Saline-Water Resources of North Dakota

By C. J. ROBINOVE, R. H. LANGFORD, *and* J. W. BROOKHART

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1428

A description of the principal saline-water aquifers and surface-water bodies, with available analyses

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1958

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.

CONTENTS

ILLUSTRATIONS

TABLES

CONTENTS

SALINE-WATER RESOURCES OF NORTH DAKOTA

By C. J. Robinove, R. H. Langford, and J. W. Brookhart

ABSTRACT

Natural waters in North Dakota have been arbitrarily defined in this report as saline or fresh; water containing more than 1,000 ppm (parts per million) of dissolved solids or having a specific conductance greater than 1,400 micromhos per centimeter at 25°C is considered to be saline. A large proportion of the available water supply of North Dakota is saline.

Saline ground water is available in small to large amounts from aquifers of Paleozoic age; in moderate to large amounts from the Dakota sandstone, in small amounts from the Fox Hills sandstone, and in small to moderate amounts from the Hell Creek formation, all of Mesozoic age; and in small to moderate amounts from the Fort Union formation of Cenozoic age; and in extremely variable amounts from the glacial drift and alluvium of Cenozoic age. In this report, yields of less than 150 gpm (gallons per minute) to individual wells are considered to be small; 150 to 350 gpm, moderate; and more than 350 gpm, large.

Generally, the saline ground water is only slightly saline (contains 1,000 to 3,000 ppm of dissolved solids). However, some water from the Dakota sandstone is moderately saline (3,000 to 10,000 ppm), some from glacial drift and alluvium is very saline (10,000 to 35,000 ppm), and some from aquifers of Paleozoic age is briny (more than 35,000 ppm).

Saline water from aquifers of Paleozoic age is generally of the sodium chloride type; from the Dakota sandstone, of the sodium chloride sulfate type; from the Fox Hills sandstone, of the sodium bicarbonate type; from the Hell Creek formation and upper part of the Fort Union formation, of the sodium bicarbonate sulfate type; and from the Cannonball member of the Fort Union formation, of the sodium chloride type. Saline water from glacial drift and alluvium varies widely in type.

Tributaries of the Missouri River are slightly saline at low flow. Investigations of the chemical quality of the major tributaries show that the water is generally of the sodium sulfate bicarbonate type. Many lakes in the Devils Lake basin are saline. The water in these lakes is of the sodium sulfate type and is from slightly saline in Sixmile Bay of Devils Lake to briny in eastern Stump Lake and East Devils Lake.

INTRODUCTION

PURPOSE AND SCOPE

Public Law 448 (U. S. Congress, 1952) authorized the establishment of the Saline Water Conversion Program of the U. S. Department of the Interior. The law provides for research into and development of practicable and economical means of producing fresh water from sea water or other saline water for the purpose of conserving and increasing the water resources of the Nation. A necessary part of the program is the determination of the quantity and quality of water that is available for demineralization.

A large proportion of the available water supply of North Dakota is saline. Water-resources investigations in North Dakota in the past have been confined principally to a search for water of the best quality available. This report is a compilation and an evaluation of the available data on the quality and quantity of saline water in North Dakota. It is one of a series of reports describing the saline-water resources in different areas of the United States.

The scope of this reconnaissance report is limited by lack of information on the quantity of saline ground water. The lack of information is due partly to the practice of abandoning wells as soon as the water is found to be too highly mineralized for general use. Therefore, only rough estimates of the yields from some water-bearing formations have been made for the evaluation of saline ground-water supplies.

The scope of this report is limited also because a complete inventory of the available analyses of saline water was not made. Analyses made by oil companies and railroad companies and by Federal agencies other than the Geological Survey are not included.

Many of the data on the saline waters of North Dakota were extracted from reports of the North Dakota Geological Survey. Some data were obtained from the North Dakota State Health Department.

This cooperative investigation was under the general supervision of A. N. Sayre, Chief, Ground Water Branch, and S. K. Love, Chief, Quality of Water Branch, of the Water Resources Division, U. S. Geological Survey.

CHEMICAL ANALYSES OF WATER

In some areas of the United States where water generally contains less than 100 ppm of dissolved solids, water containing 500 ppm might be considered saline. In North Dakota, however, relatively highly mineralized water is common.

In this report natural waters are arbitrarily classified as fresh or saline on the basis of their dissolved-solids content.

Because many of the available quality-of-water data do not show dissolved-solids concentrations, specific conductance was often used for classification. Fresh water is classified as that containing dissolved solids of less than 1,000 ppm or having a specific conductance of less than 1,400 micromhos at 25°C. Saline water is classified as follows:

Class	*Dissolved solids (ppm)*	*Specific conductance (micromhos at 25°C)*
Slightly saline	1,000 to 3,000	1,400 to 4,000
Moderately saline	3,000 to 10,000	4,000 to 14,000
Very saline	10,000 to 35,000	14,000 to 50,000
Briny	More than 35,000	More than 50,000

Tables of analyses of ground water include data from several sources (Abbott and Voedisch, 1938; Akin, 1952; Aronow, Dennis, and Akin, 1953; Dennis, 1947a, 1947b, 1947c, 1948a, and 1948b; Dennis and Akin, 1950; Dingman and Gordon, 1955; Filaseta, 1946; LaRocque, Swenson, and Greenman;[1] N. Dak. Geol. Survey, 1949–55; Simpson, 1929; and Tychsen, 1950). Therefore, the concentrations of any given constituent are not shown to the same number of significant figures in all analyses. Percent sodium, total hardness, and noncarbonate hardness were calculated if data were sufficient. The data from Abbott and Voedisch do not show the date of collection; however, these analyses probably represent samples collected during 1936–37.

Tables of analyses of surface waters show data for samples collected and analyzed by the U. S. Geological Survey during 1946–55.

Concentrations of the constituents are given in parts per million. One part per million is a unit weight of a constituent in a million unit weights of water.

Specific conductance, which is expressed in micromhos per centimeter at 25°C, is a measure of the ability of a solution to conduct an electrical current. It is approximately proportional to the content of dissolved solids. Most of the concentrations of dissolved solids shown in the tables of analyses represent the residue on evaporation at 180°C. They may include organic matter and water of hydration, and they are generally greater than the sum of the determined constituents. The sum is computed by adding the concentrations in parts per million of all the

---

[1] LaRocque, G. A., Jr., Swenson, H. A., and Greenman, D. W., Geology and ground-water resources of a part of the Souris River basin in North Dakota: U. S. Geol. Survey Ms. rept.

determined constituents except bicarbonate, which is divided by 2.03 before summation.

The ratio of sodium to the principal cations (calcium, magnesium, sodium, and potassium), expressed as a percentage, is referred to as "percent sodium"; all concentrations in the computation are expressed in equivalents per million. The following table shows factors for converting parts per million to equivalents per million.

Cation	*Factor*	*Anion*	*Factor*
Calcium	0.0499	Bicarbonate	0.0164
Magnesium	.0822	Carbonate	.0333
Sodium	.0435	Sulfate	.0208
Potassium	.0256	Chloride	.0282
		Fluoride	.0526
		Nitrate	.0161

A discussion of the significance of the dissolved constituents of water is not included in this report but may be found in many reports, including the current series of U. S. Geological Survey water-supply papers entitled "Quality of surface waters of the United States."

The locations of wells from which samples were collected are shown by means of numbers; the first number indicates the township, the second indicates the range, and the third indicates the section. (See fig. 1.) The lowercase letters that follow the section number indicate the location of the well within the section; the first letter indicates the quarter section, the second indicates the quarter-quarter section, and the third indicates the quarter-quarter-quarter section, or 10-acre tract. The letters are assigned in a counterclockwise direction and begin with "a" in the northeast quarter of the section or smaller subdivision. If more than one well is within the 10-acre tract, the well number for each is assigned an additional numeral.

Plate 1 is a base map of North Dakota which may be used to locate the wells or springs. Figure 2 is a map of North Dakota showing the number of analyses of saline ground water from each county and the sampling points on saline streams and lakes.

OCCURRENCE OF SALINE WATER

GROUND WATER

Ground water may become saline by six main processes: (1) being trapped with sediments at the time of deposition in sea

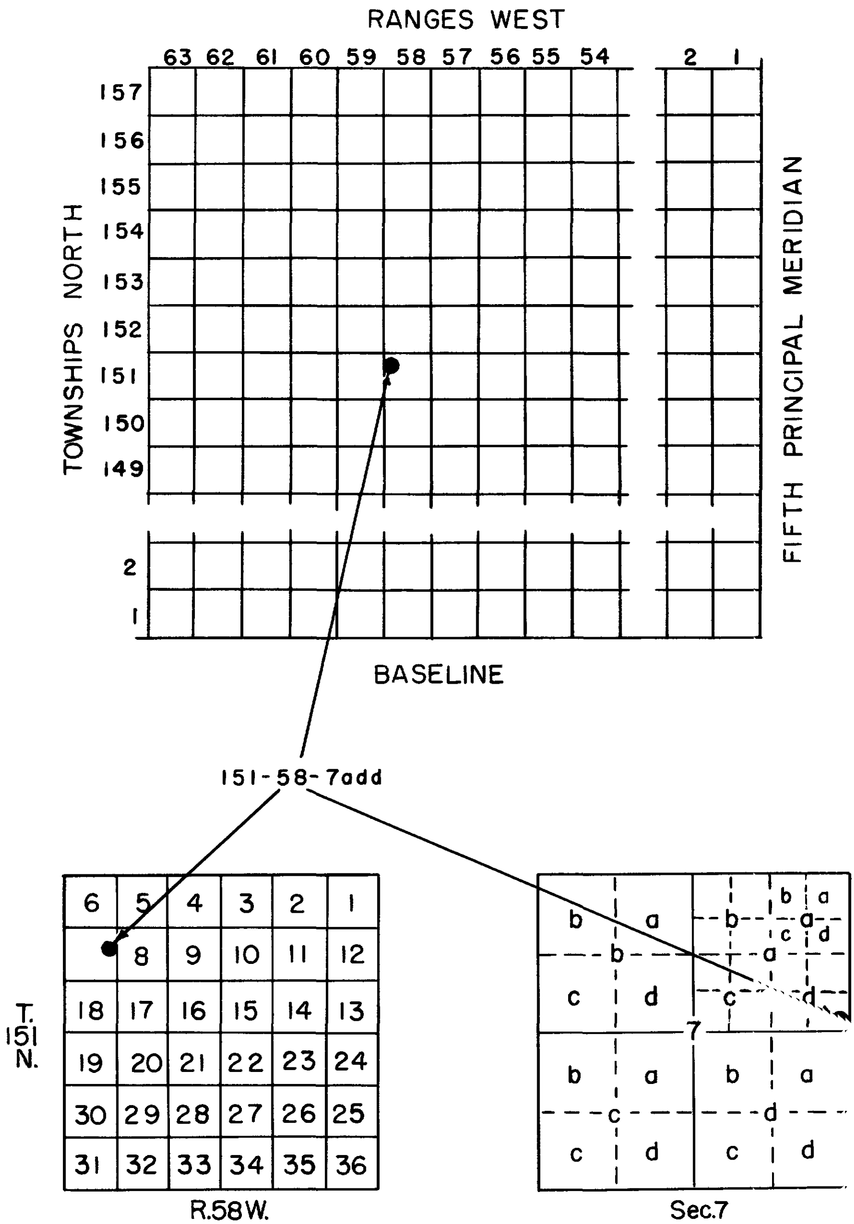


Figure 1. —Sketch illustrating well-numbering system.

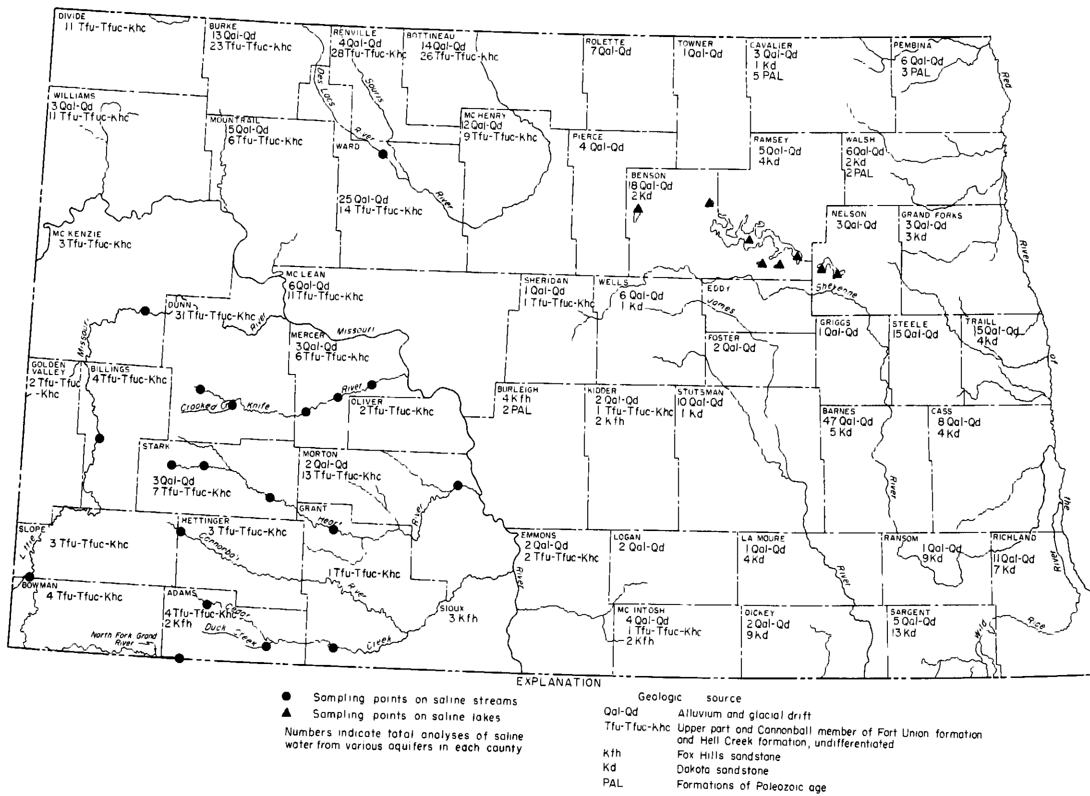


Figure 2. —Map of North Dakota showing distribution of saline-water analyses.

water or saline lakes (connate water), (2) hydrologic interconnection of aquifers containing fresh water with those containing saline water, (3) movement of saline water from a saline-water section of an aquifer to a fresh-water section of the same aquifer as a result of heavy withdrawal of fresh water, (4) solution of mineral constituents in the rocks, (5) seepage of water from saline surface-water bodies into aquifers, and (6) concentration as the result of transpiration by plants and evaporation. Only those processes that apply to North Dakota will be discussed.

