usually flow during periods of spring snowmelt and precipitation and are dry the rest of the year. Potential development of water supplies from this source probably is limited to small dams and dugouts to retain water for livestock and recreational use.

Several glacial and bedrock aquifers in the county contain substantial volumes of water for domestic, livestock, irrigation, municipal, and industrial use. The glacial aquifers consist of sand and gravel deposits that interfinger with till which accounts for considerable variation in aquifer thickness, depth to aquifer, and yield. The Floyd aquifer underlies about 195 square miles in Miner County and ranges from 10 to 100 feet thick. Wells in the Floyd may produce as much as 1,200 gallons per minute. The Howard aquifer underlies 165 square miles of the eastern one-half of the county at depths of 80 to 350 feet below land surface. Wells may produce 300 gallons per minute. The Ramona aquifer underlies 70 square miles in northeastern Miner County at depths of 25 to 170 feet below land surface. Wells may produce 300 gallons per minute. The predominant chemical constituents in water from the Floyd and Howard aquifers are sodium, calcium, and sulfate.

The Niobrara Formation is the uppermost bedrock aquifer in Miner County. The top of the aquifer is between 60 and 600 feet below land surface and the aquifer ranges from 10 to 120 feet thick. Water from the Niobrara aquifer is suitable for domestic, livestock, and municipal use.

The Codell Sandstone Member of the Carlile Shale underlies the Niobrara Formation at depths ranging from 120 to 720 feet below land surface. Its thickness ranges from 10 to 120 feet. Water from the Codell aquifer is suitable for domestic, livestock, and municipal use.

The Dakota Formation underlies most of northwest Miner County and is separated from the overlying Codell aquifer by shale and carbonate beds. The top of the Dakota aquifer ranges from 400 to 1,000 feet below land surface. Thickness of the aquifer ranges from 10 to 400 feet. Water from the Dakota is acceptable for domestic, livestock, municipal, and possibly industrial use.

The predominant chemical constituents in water from the Niobrara, Codell, and Dakota aquifers are sodium and sulfate. Water from the Niobrara is suitable for irrigation under more permeable soil texture conditions, and water from the Codell and Dakota generally is not suitable for irrigation.

The Sioux Quartzite wash underlies the Dakota Formation and overlies the Sioux Quartzite ridge. The quartzite wash may exceed 50 ft in thickness in Miner County and is the hydraulic connection between deep and shallow aquifers in the county. The weathered wash is permeable and properly constructed wells in the aquifer may produce as much as 200 gallons per minute. Additional water may be obtained from fractures and joints in the upper part of the Sioux Quartzite. Water from the Sioux Quartzite and the Sioux Quartzite wash is acceptable for domestic, livestock, and municipal use.

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