In some formations, connate water has become more mineralized through natural processes so that the salinity is greater than that of modern sea water. Such water is found mainly when drilling for oil and gas.

Aquifers containing saline water and those containing fresh water may be connected by natural means, which include depositional contact, juxtaposition by faulting, or fracturing by folding or faulting, so that leakage develops. Water may move between aquifers through confining beds, which are never completely impermeable although they have a permeability lower than that of the aquifers.

Aquifers may be connected also by several artificial means. Wells that have been drilled through both saline-water and fresh-water aquifers and that have faulty construction, such as uncemented or corroded and leaky casings or no casings at all, may allow saline water to enter a fresh-water aquifer. A well may tap both a fresh-water aquifer containing water under a relatively high head and a saline-water aquifer containing water under a lower head; pumping such a well may lower the fresh-water head sufficiently to allow water from the saline-water aquifer to enter the fresh-water aquifer. Deep exploration holes for dams and building foundations or other test holes may be drilled through a confining bed and cause leakage from an artesian aquifer containing saline water into an aquifer containing less mineralized water.

Ground water may become saline by solution of mineral constituents in the rocks. Solution takes place as the water percolates downward from the surface and also in the zone of saturation. The total content of dissolved solids in the water is dependent on many factors, such as the solubility of the rocks, the length of time the water is in contact with the rocks, the temperature of the water, and the distance the water travels in the aquifer. If mineralized water comes in contact with ion-exchange minerals in the aquifer, the chemical character of the water may be changed; for example, calcium and magnesium ions, when adsorbed on zeolites, may be replaced by sodium ions.

SURFACE WATER

Surface water may become saline by effluent seepage of mineralized ground water, solution of mineral matter by surface runoff, concentration by transpiration and evaporation, and disposal of mineralized wastes into streams.

The salinity of streams and lakes may be due to any combination of the above factors. In western North Dakota those streams that are saline only at base flow probably owe their salinity primarily to seepage of mineralized ground water. In central and eastern North Dakota, uncapped flowing wells may introduce saline water into streams and lakes.

GENERAL GEOLOGY

North Dakota includes sections of three physiographic regions of the Interior Plains of the United States. (See pl. 1.) These are the Red River Valley, the Drift Prairie, and the Missouri Plateau (Simpson, 1929, p. 4).

The Red River Valley in the eastern part of the State is underlain by sand, silt, and clay that were deposited in glacial Lake Agassiz. These lacustrine deposits rest upon older glacial drift and are bounded by beaches that mark the successive levels of the lake. The drift of Wisconsin age or older rests unconformably on rocks of Paleozoic and, in places, Mesozoic age, which have a gentle dip to the west into the Williston Basin. The rocks of Paleozoic age in turn rest unconformably on the Precambrian complex of igneous and metamorphic rocks. In Grand Forks County the Precambrian rocks are 500 to 900 feet below the land surface.

The Drift Prairie west of the Red River Valley contains surficial deposits of glacial drift that are continuations of the drift underlying the Lake Agassiz basin. The western boundary of the Drift Prairie is a line east of and approximately parallel to the Missouri River. (See pl. 1.) The Drift Prairie is a region of rolling uplands interspersed with areas of ground moraine and glacial outwash. The most prominent physiographic feature is the Turtle Mountains. Several glacial-lake basins occupy depressions in the drift, notably the basins of glacial Lake Souris in the north-central section of the State and glacial Lake Dakota in the James River valley near the southern boundary of the State.

Sedimentary rocks of Cretaceous age directly underlie the glacial drift in most parts of the Drift Prairie. The Pierre shale, about 900 feet thick, is the most widely distributed subdrift formation of Cretaceous age in this region. Below the rocks of the Cretaceous system lie older rocks of Mesozoic, Paleozoic, and Precambrian age. (See fig. 3.)

The Missouri Plateau is south and west of the Drift Prairie. A thin veneer of glacial drift mantles the bedrock at the north edge of the Missouri Plateau and ends at the Altamont moraine, which marks the maximum extent of Wisconsin glaciation in North Dakota.

South and west of the Altamont moraine, sedimentary rocks of Late Cretaceous and Tertiary age form the surficial deposits, except in a few places where there is a thin cover of glacial drift older than Wisconsin. The topography of the Missouri Plateau is more rugged than that of the Drift Prairie; large and small buttes form the drainage divides, and in the western counties badlands have formed in the Fort Union formation.

Older rocks of Mesozoic and Paleozoic age overlie Precambrian rocks in the Williston Basin. The center of the basin is in McKenzie County and the sedimentary rocks, which dip into the basin, have only slight structural irregularities (Kunkel, 1954).

AQUIFERS YIELDING SALINE WATER

Many of the formations shown in figure 3 are capable of yielding only very small supplies of water. The Pierre shale, for example, yields only meager amounts of saline water to many wells in the eastern part of the State. In this report only those aquifers capable of yielding more than 50 gpm to individual wells will be described. (See table 1.) Yields of 50 to 150 gpm are considered small; 150 to 350 gpm, moderate; and more than 350 gpm, large.

The chemical characteristics of saline water from various formations and from the glacial drift and alluvium are shown on figures 4 and 5 by means of patterns similar to those proposed by Stiff (1951). The patterns are scaled in equivalents per million of the ions and are useful in comparing different types of water. Figures 4 and 5 show that each major aquifer may yield several types of saline water.

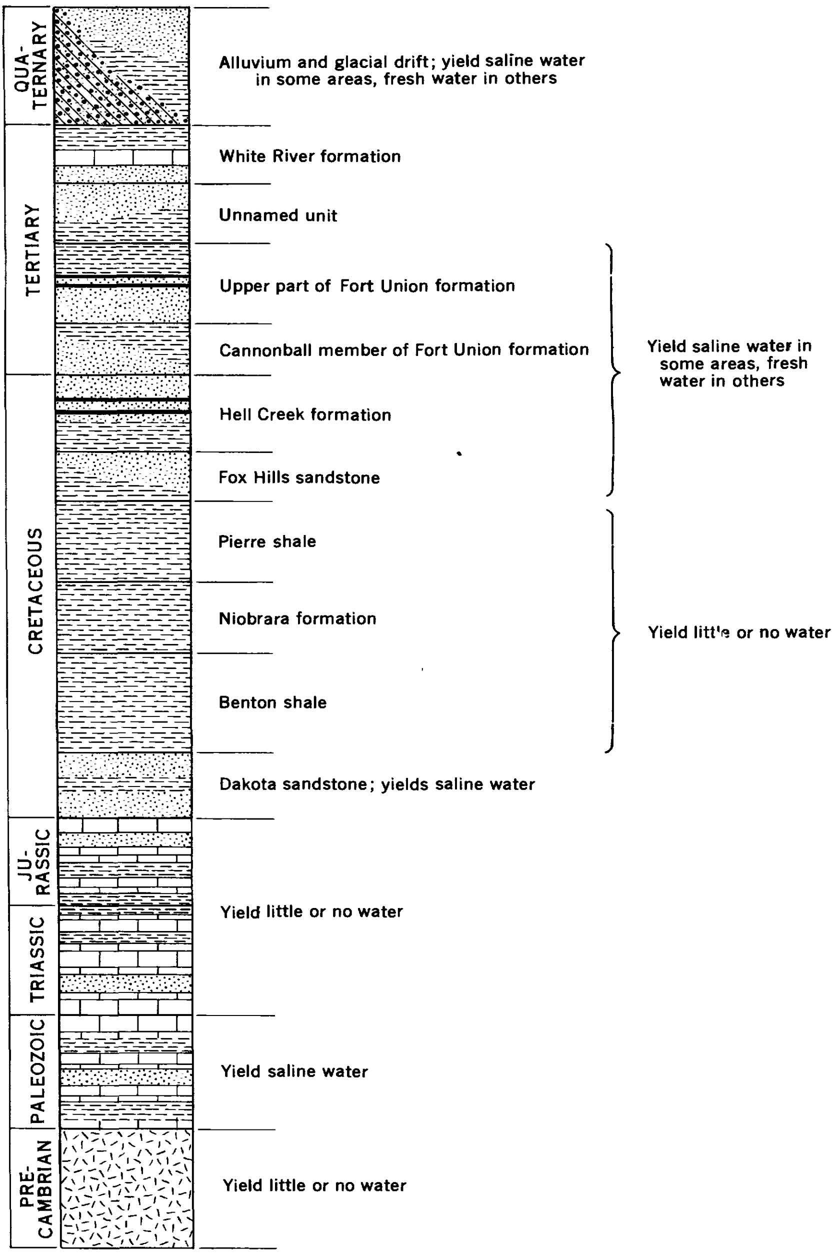


Figure 3. —Generalized stratigraphic section of North Dakota showing saline-water aquifers. Not drawn to scale.

Table 1.—*Description of aquifers of which some parts are capable of yielding 50 gpm or more of saline water to individual wells*

Era	System	Formation	Character of rocks	Saline water supply
Cenozoic	Quaternary	Alluvium and glacial drift	Recent: Alluvium; gravel, sand, silt, and clay. Pleistocene: Till, glacial outwash, and glacio-lacustrine deposits.	Extremely variable in quantity and quality.
	Tertiary	Upper part of Fort Union formation	Sandstone, shale, and lignite.	Small to moderate supplies in some areas.
		Cannonball member of Fort Union formation	Marine sandstone and sandy shale.	
Mesozoic	Cretaceous	Hell Creek formation	Sandstone and shale.	
		Fox Hills sandstone	Sandstone.	Small quantities. Fresh water in some areas.
		Dakota sandstone	Sandstone and shale.	Moderate to large supplies. Artesian flows in some areas.
Paleozoic			Shale, sandstone, limestone, and dolomite.	Small to large supplies in eastern North Dakota.

AQUIFERS OF PALEOZOIC AGE

Formations of Paleozoic age underlie nearly all of North Dakota (see fig. 6) but do not crop out at the surface. The top of the formations lies about 6,000 feet below the land surface in the western part of the State but less than 500 feet below in the eastern part. The formations become thinner and both structurally and topographically higher toward the east; some, and in places perhaps all, are absent in the Red River Valley. Figure 6 indicates by contours on the Dakota sandstone of Cretaceous age the general structure of the rocks of Paleozoic age.

Because the formations are deeply buried, they were penetrated by few wells and were not defined in detail until extensive oil exploration began in the Williston Basin in 1951. Since that time lithologic logs of oil wells and drill-stem tests have provided information about the rock types and about the quality of the water.

Simpson (1929, p. 42) reports saline water from sandstones of Paleozoic age in Pembina and Walsh Counties. Very saline water and brine have been reported from drill-stem tests, mainly in the western part of the State, but data on the quantity of the water are lacking.

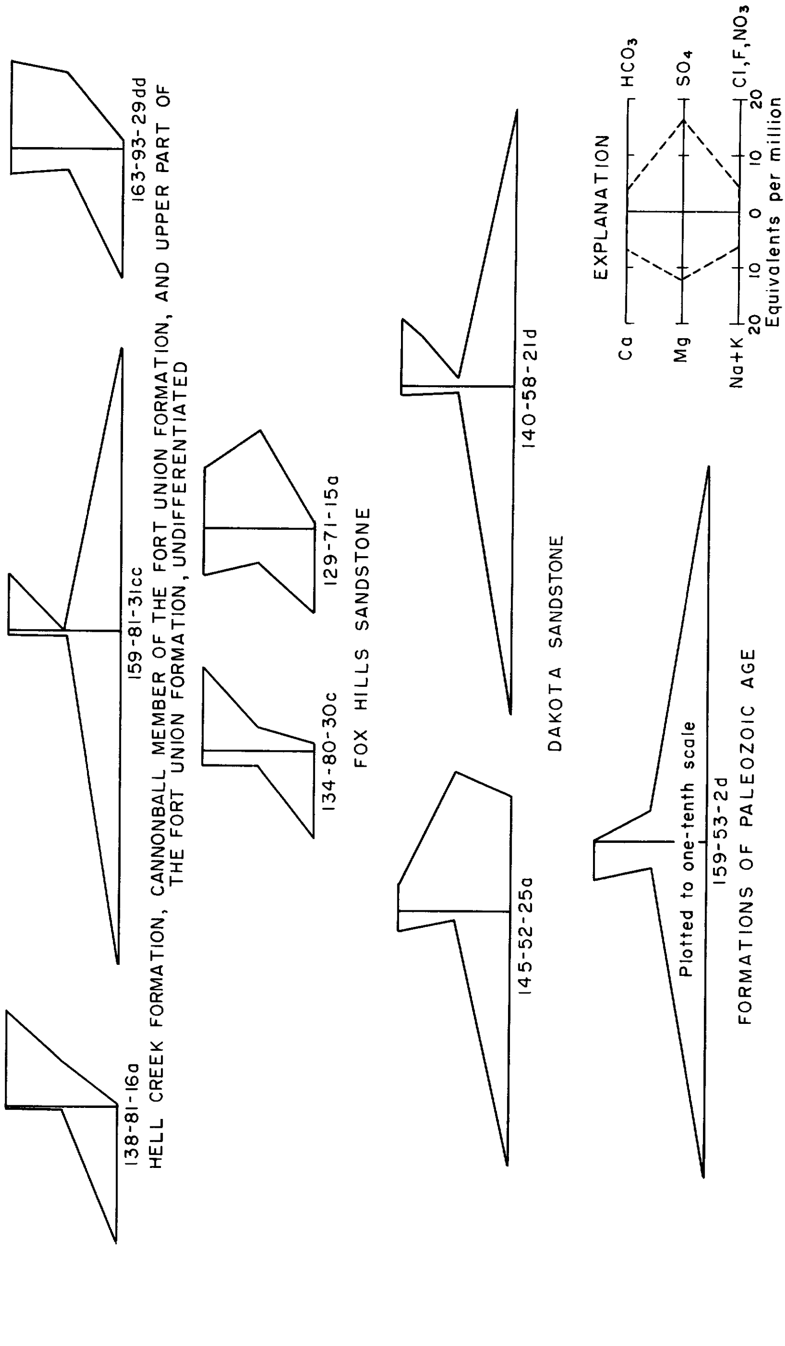


Figure 4.—Chemical characteristics of saline water from consolidated rocks.

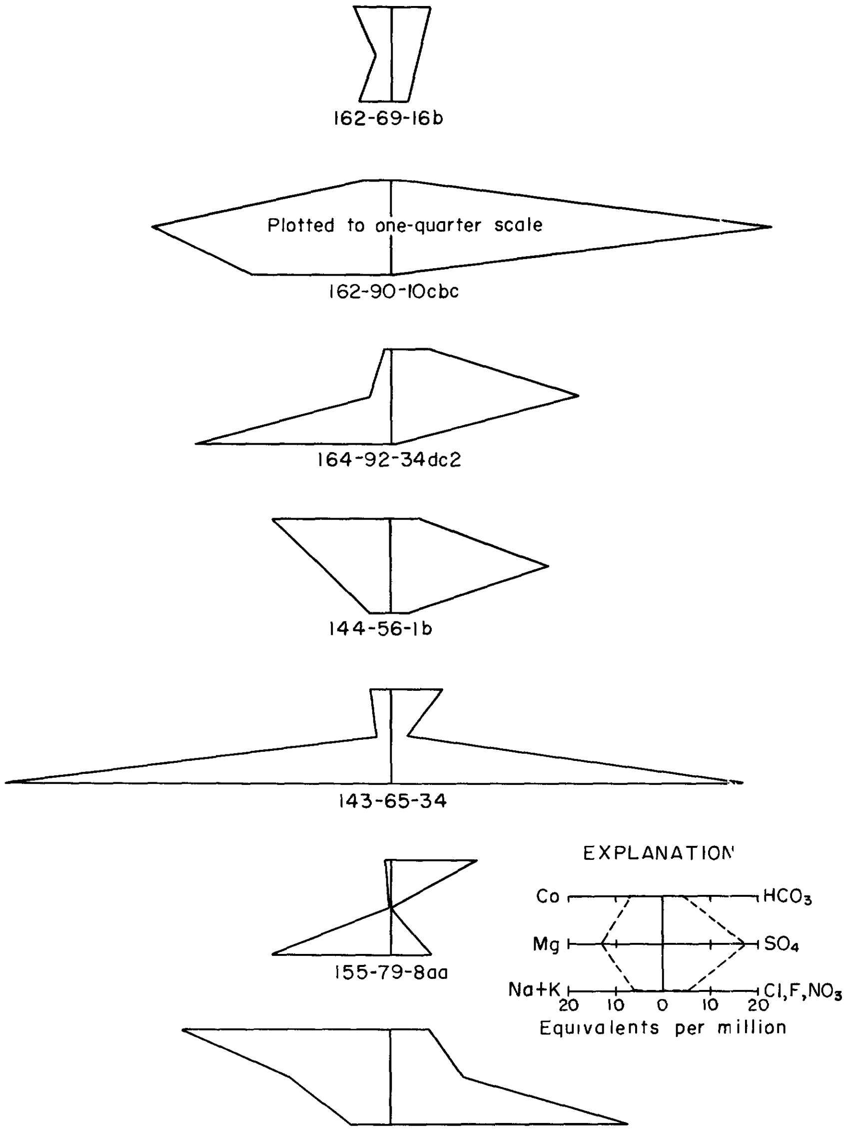


Figure 5.—Chemical characteristics of saline water from glacial drift and alluvium.

461397 O - 58 - 2

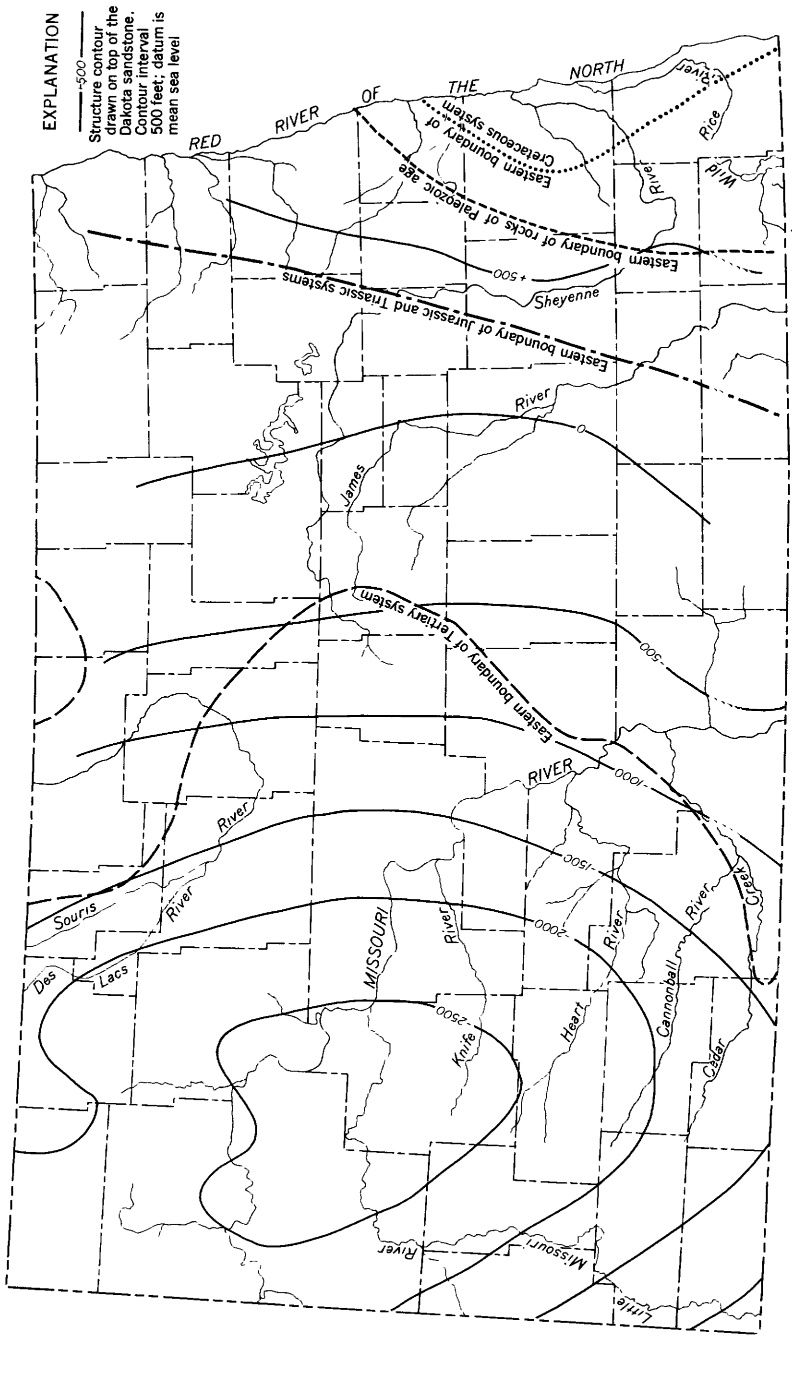


Figure 6. —Map of North Dakota showing structure contours on the top of the Dakota sandstone and extent of geologic systems (modified after Laird and Towse, 1953).

Chemical analyses of saline water from aquifers of Paleozoic age are shown in table 2. Wells 248 to 320 feet deep and 915 feet deep in Walsh County produce moderately saline water, but wells in Pembina, Burleigh, and Cavalier Counties produce brine. Sodium chloride constitutes about 80 percent of the dissolved solids in saline water from these aquifers. The chemical characteristics of water from aquifers of Paleozoic age are compared with those from other sources in figures 4 and 5. Water from well 159-53-2d was analyzed in 1921 and again in 1954. The change in quality during this 34-year period was insignificant.

Brine from aquifers of Paleozoic age can be used only for cooling, fire protection, or nonconsumptive uses unless an economical treatment or conversion technique is developed. At Grand Forks, in Grand Forks County, wells drilled to aquifers of Paleozoic age produce up to 400 gpm of very saline water, which is used for air conditioning.

AQUIFERS OF MESOZOIC AND CENOZOIC AGE

Cretaceous rocks are the most important aquifers of Mesozoic age in North Dakota because rocks of Triassic and Jurassic age are deeply buried and are not known to yield water.

In the major part of the drift-covered area of North Dakota the drift is directly underlain by formations of Cretaceous age. These formations are important aquifers in that part of the drift-covered area where the water from the drift is unsatisfactory in quality or quantity or both.

Saline-water supplies from the Hell Creek formation of Mesozoic age and the Fort Union formation of Cenozoic age are undifferentiated in this report. Although in most of the western part of the State the upper part of the Fort Union formation, which includes the Tongue River and Ludlow members, can be differentiated lithologically from the Cannonball member of the Fort Union formation, the information on available well logs was insufficient to differentiate them for this report.

Alluvium and glacial drift are the most important aquifers of Cenozoic age in the State.

DAKOTA SANDSTONE

The oldest aquifer of Cretaceous age that yields saline water is the Dakota sandstone, which includes a sandstone unit at the base,

Table 2.— *Chemical analyses of saline ground water*

[Source of data: a, U. S. Geological Survey; b, North Dakota Geological Survey

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
										Formations of
			1952							
140-80-18ccc[1]	Burleigh.	8,115	Nov. 10..	....	....	....	1,558	175	8,406	....
140-80-18ccc[2]	...do.....	8,115	...do......	....	....	....	2,830	487	52,012	....
			1921							
157-53.........	Walsh....	915	Apr. 25..	44	24	....	44	22	1,640	
159-53-2d	Pembina.	450	...do......	....	9.4	6.6	1,385	556	13,450	327
			1954							
159-53-2d.....	...do.....	450	Oct. 26..	42	7.4	17	1,320	535	13,600	268
			1921							
162-53-35d...	...do.....	1,560	Apr. 23..	47	10	10	1,285	517	8,970	177
										Formations of
			1951							
157-53[3]........	Walsh....	248-320	May 23..	....	11	0.78	49	28	1,760	18
										Formations of
			1951							
162-64-26bc[4].	Cavalier.	3,380	Sept. 20..	....	....	....	38	....	....	....
162-64-26bc[5].	...do.....	3,380	...do......	....	....	....	15	....	....	....
162-64-26bc[6].	...do.....	3,380	...do......	....	....	....	1,825	1,125	....	....
162-64-26bc[7].	...do.....	3,380	...do......	....	....	....	3,333	2,013	....	....
162-64-26bc[8].	...do.....	3,380	...do......	....	....	....	2,821	1,756	....	....

1 From top of drill stem test.
2 From middle and bottom of drill stem test.
3 Composite sample of water from several wells.
4 Top fluid, drill stem test 1.

a middle unit of shale, and a sandstone unit at the top. The Dakota sandstone as used in this report may include the Fuson shale and Lakota sandstone or their equivalents. Thus, the Dakota is used in a broad sense as Simpson used it in 1929.

The lower sandstone unit is ferruginous; in some places, however, it is white and micaceous. It yields saline water under artesian head and is sometimes referred to as the "second artesian flow" by well drillers. The shale unit acts as the lower confining bed of the upper unit of sandstone. The upper sandstone unit is similar in lithology to the lower sandstone unit and yields the "first artesian flow." The total thickness of the Dakota sandstone ranges from 150 to 450 feet.

from formations of Paleozoic age, North Dakota

(Circ. 33 and 57). Analytical results in parts per million except as indicated]

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
							Calcium, magnesium	Noncarbonate				
Ordovician age												
1,295	......	2,872	12,800	......	......	......	4,610	3,550	80	......	7.9	b
120	......	2,773	84,500	......	......	......	9,060	8,960	93	......	7.15	b
881	0	605	1,720	......	9.0	4,560	200	0	95	......	......	a
223	0	2,557	23,370	......	......	42,345	5,740	5,560	83	......	......	a
201	0	2,470	23,300	1.6	......	44,300	5,490	5,330	84	57,400	7.0	a
174	0	3,714	15,050	......	4.0	30,290	5,330	5,190	78	......	......	a
Silurian age(?)												
867	0	618	1,940	2.8	18	4,880	238	0	94	7,980	7.5	a
Devonian age												
156	52	969	473	......	......	......	......	......	......	......	......	b
164	65	996	489	......	......	......	......	......	......	......	......	b
116	......	2,044	19,311	......	......	......	9,180	9,090	......	......	......	b
918	......	1,127	40,551	......	......	......	16,600	15,800	......	......	......	b
75	......	2,396	34,748	......	......	......	14,300	14,200	......	......	......	b

[5] Bottom fluid, drill stem test 1.
[6] Top fluid, drill stem test 2.
[7] Middle fluid, drill stem test 2.
[8] Bottom fluid, drill stem test 2.

The Dakota sandstone supplies flowing wells in a large area in southeastern and central North Dakota (Simpson, 1929, pl. 1). The area of flowing wells has been considerably reduced in size, and the artesian pressure of the water has been reduced, as the result of the discharge of many flowing wells. Many wells that at one time flowed at high pressure now flow under reduced pressure or do not flow at all and have to be pumped.

The quality of saline water from the Dakota sandstone is represented by 69 analyses in table 3. Generally, in the southeastern part of the State, the water is slightly saline; however, north of about T. 144 N., the water is moderately saline. A well (151-50-15b) near Grand Forks produces very saline water, as does a well (161-60-23) at Langdon.

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone, North Dakota.*

[Source of data: a, U. S. Geological Survey; b, North Dakota Geological Survey; c, North Dakota State Health Department or State Laboratories Department. Analytical results in parts per million except as indicated]

Location	County	Depth of well (feet)	Date of collection	Source of data	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
129-59-7	Dickey	980	...	b	14	0.4	18	28	875	...
129-63-12	do	1,080	...	b	28	.5	29	9.8	993	...
			1921							
129-63-12c	do	1,087	June 28	a	19	2.0	30	13	990	
129-63-12c	do	1,385	do	a	17	2.3	204	64	320	
129-65-35	do	1,100	...	b	21	1.4	18	24	837	...
			1951							
130-47-20dbc1	Richland	231	Aug. 23	c	...	.3	15	10	550	
			1952							
130-48-1ddc	do	270	May 22	c	...	.8	26	11	410	
130-52-13	do	360	...	b	25	.4	20	10	1,070	
			1921							
130-52-13a	do	960	June 27	a	9.2	.30	17	6.5	1,046	
130-54-19	Sargent	665	...	b	8	.1	202	69	574	...
130-56-1	do	840	...	b	19	.9	24	20	858	
130-56-1	do	900	...	b	7.0	1.4	58	38	827	...
130-56-1	do	785	...	b	16	.4	21	11	910	...
130-56-1	do	700	...	b	7.0	2.8	23	9.2	930	...
130-56-1a	do	840	June 28	a	16	.40	19	6.5	861	
130-56-1a	do	940	do	a	14	.16	16	6.3	864	
130-57-2	do	1,000	...	b	19	.05	26	7.9	815	...
130-57-2	do	900	...	b	23	.5	24	7.4	834	...
130-57-2a	do	1,060	June 28	a	9.6	.07	24	7.8	800	
			1952							
131-48-36ccb	Richland	280	May 22	c	...	1.6	37	16	1,170	
131-54-30	Sargent	630	...	b	27	.8	116	61	691	...

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone, North Dakota*—Continued

Location	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium
								Calcium, magnesium	Noncarbonate	
129-59-7	486	.....	537	781	3.6	1.3	2,568	124	0	92
129-63-12	591	.....	435	939	3.2	6.2	2,777	114	0	95
129-63-12c	495	0	236	1,150	.....	.....	2,700	128	0	94
129-63-12c	171	0	1,200	70	.....	.....	2,079	772	632	47
129-65-35	810	.....	177	781	1.8	26	2,377	154	0	93
130-47-20dbc1	400	0	360	390	1.3	43	1,570	80	0	94
130-48-1ddc	450	0	300	230	.5	4	1,200	110	0	89
130-52-13	466	.....	1,248	502	7.5	11	3,152	92	0	96
130-52-13a	498	0	1,235	482	.....	.....	3,140	69	0	97
130-54-19	371	.....	1,144	371	7.3	6.2	2,647	795	491	61
130-56-1	420	.....	981	449	5.0	5.7	2,571	150	0	93
130-56-1	239	.....	1,080	555	4.4	6.6	2,823	321	125	86
130-56-1	367	.....	1,015	485	5.0	27	2,652	100	0	95
130-56-1	385	.....	1,170	398	6.0	6.6	2,790	113	0	95
130-56-1a	390	0	954	456	.....	4.0	2,568	74	0	96
130-56-1a	415	0	932	464	.....	2.9	2,559	66	0	97
130-57-2	315	.....	1,162	293	4.0	4.4	2,502	115	0	95
130-57-2	327	.....	1,128	328	3.8	9.7	2,523	108	0	95
130-57-2a	256	24	1,146	292	.....	.....	2,471	92	0	95
131-48-36ccb	250	22	920	1,080	1.0	9	3,380	160	0	94
131-54-30	361	.....	1,173	368	6.5	3.5	2,696	553	257	74

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone. North Dakota*—Continued

Location	County	Depth of well (feet)	Date of collection	Source of data	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
131-58-17c	Sargent	1,120	June 19	a	16	1.1	36	11	1,130	
131-59-8c	Dickey	1,145	do	a	19	2.4	68	19	1,345	
131-60-18d	do	950	do	a	16	.47	17	4.6	928	
131-62-15	do	1,180		b	23	3.0	37	4.4	1,029	...
131-63-8d	do	1,230	June 29	a	23	3.2	30	14	954	
132-47-8d	Richland	283	June 27	a	17	.48	6.8	4.1	394	
132-51-6	do	545		b	5.0	.1	16	8.3	915	...
132-54-9	Sargent	665		b	1	.7	32	15	898	...
133-59-2	LaMoure	1,100		b	15	.3	26	16	717	...
133-59-2b	do	1,100	June 29	a	17	1.4	23	4.6	836	
133-60-6b	do	1,440	do	a	18	1.4	120	34	495	
133-60-6b	do	875	do	a	16	1.1	56	19	635	
134-56-11	Ransom	890		b	5.0	.3	36	7.6	910	...
134-56-11	do	920		b	5.0	.7	34	9.2	908	...
134-56-11	do	751		b	6.0	.2	30	7.6	889	...
134-56-11	do	911		b	18	2.2	43	12	858	...
134-56-12c	do	785	June 29	a	10	.30	26	6.1	890	
134-57-23	do	1,200		b	6.0	0	7.0	1.3	904	...
136-54-17	do	624		b	17	1.3	134	56	661	...
136-54-17d	do	633	June 29	a	16	.80	132	35	702	
136-55-3(?)	do	613	June 24	a	23	4.8	136	35	960	
137-57-13	Barnes	1,350		b	22	2.4	181	76	683	...
137-60-25	do	1,300		b	20	3.0	185	74	541	...
138-58-24	do	1,100		b	12	1.0	45	22	1,007	...
138-58-24	do	1,100		b	34	.7	62	45	853	...
140-52-35	Cass	297½		b	13	.4	12	1.3	964	...
140-52-35	do	300		b	26	.6	49	11	367	...
140-52-35a	do	430	July 1	a	12	.48	12	7.3	938	
140-58-21d	Barnes	985	June 13	a	28	.20	29	13	1,361	
140-64-28d	Stutsman	1,487	June 14	a	19	1.5	57	23	707	

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone, North Dakota*—Continued

Location	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium
131-58-17c	344	0	1,666	430	....	4.4	3,542	135	0	95
131-59-8c	285	0	1,989	608	....	....	4,313	248	15	92
131-60-18d	476	0	560	812	....	....	2,618	61	0	97
131-62-15	566	....	231	1,160	2.4	22	2,748	126	0	95
131-63-8d	720	0	95	1,075	....	....	2,588	132	0	94
132-47-8d	739	0	147	102	....	5.3	1,056	34	0	96
132-51-6	302	....	1,178	412	6.5	2.2	2,646	78	0	96
132-54-9	310	....	1,214	405	4	4.4	2,613	151	0	93
133-59-2	317	....	1,136	172	.8	2.2	2,295	130	0	92
133-59-2b	364	0	1,073	366	....	....	2,552	76	0	96
133-60-6b	171	0	1,164	94	....	7.7	2,071	439	299	71
133-60-6b	242	0	1,074	194	....	....	2,151	218	20	86
134-56-11	271	....	1,316	357	2.8	2.7	2,786	168	0	94
134-56-11	273	....	1,318	352	3.2	.7	2.798	126	0	94
134-56-11	278	....	1,264	355	3.8	.4	2,753	120	0	95
134-56-11	271	....	1,298	322	3.0	.7	2,777	169	0	92
134-56-12c	278	0	1,184	390	....	2.0	2,663	90	0	96
134-57-23	261	....	1,137	379	3.2	.71	2,598	23	0	99
136-54-17	225	....	1,263	355	2.0	11	2,669	572	387	72
136-54-17d	195	0	1,254	372	....	4.5	2,671	474	314	76
136-55-3(?)	249	0	1,263	734	....	7.5	3,448	484	280	81
137-57-13	219	....	1,356	468	1.6	8.8	2,995	778	598	66
137-60-25	207	....	1,315	280	1.4	22	2,640	779	609	61
138-58-24	394	....	471	1,115	2.8	44	2,964	240	0	92
138-58-24	342	....	646	861	3.4	26	2,703	342	62	35
140-52-35	351	....	1,086	487	5.0	3.5	2,770	35	0	98
140-52-35	380	....	288	250	1.0	.18	1,143	171	0	33
140-52-35a	344	0	1,091	492	....	9.5	2,767	60	0	97
140-58-21d	727	0	64	1,740	....	....	3,584	126	0	96
140-64-28d	378	0	1,048	276	....	....	2,372	237	0	87

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone, North Dakota*—Continued

Location	County	Depth of well (feet)	Date of collection	Source of data	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
141-52-23	Cass	300		b	35	0.8	82	50	625	
145-52-25a	Traill	394	July 1	a	15	1.2	72	18	1,042	
146-52-6a	do	365	July 18	a	14	2.2	177	70	867	
146-53-1	do	427		b	25	6	246	71	875	
147-53-35	do	457		b	76	.8	222	96	874	
149-50-31	Grand Forks	300		b	28	1.9	158	89	966	
150-72-31c	Wells	2,235	June 12	a	33	3.2	5.6	2.4	1,248	
151-50-15b	Grand Forks	322	July 18	a	16	7.2	736	164	2,670	
151-50-22a	do	135	July 18	a	30	9.9	402	149	1,440	
154-64-34	Ramsey	1,514	May 4	a	15		13	9.1	1,390	
154-64-34	do	1,514		b	19	.2	29	12	1,357	
			1950							
154-64-34dcc3	do	1,496	Nov. 13[1]	a	13		12	5.0	1,370	7.0
			1952							
154-64-34dcc4	do	1,500	June 14[2]	a	14		8.0	7.3	1,400	7.0
156-68-31	Benson	1,670		b	19	1.4	44	14	1,484	
			1921							
156-68-31a	do	2,100	May 14	a	14	.12	27	12	1,545	
157-53-13a	Walsh	312	Apr. 26	a	7.6	.70	43	26	1,710	28
157-55-28d	do	494	Apr. 29	a	14	.50	29	17	1,637	
161-60-23	Cavalier	1,100		b	36	.4	545	296	6,205	

Table 3.—*Chemical analyses of saline ground water from the Dakota sandstone, North Dakota*—Continued

Location	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium
								Calcium, magnesium	Noncarbonate	
141-52-23	327	....	920	393	2.2	11	2,364	437	169	77
145-52-25a	276	0	1,200	734	....	....	3,262	254	28	90
146-52-6a	254	0	1,227	790	....	15	3,369	730	522	72
146-53-1	224	....	1,410	822	1	11	3,703	918	734	68
147-53-35	217	....	1,426	839	1.2	16	3,857	959	781	67
149-50-31	312	....	1,250	912	1.2	22	3,665	766	510	73
150-72-31c	1,025	48	764	710	....	....	3,400	24	0	99
151-50-15b	90	0	2,158	4,240	....	....	10,484	2,512	2,438	70
151-50-22a	207	0	1,211	2,350	....	....	5,786	1,616	1,446	66
154-64-34	825	22	1,091	885	....	....	3,835	70	0	98
154-64-34	872	....	1,054	888	4.0	1.5	3,860	125	0	96
154-64-34dcc3	844	12	1,050	880	6.0	1.4	3,900	51	0	98
154-64-34dcc4	749	41	1,130	878	5.0	1.4	3,920	50	0	98
156-68-31	867	....	1,262	950	3.6	31	4,291	173	0	95
156-68-31a	878	0	1,251	1,046	....	....	4,310	117	0	97
157-53-13a	900	0	603	1,882	....	....	4,799	227	0	94
157-55-28d	866	0	988	1,420	....	....	4,575	142	0	96
161-60-23	240	....	1,688	9,958	2.4	.2	19,438	2,579	2,382	84

[1]Specific conductance (micromhos at 25°C), 6,000; boron, 5.6 ppm; pH, 8.2.
[2]Specific conductance (micromhos at 25°C), 6,100; boron, 4.5 ppm; pH, 8.5.

Sodium sulfate and sodium chloride are the major salts in solution. (See fig. 4.) Hardness exceeded 200 ppm in about half the samples and was greater than 500 ppm in 13 samples. Because of excessive concentrations of fluoride, iron, and dissolved solids, the water is undesirable for domestic use, although it is used where water of better quality is not available. Water from the Dakota sandstone is unsuitable for irrigation because of high sodium and dissolved-solids concentrations; furthermore, in few places would the supply be adequate in quantity for irrigation.

FOX HILLS SANDSTONE

The Fox Hills sandstone directly overlies the Pierre shale throughout the Missouri Plateau and in places in the Drift Prairie. In the Missouri Plateau it is between 180 and 320 feet in thickness, but in the Drift Prairie it is partly eroded or absent.

Fresh water is obtained from the Fox Hills sandstone at several places, including Hettinger in Adams County, Bowman and Scranton in Bowman County, and Lemmon, S. Dak. Small supplies of saline water are found in Adams, Burleigh, Kidder, McIntosh, and Sioux Counties.

Water from the Fox Hills sandstone is primarily of the sodium bicarbonate type. (See fig. 4.) Twelve analyses of saline water in table 4 show that the water is only slightly saline; the average dissolved-solids content is about 1,500 ppm. Generally, the water in Adams, Burleigh, and Sioux Counties is soft; and, although fluoride concentrations are high, it is used for domestic and municipal

Table 4.—*Chemical analyses of saline ground water*

[Source of data: a, U. S. Geological Survey; b, North Dakota Geological Survey; c, North per million except

Location	County	Depth of well (feet)	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921						
129-71-10	McIntosh	130	...	44	1.1	108	48	409	...
129-71-15a	do	146	June 20	37	.80	163	76	346	
129-96-13	Adams	1,152	...	15	0	2.4	4.5	423	...
129-96-13bbb	do	1,150	...	...	.7	...	...	418	1.8
134-80-30c	Sioux	67	June 27	17	.63	8.0	2.6	520	
134-80-30c	do	65	do	21	...	12	4.6	580	
134-80-30c	do	65	do	16	.20	46	32	350	
138-80-4b	Burleigh	75	June 16	17	.15	15	2.4	540	
139-73-17d	Kidder	120	June 15	46	.72	150	62	101	
139-73-17d	do	110	do	45	...	193	65	55	
139-77-28c	Burleigh	125	do	19	4.0	476	814	2,362	
139-80	do	200	June 16	13	...	7.4	2.3	659	
139-80	do	400	do	37	.27	9.6	2.8	951	

supplies. Farther east, in McIntosh and Kidder Counties, saline water from the Fox Hills sandstone is harder and has a lower percent sodium and thus is more suitable for irrigation.

Well 139-77-28c produces a very saline water of the sodium sulfate type. The well is in a poorly drained area, and the high salinity of the water may be a result of concentration by evaporation (Simpson, 1929, p. 96).

HELL CREEK FORMATION AND FORT UNION FORMATION, UNDIFFERENTIATED

The Hell Creek formation and the Cannonball member and the upper part of the Fort Union formation crop out in a major part of the Missouri Plateau in North Dakota. The Tongue River member, which together with the Ludlow member constitutes the upper part of the Fort Union formation, is widely distributed in the plateau uplands; but the stratigraphically lower Hell Creek formation and Cannonball member of the Fort Union crop out only in the banks of the Missouri River and its tributaries south of Washburn and in the Little Missouri River basin in the southwestern corner of the State.

These aquifers are discussed together because of the difficulty in differentiating between them by means of well logs. Because of lateral discontinuity of the beds and pinchouts of aquifers between confining beds of shale, the aquifers may be dewatered or water levels lowered by heavy or prolonged pumping.

Chemical analyses of saline water from these aquifers are given in table 5. Generally, the water is only slightly saline.

from the Fox Hills sandstone, North Dakota

Dakota State Health Department or State Laboratories Department. Analytical results in parts as indicated]

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	pH	Source of data
597	....	702	94	0.8	4.9	1,700	469	0	66	.....	b
671	0	848	16	....	3.0	1,905	732	182	51	.....	a
894	....	24	128	3.2	.3	1,070	28	0	97	.....	b
368	57	45	130	3.5	6	1,096	90	0	91	8.7	c
1,039	0	227	60	....	10	1,367	31	0	97	.....	a
1,078	0	346	47	....	7.4	1,539	49	0	96	.....	a
903	0	200	45	....	24	1,168	246	0	76	.....	a
1,015	0	323	64	....	3.0	1,509	47	0	96	.....	a
561	0	366	6.0	....	....	1,038	629	169	26	.....	a
554	0	389	4.0	....	.33	1,059	749	295	14	.....	a
1,188	0	7,838	386	....	7.2	13,807	4,530	3,560	53	.....	a
1,035	0	491	66	....	1.7	1,776	28	0	98	.....	a
1,174	0	5.9	824	....	....	2,441	35	0	98	.....	a

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, und'fferentiated,*

[Source of data: a, U. S. Geological Survey; b, North Dakota Geological

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
129-94-29	Adams	18	....	....	16	0.30	188	170	310	....
129-94-29	....do	120	....	....	10	.80	47	32	913	....
130-74-31	Emmons	120	....	....	27	.8	162	51	297	....
130-97-23	Adams	53	....	....	18	.30	93	145	256	....
130-98-4	....do	72	....	....	8.0	6.0	160	103	120	....
131-99-33	Bowman	75	....	....	9	6.0	72	55	232	....
131-100-26	....do	98	....	....	6	0	30	.65	453	....
131-102-11	....do	1,042	....	....	4	0	3.3	4.1	359	....
132-69-6	McIntosh	254	....	....	42	.7	144	35	204	....
132-104-27	Bowman	25	....	....	6	1.1	112	85	215	....
133-105-31	Slope	200	1921 July 22	....	17	.69	9.6	3.3	570	
133-106-31	....do	185	....	....	2	.1	10	4.8	584	....
134-84-4	Morton	200	....	....	21	.5	30	33	420	....
134-90-35	Grant	431	....	....	23	.02	7.8	8.2	640	....
134-93-35	Hettinger	378	....	....	17	0	5.1	2.8	502	....
134-93-35c	....do	177	June 28	....	14	.80	7.6	4.3	430	
135-76-30	Emmons	185	....	....	25	.3	16	12	400	....
135-97-4	Hettinger	78	....	....	12	.5	63	9.0	311	....
135-101-26	Slope	265	....	....	134	.8	10	8.1	398	....
137-84-10cc	Morton	47.4	1946 Sept. 17	....	....	....	140	68	133	
138-81-16a	....do	400	1954 Sept. 22	49	14	.32	5.3	3.9	565	2.2
138-81-16	....do	318	1921 June 20	....	14	.07	4.0	3.1	520	
139-81-27	....do	400-500	....do	....	28	.20	18	7.6	795	
139-81-33c	....do	330	....do	....	15	.40	5.6	2.7	575	
139-85-21	....do	365	....	....	23	3.0	77	76	225	....
139-85-21	....do	70	....	....	17	0	250	112	89	....
139-85-21	....do	56	....	....	24	.6	13	12	580	....
139-88-31	....do	78	....	....	26	.1	67	41	272	....
139-92-5	Stark	110	....	....	14	2.2	64	51	235	....
139-95-3	....do	200	....	....	12	.8	91	66	287	....
139-96-4ac1	....do	154.0	1947 July 18	....	12	.10	9.0	7.0	574	6.4
139-96-10dd	....do	120	....do	....	11	8.0	107	59	508	12
139-96-12bb	....do	68	1946 Oct. 6	....	....	.30	82	49	949	
139-99-5	....do	230	....	....	11	.2	6.4	13	475	....
139-104-5c	Golden Valley.	Spring	1921 July 20	....	27	.70	44	24	645	
140-90-28	Morton	434	....	....	15	.6	19	13	633	....
140-90-28	....do	238	....	....	20	.5	9.7	23	633	....
140-90-33b	....do	215	June 23	....	19	.68	8.4	7.2	691	
140-93-34d	Stark	80	June 24	....	16	.80	429	415	424	
140-102-27	Billings	265	....	....	13	.40	27	14	384	....
140-102-27	....do	515	....	....	56	2.4	11	22	458	....
140-102-27a	....do	300	July 20	....	8.6	.33	4.0	2.9	456	

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota

Survey. Analytical results in parts per million except as indicated]

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
								Calcium, magnesium	Noncarbonate				
234	......	1,354	71	0.2	176	......	2,546	1,170	978	37	....	.....	b
572	......	1,674	14	.8	4.4	......	3,061	250	0	89	....	.....	b
721	......	621	19	.8	4.4	......	1,604	620	29	51	....	.....	b
426	......	794	50	0	176	......	1,772	830	480	40	....	.....	b
669	......	524	4.4	.2	4.4	......	1,352	843	295	24	....	.....	b
289	......	647	8.0	1.0	2.7	......	1,231	420	84	55	....	.....	b
789	......	384	7.5	1.6	.08	......	1,298	76	0	93	....	.....	b
621	......	252	22	1.6	3.1	......	1,022	25	0	97	....	.....	b
549	......	364	90	.8	5.7	......	1,229	515	65	47	....	.....	b
610	......	573	5.0	.2	1.3	......	1,292	637	137	43	....	.....	b
566	38	729	11	......	3.0	......	1,673	38	0	97	....	.....	a
493	......	853	13	.6	6.7	......	1,759	45	0	97	....	.....	b
643	......	556	7.0	2.8	4.4	......	1,463	214	0	81	....	.....	b
1,557	......	59	60	2.0	1.3	......	1,603	53	0	96	....	.....	b
1,290	......	15	23	3.2	3.5	......	1,227	24	0	98	....	.....	b
590	34	400	6.0	......	2.0	......	1,208	37	0	96	....	.....	a
665	......	378	6.0	0	16	......	1,236	90	0	91	....	.....	b
590	......	289	60	.8	1.3	......	1,019	197	0	78	....	.....	b
607	......	394	9.5	.4	4.4	......	1,315	61	0	94	....	.....	b
413	0	530	20	.1	.0	......	1,230	629	290	32	1,540	7.3	a
1,020	8	387	14	.7	3.8	......	1,530	29	0	97	2,270	8.3	a
1,200	41	22	66	......	2.7	......	1,272	23	0	98	....	.....	a
1,271	16	4.9	533	......	......	......	2,059	76	0	96	....	.....	a
1,220	0	11	208	......	......	......	1,427	25	0	98	....	.....	a
521	......	467	57	.2	11	......	1,203	512	83	49	....	.....	b
412	......	535	205	.2	212	......	1,671	1,087	750	15	....	.....	b
1,195	......	329	6.5	3.0	6.7	......	1,600	83	0	94	....	.....	b
720	......	323	5.0	.2	2.2	......	1,092	343	0	64	....	.....	b
449	......	445	11	.4	53	......	1,053	379	11	58	....	.....	b
689	......	524	6	.8	3.1	......	1,322	498	0	56	....	.....	b
816	47	528	7.0	.2	.5	0.48	1,580	51	0	95	2,260	8.4	a
671	0	1,020	12	.2	1.2	......	2,060	510	0	68	2,670	7.1	a
878	0	1,660	9.6	.8	.8	......	3,310	406	0	84	4,150	7.8	a
1,250	......	44	13	6.5	.9	......	1,160	74	0	94	....	.....	b
1,274	0	537	4.0	......	2.7	......	1,963	208	0	87	....	.....	a
847	......	733	10	1.0	9.8	......	1,950	104	0	93	....	.....	b
844	......	755	7.0	1.2	8.0	......	1,969	120	0	92	....	.....	b
1,139	58	510	5.0	......	2.6	......	1,874	51	0	97	....	.....	a
593	0	2,994	8.0	......	2.8	......	4,980	2,770	2,284	25	....	.....	a
501	......	506	11	1.6	4.4	......	1,290	125	0	87	....	.....	b
863	......	290	14	1.6	6.7	......	1,403	123	0	89	....	.....	b
522	38	506	8.0	......	......	......	1,294	22	0	98	....	.....	a

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, undifferentiated,*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
140-102-27a..	Billings.....	505	July 20..	....	12	0.27	5.2	2.2	470	
140-104-29...	Golden Valley.	186	....	....	19	1.8	22	28	631	....
142-74-1......	Kidder......	160	....	....	29	.20	26	14	388	....
143-80-35....	McLean....	160	....	....	11	.8	59	24	341	....
143-83-6b.....	Oliver......	130	June 22	....	11	.69	6.4	4.9	765	
143-83-6b.....	....do.......	200	....do....	....	15	.40	7.2	2.6	670	
144-88-25.....	Mercer.....	176	....	....	14	.1	13	16	596	....
			1947							
144-88-25cb..	....do.......	63.3	May 13..	....	11	.20	12	5.9	504	7.2
144-91-10.....	Dunn........	....	....	....	5.0	1.2	81	36	502	....
145-92-25.....	....do.......	20	....	....	28	0	85	61	219	....
145-92-25.....	....do.......	18	....	....	14	1.4	78	92	344	....
145-92-25.....	....do.......	14	....	....	18	.40	138	100	156	....
145-92-25.....	....do.......	14	....	....	22	.40	133	85	249	....
145-92-25.....	....do.......	16	....	....	24	.50	132	96	111	....
145-92-25.....	....do.......	19	....	....	28	1.2	187	108	160	....
145-92-25.....	....do.......	12	....	....	19	.40	50	58	224	....
145-92-25.....	....do.......	11	....	....	35	.90	70	48	485	....
145-92-25.....	....do.......	18	....	....	33	1.3	92	79	360	....
145-92-25.....	....do.......	20	....	....	30	.60	72	49	378	....
145-92-25.....	....do.......	18	....	....	31	.8	70	59	376	....
145-92-25.....	....do.......	14	....	....	32	.60	211	113	712	....
145-92-25.....	....do.......	20	....	....	20	2.4	70	75	605	....
145-92-25....	....do.......	20	....	....	18	.2	96	85	774	....
145-92-25....	....do.......	20	....	....	18	.9	61	39	604	....
145-92-25....	....do.......	110	....	....	74	2.6	25	13	680	....
145-94-26....	....do.......	50-60	....	....	22	4.0	22	25	312	....
145-94-26....	....do.......	18	....	....	6.0	8.0	167	132	130	....
			1921							
145-95-9a....	....do.......	Spring	June 22..	....	18	.14	16	15	342	
146-77-11....	Sheridan...	430	....	....	22	1.2	50	14	447	....
			1950							
146-88-5cab..	Mercer.....	65	Aug. 9..	....	28	.26	84	40	340	7.6
146-91-5cbal	Dunn.......	Spring	....do....	48	15	.20	11	8.3	744	4.8
147-80-28.....	McLean....	413	....	....	16	0	13	23	618	....
147-89-18cdc	Mercer.....	105	Aug. 9	....	18	8.1	77	53	260	7.8
147-90-5aaa.	McLean....	620	Aug.10	49	12	.16	6.0	1.2	914	3.3
147-90-22ccc	Mercer.....	150	Nov. 3..	47	17	1.7	80	54	332	8.5
147-90-25abc	....do.......	155	....do....	....	13	1.5	26	18	928	5.6
147-93-3dbb.	Dunn.......	223	Oct. 19..	....	26	.16	9.0	11	1,060	4.4
147-94-4dda.	....do.......	Spring	Aug. 8..	45	28	21	206	95	244	7.6
148-84-4......	McLean....	121	....	....	20	1.4	33	29	448	....
148-84-8......	....do.......	140	....	......	27	1.3	59	33	368	....
148-84-8......	....do.......	122	....	......	30	2.0	34	29	359	....
			1921							
148-84-8c....	....do.......	125	June 18..	....	27	3.0	47	24	437	
			1950							
148-88-9add.	....do.......	58	Aug. 9..	....	10	.87	23	12	680	8.9

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
810	34	294	16	......	3.4	......	1,308	22	0	98	....	.....	a
422	....	1,131	13	1.8	.9	......	2,070	175	0	89	....	.....	b
722	....	334	18	0	6.7	......	1,136	126	0	87	....	.....	b
841	....	279	4.0	.4	8.0		1,145	253	0	75	....	.....	b
1,674	72	145	56	......	4.0	......	1,925	36	0	98	....	.....	a
1,444	82	11	112	......	....	......	1,610	29	0	98	....	.....	a
1,570	....	58	30	1.8	3.5	......	1,520	99	0	93	....	.....	b
1,020	79	190	.0	1.1	1.8	0.23	1,330	54	0	94	2,050	8.7	a
629	....	879	6.0	0	6.7	......	1,894	353	0	76	....	.....	b
476	....	306	80	.2	155	......	1,269	469	79	51	....	.....	b
523	....	828	13	.2	18	......	1,713	535	107	57	....	.....	b
441	....	559	26	0	155	......	1,336	765	403	31	....	.....	b
400	....	441	70	0	425	......	1,550	683	355	44	....	.....	b
468	....	408	24	0	159	......	1,143	729	345	25	....	.....	b
487	....	768	48	.4	1.3	......	1,680	914	0	28	....	.....	b
578	....	272	38	1.2	49	......	1,129	367	0	57	....	.....	b
760	....	579	40	1.2	6.6	......	1,634	374	0	74	....	.....	b
807	....	619	20	1.2	18	......	2,381	571	0	59	....	.....	b
734	....	427	108	1.2	8.9	......	1,424	387	0	68	....	.....	b
583	....	599	58	1.2	66	......	1,494	421	0	66	....	.....	b
522	....	1,452	326	.8	177	......	3,366	995	567	61	....	.....	b
827	....	968	9.8	1.2	133	......	2,327	490	0	73	....	.....	b
837	....	1,501	12	1.6	5.8	......	2,855	590	0	74	....	.....	b
790	....	925	7.1	2.0	2.2	......	2,012	315	0	81	....	.....	b
1,390	....	327	9.9	0	2.7	......	1,813	127	0	93	....	.....	b
628	....	306	4.5	1.0	4.4	......	1,084	166	0	81	....	.....	b
356	....	906	9.0	.1	13	......	1,798	976	684	22	....	.....	b
615	0	320	2.0	......	.5	......	1,017	102	0	88	....	.....	a
846	....	'120	232	1.2	5.3	......	1,290	185	0	84	....	.....	b
804	0	435	3.0	.4	3.2	.20	1,370	374	0	66	1,900	7.5	a
780	18	955	5.0	.8	1.7	.20	2,220	62	0	96	3,070	8.2	a
1,183	....	35	328	2.0	.2	......	1,567	125	0	91	....	.....	b
608	0	440	4.0	.4	.7	.10	1,160	410	0	57	1,650	7.5	a
1,940	0	2.5	314	.6	.8	.20	2,260	20	0	99	3,460	8.1	a
493	0	698	5.0	......	1.5	.30	1,450	422	18	63	2,010	7.9	a
1,200	14	1,150	17	.6	2.2	.00	2,780	139	0	93	3,900	8.2	a
1,510	86	920	11	1.0	2.5	.00	2,890	68	0	97	4,060	8.7	a
756	0	760	2.0	.2	.9	.10	1,800	905	285	37	2,250	7.2	a
926	....	363	27	.6	4.4	......	1,382	210	0	83	....	.....	b
708	....	446	28	.4	2.2	......	1,382	288	0	74	....	.....	b
695	....	368	21	.6	6.6	......	1,253	243	0	79	....	.....	b
922	0	368	10	......	1.1	......	1,386	216	0	81	....	.....	a
1,280	0	490	5.0	.4	4.2	.20	1,900	107	0	93	2,650	7.3	a

461397 O - 58 - 3

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, undifferentiated,*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1950							
148-88-36cdd1	McLean.....	Spring	Aug. 9...	52	19	25	56	39	317	8.0
148-90-33dcc.	....do.......	450-500	Aug.10...	49	8.9	.14	6.0	2.0	996	4.0
148-91-33daa.	Dunn.........	136	Aug. 9...	....	26	44	144	81	820	8.4
148-93-17bdd.	....do.......	Spring	Aug. 8...	49	24	1.2	66	44	496	4.4
148-93-31dbd.	....do.......	Spring	....do.....	45	14	.83	121	68	162	5.2
148-94-20ddd.	....do.......	134	Oct. 12...	....	23	.44	74	28	250	4.6
149-92-30cab.	....do.......	Spring	Aug. 8...	45	16	.19	38	22	359	3.4
149-94-3aba..	....do.......	Spring	....do.....	48	13	.12	5.0	3.7	792	3.6
149-94-15ccd.	....do.......	Spring	....do.....	49	14	.22	34	23	477	3.8
149-94-25abc.	McKenzie...	109	Oct. 7...	47	16	.42	13	5.2	874	4.6
149-94-36dad.	Dunn.........	Spring	Aug. 8...	44	15	.54	7.0	5.2	500	3.4
150-81-7.......	McLean.....	210	....	....	21	2.2	203	97	174	....
150-94-28ada.	McKenzie...	414	Aug.18...	52	21	1.1	10	4.1	1,090	3.7
151-76-3.......	McHenry....	300	....	....	25	10.0	13	17	421	....
151-76-3.......	....do.......	300	....	....	10	.4	15	24	486	....
151-94-6bbd..	McKenzie...	Spring	Nov. 8...	45	20	.04	25	10	542	2.2
152-90-25.....	Mountrail...	90	....	....	36	.6	45	15	631	....
152-91-32.....	....do.......	259	....	....	19	1.7	23	13	742	....
152-91-32.....	....do.......	302	....	....	29	2.0	40	23	632	....
			1947							
154-79-5cb....	McHenry....	144	Sept.11...	46	8.0	1.3	8.3	3.2	860	10
154-80-28dc..	....do.......	318	....do.....	50	8.0	.61	4.7	3.0	706	5.2
			1921							
154-100-29c..	Williams....	2,100	June 22...	....	21	.31	4.8	3.4	640	
154-100-29c..	....do.......	640	May 28...	50	15	....	5.2	4.5	796	
			1947							
155-82-11cc...	Ward.........	250	Sept.11...	49	6.0	.47	7.5	3.9	980	7.2
			1921							
155-85-11d....	....do.......	340	May 24...	....	16	1.7	10	3.4	920	
155-85-17c....	....do.......	185	July 5...	....	14	....	....	....	....	....
155-85-21d....	....do.......	175	....do.....	....	15	.75	16	4.8	882	
155-97-36d....	Williams....	833	June 22	....	39	.24	10	3.4	832	
155-99-1.......	....do.......	142	....	....	33	7	7	6.1	504	....
155-99-18.....	....do.......	45	....	....	19	1	76	38	368	....
			1946							
156-79-10aa2.	McHenry....	121.0	July 15...	48	7.4	....	5.0	2.3	562	12
			1947							
156-79-22dd..	....do.......	114	Sept.11...	49	9.0	1.8	12	3.8	863	5.6
156-81-23aa...	Ward.........	238	....do.....	45	8.0	....	11	3.7	994	8.8
156-83-5bb....	....do.......	580	Sept.12...	51	7.0	.32	10	5.7	1,050	11
156-83-12dc...	....do.......	290	....do.....	48	7.0	.62	12	3.7	718	8.8
156-87-21.......	....do.......	252	....	....	19	2.4	119	79	508	....
156-87-21.......	....do.......	277	....	....	45	8.0	9.6	15	1,015	....
156-87-21.......	....do.......	570	....	....	20	.3	13	12	968	....
156-91-21.......	Mountrail...	100	....	....	20	.1	19	4.4	1,354	....
			1921							
156-91-21c....	....do.......	216	May 25...	....	14	.09	18	7.4	1,499	
			1954							
156-92-28b....	....do.......	185	Sept.30...	42	17	.50	16	3.6	520	3.1

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
								Calcium, magnesium	Noncarbonate				
688	0	415	5.0	0.2	1.9	0.20	1,230	300	0	69	1,750	7.3	a
2,420	0	2.5	149	1.4	1.1	.20	2,400	23	0	99	3,540	8.1	a
1,090	0	1,590	11	.2	7.1	.10	3,270	693	0	72	4,100	7.3	a
862	0	700	2.0	.6	1.7	.20	1,820	346	0	75	2,500	7.7	a
590	0	435	3.0	.4	1.2	.20	1,150	582	98	37	1,560	7.5	a
581	0	378	2.0	.6	1.5	.10	1,050	300	0	64	1,490	8.0	a
636	0	420	2.0	.4	1.8	.20	1,210	186	0	80	1,740	7.7	a
972	59	790	3.0	1.4	5.2	.20	2,230	28	0	98	3,100	8.3	a
870	0	500	2.0	.8	3.8	.30	1,510	180	0	85	2,140	7.5	a
964	18	1,110	4.0	1.0	2.8	.30	2,540	54	0	97	3,440	8.3	a
720	0	505	6.5	1.0	8.5	......	1,490	39	0	96	2,090	7.7	a
784	......	608	7.1	.8	16	......	1,579	921	278	29	....	.....	b
1,440	47	1,140	4.5	.8	2.7	.20	3,070	42	0	98	4,140	8.5	a
828	......	254	62	.2	11	......	1,300	123	0	90	....	.....	b
1,020	......	248	66	.2	6.7	......	1,364	138	0	89	....	.....	b
1,010	0	450	8.0	.6	1.7	......	1,580	104	0	92	2,310	8.0	a
1,218	......	519	5.0	.2	.3	......	1,938	176	0	89	....	.....	b
686	......	736	8.6	1.0	.9	......	2,096	84	0	94	....	.....	b
1,010	......	721	9.0	.4	.9	......	2,097	215	0	88	....	.....	b
908	0	4.8	825	.3	2.5	2.4	2,260	34	0	99	3,880	7.7	a
1,010	102	1.0	392	.6	14	2.7	1,750	24	0	98	2,920	8.8	a
1,332	0	6.6	236	......	......	......	1,580	26	0	98	....	.....	a
2,089	29	7.1	2.2	......	......	......	1,936	31	0	98	....	.....	a
1,030	0	.8	940	.5	1.2	2.4	2,500	34	0	98	4,340	7.6	a
1,954	0	2.6	294	......	......	......	2,244	39	0	98	....	.....	a
1,920	55	30	106	......	1.3	......	2,300	......	......	......	....	.....	a
2,152	29	31	110	......	......	......	2,345	60	0	97	....	.....	a
1,479	34	8.7	422	......	1.9	.....	2,124	39	0	98	....	.....	a
664	......	576	7.4	.8	3.1	......	1,519	64	0	96	....	.....	b
666	......	564	15	1.2	.09	......	1,433	360	0	70	....	.....	b
936	22	7.5	340	.3	2.8	4.6	1,460	22	0	97	2,380	8.0	a
758	43	1.9	885	.3	5.2	2.2	2,280	46	0	96	3,930	8.8	a
720	0	1.6	1,150	.3	1.5	1.9	2,610	42	0	98	4,540	8.2	a
936	0	1.4	1,120	.3	2.2	2.7	2,750	48	0	97	4,790	7.3	a
1,280	0	137	295	.3	10	1.3	1,870	45	0	97	2,950	8.2	a
820	......	893	87	3	.1	.....	2,131	628	0	64	....	.....	b
1,065	......	1,351	19	1.6	2.7	......	3,004	101	0	96	....	.....	b
2,030	......	1.5	354	3	1.8	......	2,391	80	0	96	....	.....	b
1,125	......	1,959	31	.4	.2	.....	3,971	35	0	98	....	.....	b
1,227	0	2,185	30	......	4.5	......	4,386	75	0	98	....	.....	a
807	0	494	5.5	.0	2.6	......	1,440	55	0	95	2,170	8.1	a

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, undifferentiated,*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1954							
156-97-9	Williams	68	....	......	24	1.1	274	94	31	....
156-97-9	....do	68	....	......	33	3.2	275	102	121	....
156-97-9	....do	65	....	......	26	1	236	108	63	....
156-98-35	....do	189	....	......	28	1	89	52	265	....
			1947							
157-79-6dc	McHenry	80	Sept. 11	47	10	......	26	12	1,670	10
158-80-31cc	....do	160	....do	46	7.0	.62	19	5.9	1,330	8.4
			1948							
158-81-2cd	Renville	180	May 28	......	4.5	5.5	30	6.0	1,300	8.4
158-82-7dd	....do	345	June 1	......	11	.90	12	.0	745	4.4
158-82-17ab	....do	250	....do	......	11	......	12	3.0	809	6.8
158-82-19ad	....do	341	....do	......	9.9	......	7.0	2.1	843	15
			1947							
158-84-28aa	....do	326	Sept. 10	48	11	......	3.6	1.8	710	5.2
158-85-26dc	....do	599	....do	48	9.0	1.1	6.8	3.5	1,040	8.0
			1948							
158-85-33bb	....do	535	Sept. 13	46	13	1.6	4.4	6.6	1,000	2.0
159-80-31dc	McHenry	....	....do	......	11	18	25	9.6	1,590	4.8
159-81-5cb	Bottineau	181	May 28	......	29	......	54	9.8	603	4.8
159-81-31cc	....do	320	Sept. 13	44	11	2.4	19	6.3	1,380	1.7
159-82-2cc	....do	213	May 28	......	9.0	......	18	13	880	6.8
159-82-31cb	....do	270	....do	......	6.6	12	12	3.2	791	3.6
			1921							
159-83-3ba	....do	254	May 18	......	9.8	1.9	14	4.3	1,026	
			1947							
159-83-11ab	....do	310	June 14	47	11	2.8	23	11	1,180	6.4
159-84-25dd	Renville	450	Sept. 10	49	16	1.6	11	4.6	1,200	6.8
			1948							
159-85-31bc	....do	600	Sept. 13	46	12	3.2	8.3	7.0	1,130	1.2
159-86-33bc2	....do	185	June 1	......	7.0	.36	11	1.5	922	15
159-86-36ad	....do	....	May 28	......	8.5	.10	11	2.5	1,080	8.8
			1947							
159-87-25dd	Ward	410	Sept. 10	46	8.0	4.1	3.5	1.7	872	6.4
159-102-12	Williams	78	....	......	14	1	79	66	439	....
159-103-12	....do	165	....	......	32	10	4	109	583	....
160-76-8	Bottineau	80	....	......	23	23	483	297	402	....
160-78-11	....do	60	....	......	38	.7	11	11	643	....
160-78-11	....do	50	....	......	11	.2	11	9.4	591	....
160-78-14	....do	66	....	......	24	.3	19	20	681	....
160-79-6	....do	108	....	......	60	3.6	89	37	445	....
160-79-6	....do	150	....	......	17	26	76	55	421	....
			1948							
160-82-5cb	....do	300	May 28	......	29	18	208	67	392	11
160-82-31cc	....do	265	Sept. 12	45	22	1.7	21	10	681	4.4
160-83-5cb	....do	265	May 28	......	11	20	133	52	950	7.2
160-83-8cd	....do	246	Sept. 12	45	14	.40	24	10	1,360	6.0
160-83-10bc	....do	250	May 8	......	11	1.2	13	2.6	766	3.2
160-83-12ad	....do	217	May 28	......	30	11	143	43	346	7.6
160-83-21da	....do	250	June 1	......	11	24	46	10	823	7.2
160-84-14dc	Renville	600	May 28	......	11	......	30	8.0	883	4.4

[1] Sum of determined constituents.

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
478	......	618	49	0	53	......	1,460	1,079	687	6	....	.....	b
740	......	706	24	1.6	1.3	......	1,597	1,116	510	19	....	.....	b
583	......	632	20	0	16	......	1,329	1,037	559	12	....	.....	b
818	......	310	5.5	.8	3.1	......	1,164	437	0	57	....	.....	b
476	0	1.8	2,380	.3	3.5	2.5	4,410	114	0	97	7,800	7.8	a
650	0	1.9	1,730	.4	1.5	2.2	3,530	72	0	97	6,310	7.8	a
420	55	45	1,740	.0	1.9	2.1	3,390	100	0	96	5,670	8.9	a
1,320	30	200	228	.4	.5	1.7	1,890	30	0	98	2,810	8.4	a
1,110	60	276	378	.2	2.5	1.5	2,150	62	0	97	3,200	8.4	a
1,070	0	14	712	.3	3.2	1.8	2,170	26	0	98	3,470	7.8	a
1,470	0	4.5	250	1.0	2.2	1.1	1,780	16	0	99	2,850	8.1	a
1,140	0	1.8	960	.6	1.8	1.7	2,630	32	0	98	4,540	8.3	a
1,320	71	16	736	.2	3.8	1.2	2,520	38	0	98	4,070	8.4	a
472	16	12	2,240	.1	2.4	2.6	4,140	102	0	97	7,120	8.2	a
672	0	181	516	.3	3.7	.83	1,750	176	0	88	2,690	7.9	a
626	0	4.0	1,810	.2	.8	2.1	3,550	73	0	98	5,450	7.8	a
976	13	2.4	842	.3	1.2	2.9	2,300	98	0	95	3,670	8.4	a
522	212	508	310	.4	2.9	1.7	2,120	43	0	97	3,170	9.5	a
848	0	12	1,135	......	....	......	2,651	53	0	98	....	.....	a
736	14	61	1,420	.4	8.0	3.1	3,130	103	0	96	5,450	8.2	a
644	71	1.3	1,430	.5	2.5	2.4	3,120	46	0	98	5,450	9.2	a
1,250	67	4.0	970	.4	.7	.55	2,820	50	0	98	4,140	8.1	a
1,880	0	26	328	2.3	4.2	.19	[1]2,260	34	0	97	3,430	8.0	a
1,490	92	6.4	709	.5	.9	.53	2,670	38	0	98	4,230	8.1	a
1,810	0	.5	305	1.8	1.5	.20	2,140	16	0	99	3,440	7.2	a
1,057	......	522	4.8	.8	6.2	......	1,644	470	0	67	....	.....	b
805	......	1,033	6.9	.6	1.3	......	2,245	479	0	73	....	.....	b
620	......	2,663	44	.8	1.8	......	4,835	2,473	1,965	26	....	.....	b
1,450	......	99	78	.4	4.4	......	1,594	75	0	95	....	.....	b
1,450	......	13	85	.4	40	......	1,456	67	0	95	....	.....	b
1,670	......	106	92	1.0	4.4	......	1,774	135	0	92	....	.....	b
566	......	127	555	.8	2.7	......	1,588	413	0	72	....	.....	b
595	......	578	201	.8	1.8	......	1,717	462	0	69	....	.....	b
764	0	26	773	.0	.5	.24	1,980	729	103	51	2,940	7.9	a
904	28	524	165	.4	3.3	2.1	1,940	94	0	94	2,850	8.2	a
290	0	68	1,640	.2	1.2	.50	3,170	546	308	79	4,860	7.6	a
496	8	14	1,890	.2	1.4	2.2	3,560	101	0	96	6,220	8.1	a
720	20	4.0	780	.4	3.2	2.2	1,980	43	0	97	3,270	8.5	a
566	0	7.2	580	.2	4.6	.23	1,500	534	70	58	2,480	7.6	a
618	38	520	596	.4	8.7	1.9	2,390	156	0	92	3,460	8.4	a
870	0	2.4	906	.2	3.0	2.0	2,310	108	0	94	3,670	7.8	a

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, undifferentiated,*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1947							
160-84-19dd	Renville	400+	Sept. 10	49	26	3.0	112	13	834	10
160-87-24bc1	Ward	280	Sept. 9	46	8.0	....	3.2	3.0	682	14
160-88-17	....do	400	....	....	19	.6	21	16	527	....
			1921							
160-88-20c	....do	313	May 19	....	32	.58	30	16	515	
			1947							
161-82-20aa1	Bottineau	343	Sept. 8.	47	11	1.2	83	21	2,730	19
			1948							
161-83-1aa	....do	350	Sept. 12.	47	11	5.0	40	9.4	1,930	.4
			1947							
161-83-18cc	....do	340	Sept. 8.	45	7.5	4.0	22	5.0	1,220	18
161-84-3dd	Renville	343	June 15.	45	13	28	26	7.2	1,270	6.4
			1948							
161-84-4bb1	....do	492	Sept. 12.	47	10	4.0	76	20	2,420	1.6
161-84-13	....do	343	....	....	24	.3	37	19	1,006	....
161-84-16dd	....do	....	Sept. 12.	44	9.5	4.0	55	16	2,090	1.2
			1947							
161-85-23ab	....do	300	Sept. 9.	46	9.6	2.1	26	3.3	1,000	18
161-86-6bc2	....do	400	Sept. 8.	48	9.0	27	17	13	543	.0
161-87-1bc	....do	426	....do	48	10	....	6.0	3.5	647	6.0
161-87-17bc2	....do	315	Sept. 9.	47	10	1.3	40	9.4	666	....
			1948							
161-89-3dc1	Burke	94	Sept. 11.	44	19	1.0	82	29	905	4.0
			1921							
161-89-5b	....do	155	May 20.	....	12	.10	16	6.6	585	
			1948							
161-89-5dd1	....do	97	Sept. 11.	44	12	2.0	12	5.2	605	1.6
161-89-6da	....do	70	....do	44	12	.20	7.5	4.2	565	2.0
161-89-8cb	....do	102	....do	44	9.4	8.0	89	44	577	2.4
161-89-9bb2	....do	190	....do	43	13	8.0	83	49	586	2.8
161-89-21da	....do	100	....do	44	13	.08	5.8	4.4	552	2.4
			1947							
161-89-26dc.	....do	237	June 6.	50	14	.78	8.5	5.0	763	2.4
			1948							
161-90-11cd.	....do	89	June 2.	....	24	2.8	249	45	440	12
			1921							
162-75-30b	Bottineau	150	May 17.	....	21	.10	4.4	1.5	428	
162-75-30c	....do	135	May 16.	....	31	.13	6.0	1.7	478	
			1947							
162-84-21cc.	Renville	415	Sept. 8.	48	8.0	....	65	18	2,300	14
			1948							
162-85-23dd.	....do	500	Sept. 12.	47	11	1.5	62	16	2,170	.8
			1947							
162-85-29bb.	....do	....	Sept. 8.	45	6.0	2.6	13	5.4	996	9.6
162-88-36cc.	Burke	308	June 11.	50	10	6.0	7.0	4.2	460	7.2

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
906	0	246	820	0.5	1.8	1.6	2,530	333	0	84	4,210	8.1	a
1,220	92	6.0	250	2.0	4.5	.36	1,690	20	0	97	2,760	8.7	a
1,180	...	95	137	1.6	4.4	...	1,380	117	0	91	...	...	b
1,186	0	100	134	...	4.4	...	1,433	141	0	89	...	...	a
257	0	25	4,290	.0	1.0	2.1	7,390	294	83	95	12,800	7.4	a
378	0	4.0	2,900	.0	.5	1.7	5,080	138	0	97	8,760	7.9	a
448	11	6.2	1,720	.2	5.0	1.4	3,250	75	0	96	5,710	8.5	a
468	35	4.9	1,780	.2	1.0	1.8	3,410	94	0	96	6,050	8.5	a
286	6	4.0	3,830	.7	.7	1.8	6,620	272	28	95	11,200	8.1	a
769	...	40	1,190	0	18	...	2,692	177	0	93	...	...	b
304	16	4.8	3,200	.2	1.5	1.8	5,560	203	0	96	8,380	8.3	a
708	0	6.6	1,250	.2	9.0	.63	2,700	78	0	96	4,640	7.8	a
914	37	271	138	.6	2.2	.50	1,510	96	0	92	2,320	8.7	a
1,160	0	.6	346	.8	1.8	.61	1,650	30	0	97	2,710	7.1	a
648	19	845	85	1.2	.7	.25	2,000	138	0	91	2,860	8.6	a
984	0	1,400	16	.7	5.3	.00	3,030	324	0	86	3,940	7.6	a
1,530	0	11	36	...	2.0	...	1,472	67	0	95	...	...	a
1,340	31	168	25	.8	1.8	.11	1,580	51	0	96	2,060	8.2	a
1,440	35	64	29	.4	3.1	.10	1,410	36	0	97	1,880	8.3	a
582	10	1,080	28	.3	2.5	.18	2,180	403	0	76	2,570	8.1	a
848	0	920	14	1.0	4.0	.09	2,260	409	0	76	2,870	7.8	a
1,400	24	4.0	50	.4	2.1	.11	1,400	33	0	97	1,920	8.2	a
964	24	814	36	1.4	1.8	.27	2,170	42	0	97	3,090	8.3	a
650	0	1,120	18	.2	2.4	.42	2,270	806	273	54	2,640	7.1	a
644	31	150	166	...	3.8	...	1,159	17	0	98	...	...	a
764	12	10	306	...	...	...	1,269	22	0	98	...	...	a
261	34	1.5	3,520	.0	2.2	2.1	6,220	236	0	95	10,700	8.2	a
350	0	.8	3,400	.2	.8	1.9	5,860	220	0	96	9,970	7.8	a
723	0	14	1,160	.3	2.2	1.2	2,600	54	0	97	4,620	7.4	a
864	63	112	95	1.6	.5	.51	1,290	35	0	96	2,080	8.6	a

Table 5.—*Chemical analyses of saline ground water from the Hell Creek formation, formation, undifferentiated,*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1948							
162-89-18ad..	Burke........	200	May 29.	....	3.5	....	28	15	508	11
162-89-31da..	....do........	270	Sept. 11.	47	11	0.12	7.5	4.8	752	2.0
162-91-3dd2..	....do........	360	June 2.	....	6.5	3.2	7.0	1.3	548	18
162-91-27ac..	....do........	106	Sept. 11.	45	12	.32	9.0	4.8	712	14
162-93-9ab1..	....do........	100	....do.....	45	17	.80	4.4	4.4	698	.8
162-93-15bd1.	....do........	80	....do.....	....	18	.50	4.4	6.6	834	2.0
162-95-4.......	Divide.......	365	....	....	8	0	12	3.9	786	....
162-95-4ac....	....do........	265	May 29.	....	8.7	....	2.0	2.1	787	1.2
			1947							
162-96-5dc1..	....do........	320	June 4.	47	11	3.5	14	3.3	911	13
163-79-33.....	Bottineau...	65	....	....	14	.4	80	77	419	....
163-80-34.....	....do........	140	....	....	21	4.8	44	18	495	....
			1948							
163-84-30cc..	Renville....	325	May 28.	....	22	6.0	88	29	724	3.6
			1947							
163-85-10ba..	....do........	375	June 14.	47	11	....	37	10	1,530	8.0
163-85-29cd..	....do........	500+	Sept. 8.	48	4.0	1.6	54	12	2,150	12
163-86-17bb1.	....do........	716	June 6.	54	7.6	....	24	7.0	1,400	11
163-88-28dd..	Burke........	200	June 5.	50	11	....	18	3.3	802	7.2
163-90-32.....	....do........	223	....	....	27	1.4	132	54	373	....
163-93-8ad1..	....do........	204	June 4.	46	8.0	.40	8.0	4.4	693	7.2
163-93-29dd..	....do........	82.0	....do.....	48	27	.90	89	43	519	10
163-93-32bd..	....do........	270	....	....	10	.15	.71	4.4	859	....
			1948							
163-94-6cb...	....do........	260	June 2.	....	5.5	.03	29	11	711	7.6
			1947							
163-94-33aa1.	....do........	270	June 4.	50	11	3.0	26	6.1	765	41
163-96-13da..	Divide......	105	....do.....	50	8.0	5.0	59	38	729	11
			1948							
163-97-6cc1..	....do........	264	Sept. 12.	47	13	.80	3.5	4.8	698	.8
			1921							
163-97-6d.....	....do........	253	May 21.	....	33	.27	22	8.0	617	
			1947							
163-97-6dc....	....do........	242	May 2.	....	30	.05	20	7.6	609	.0
163-97-29.....	....do........	775	....	....	18	.10	6.4	14	954	....
			1921							
163-97-29d....	....do........	407	May 21.	....	21	.07	5.6	3.6	700	
			1947							
163-97-31bc..	....do........	250	June 4.	50	9.1	.05	10	3.1	796	6.0
163-98-17aa..	....do........	216	May 2.	....	7.6	9.0	10	2.0	586	9.6

Cannonball member of the Fort Union formation, and upper part of the Fort Union North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
202	0	1,000	6.0	0.7	0.0	0.38	1,710	132	0	88	2,360	7.7	a
1,680	0	6.4	186	1.4	.0	.17	1,810	38	0	98	2,530	7.9	a
922	18	438	24	1.8	1.5	.19	1,610	23	0	96	2,340	8.2	a
1,850	0	4.0	40	1.0	.5	.10	1,730	42	0	96	2,320	8.0	a
1,620	87	12	62	1.4	.7	.07	1,730	29	0	98	2,570	8.7	a
1,900	87	68	55	1.2	2.1	.15	2,070	38	0	98	2,970	8.4	a
1,945	......	36	83	3.6	6.2	......	1,956	52	0	97	....	......	b
1,910	0	.0	90	4.0	1.2	.16	1,900	14	0	99	2,810	8.0	a
1,230	108	784	44	2.0	2.5	.59	2,520	48	0	97	3,730	8.8	a
410	......	1,019	19	1.8	.09	......	1,946	518	182	64	....	......	b
690	......	332	248	1.2	3.5	......	1,588	191	0	85	....	......	b
468	0	98	1,020	.4	14	.65	2,220	339	0	82	3,700	7.5	a
356	14	9.9	2,360	.3	1.0	1.6	4,170	133	0	96	7,590	8.4	a
310	0	.9	3,320	.4	1.0	2.3	5,800	184	0	95	10,400	6.7	a
730	24	725	1,250	.6	.2	1.9	3,880	89	0	97	6,490	8.4	a
1,090	44	758	38	1.2	1.5	.52	2,260	58	0	96	3,390	9.0	a
633	......	776	21	1.6	8.0	......	1,728	592	73	60	....	......	b
1,420	45	166	70	2.4	1.5	.48	1,740	38	0	97	2,690	8.2	a
882	31	653	60	.4	2.5	.46	1,860	399	0	73	2,630	8.3	a
1,927	......	.41	212	3.6	1.3	......	2,110	20	0	99	....	......	b
518	10	1,140	28	1.2	1.4	.16	2,250	118	0	92	3,020	8.3	a
1,500	175	2.9	133	4.0	.2	.41	1,880	90	0	92	3,040	......	a
712	71	1,080	48	1.6	1.0	.46	2,430	303	0	83	3,420	8.6	a
1,450	90	90	100	1.8	3.6	.85	1,730	28	0	98	2,590	8.5	a
1,464	0	85	100	......	3.8	......	1,620	88	0	94	....	......	a
1,380	24	99	99	.8	3.2	.57	1,600	81	0	94	2,400	8.7	a
1,375	......	72	668	1.4	2.7	......	2,457	75	0	97	....	......	b
1,405	0	52	274	......	......	......	1,721	29	0	98	....	......	a
1,490	108	2.9	258	1.2	1.0	1.2	1,960	38	0	97	3,240	......	a
652	130	518	16	.4	7.5	.51	1,620	333	0	97	2,550	9.2	a

The maximum dissolved-solids concentration was 7,390 ppm, and about 90 percent of the analyses showed dissolved-solids concentrations between 1,000 and 3,000 ppm. Most of the saline water that is known to be from the Hell Creek Formation and upper part of the Fort Union formation is of the sodium bicarbonate sulfate type; saline water from the Cannonball member is generally of the sodium chloride type. (See fig. 4.)

Because most of the saline water from these formations has a high percent sodium and a high boron content, it is unsuitable for irrigation. Water from many of the wells in these aquifers has excessive color and hardness, and high concentrations of fluoride, sulfate, and iron.

GLACIAL DRIFT AND ALLUVIUM

Glacial drift of Pleistocene age covers approximately three-fifths of North Dakota. In the unglaciated areas of the State, river alluvium of Recent age is widespread in the valleys of the Missouri River and its tributaries.

In areas covered with till, where little or no sorted material capable of yielding water is near the surface, lenses of sand and gravel in and at the base of the drift yield small supplies. However, because many of these lenses are completely drift covered, there is little recharge and they may be easily dewatered. Wells tapping sand and gravel in or at the base of the drift generally do not yield much more than 50 gpm. Wells in areas of surficial glacial outwash, however, yield small to large supplies of water, and some relatively widespread bodies of outwash buried in the drift yield similar supplies.

The hydrologic and lithologic characteristics of the drift and alluvial deposits are extremely variable both laterally and vertically; thus, the quantity and quality of the ground water that may be obtained from these surficial deposits also vary greatly.

Chemical analyses of saline water from the drift and alluvium are given in table 6, and the chemical characteristics of the water are shown in figure 5. The patterns illustrate the many variations in type of water and degree of salinity.

Most of the data in table 6 represent water that is only slightly saline. However, water from wells 143-61-30cda2, 153-67-15cab, 162-90-10cbc, and 163-84-6ad is very saline and contains large amounts of magnesium sulfate and sodium sulfate.

Analyses of samples from wells 137-60-25aca, 142-50-2a, 143-88-4cd2, and 164-53-31ccb show the composition of several different types of water, in which calcium or sodium is the predominant cation and bicarbonate, sulfate, or chloride is the predominant anion. The waters are slightly to moderately saline.

Table 6.—*Chemical analyses of saline ground water*

[Source of data: a, U. S. Geological Survey; b, North Dakota Geological Survey; c, North
per million except

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
129-63-12b......	Dickey...	22	June 28...	......	30	0.13	233	72	107	
129-71-3d......	McIntosh..	80	June 20...	......	38	3.6	135	52	296	
130-47-20d......	Richland..	263	June 27...	......	11	.75	20	9.2	578	
			1952							
130-48-24cbb....	...do......	76	May 23...	......	....	8.2	300	170	270	
			1921							
130-50-13a......	...do......	12	June 27..	......	37	1.2	189	86	60	
130-52-13......	...do......	72	....	......	50	.9	116	61	214	....
130-52-13a......	...do......	22	June 27...	......	23	.08	232	97	12	
130-56-1......	Sargent...	175	....	......	22	.9	21	24	572	....
130-56-1......	...do......	168	....	......	20	.9	183	76	277	....
130-57-2......	...do......	287	....	......	29	.2	29	13	539	....
130-69-31......	McIntosh..	70	June 20..	......	28	......	412	140	87	
130-69-31......	...do......	70	....	......	27	.5	360	92	72	....
130-69-31......	...do......	70	....	......	29	3.0	418	110	96	....
130-74-31......	Emmons...	12	....	......	34	0	266	138	43	....
131-55-30a......	Sargent....	220±	June 28...	......	28	1.4	175	43	301	
131-63-8d......	Dickey....	38	June 29...	......	32	.10	49	27	440	
132-49-7......	Richland..	140	....	......	30	4.0	135	46	589	....
132-49-7......	...do......	240	....	......	23	.8	73	.65	802	....
132-54-9......	Sargent...	28	....	......	38	4.0	153	71	102	....
132-76-7......	Emmons...	56	....	......	24	.7	97	40	290	....
133-48-28......	Richland..	140	....	......	23	1.1	156	42	415	....
133-48-29......	...do......	125	....	......	24	1.4	101	31	563	....
133-48-29......	...do......	137	....	......	26	1.1	89	29	603	....
133-48-29......	...do......	140	....	......	29	2.4	102	33	487	....
134-56-11b......	Ransom...	30	June 30..	......	33	.20	164	112	69	
134-62-33......	LaMoure..	121	....	......	21	3.0	104	49	330	....
135-72-17......	Logan......	18	....	......	19	.1	104	30	266	....
136-67-5......	...do......	74	....	......	26	1.4	76	62	292	....
137-56-13b......	Barnes.....	44	June 24..	......	34	.80	252	81	135	
137-58-14......	...do......	12	....	......	21	.7	209	103	264	....
137-58-14......	...do......	14	....	......	21	.1	357	173	305	....
			1949							
137-59-9aad....	...do......	20	Jan. 13..	......	....	.9	135	34	610	....
137-59-10bcb...	...do......	11	...do......	......	....	4.4	154	51	277	....
137-59-10bcc...	...do......	31	Jan. 8...	......	....	.7	147	75	54	....
137-59-14bdb...	...do......	35	Jan. 10...	......	....	.2	311	110	70	....
137-59-14cab...	...do......	45	Feb. 26..	......	....	2.6	12	14	380	....
137-59-14dcd1..	...do......	39	Feb. 8..	......	....	3.0	642	480	459	....
137-59-19dcc...	...do......	80	Jan. 13..	......	....	3.5	340	73	195	....
137-59-29bbb...	...do......	97	...do......	......	....	5.6	142	63	378	....
137-59-30aaa...	...do......	112	Jan. 10..	......	....	3.1	27	15	417	....
137-59-30bcb...	...do......	35	Feb. 26..	......	....	1.1	547	242	110	....

from glacial drift and alluvium, North Dakota

Dakota State Health Department or State Laboratories Department. Analytical results in parts as indicated]

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
403	0	537	166	......	2.0	......	1,143	878	548	21	....	....	a
549	0	669	42	......	3.8	......	1,524	551	101	54	....	....	a
378	0	374	472	......	10	......	1,678	88	0	93	....	....	a
200	0	1,790	30	......	4	......	2,660	1,444	1,280	29	....	....	c
410	0	453	72	......	33	......	1,207	825	489	14	....	....	a
535	......	519	22	0	0	......	1,246	543	104	46	....	....	b
410	0	517	62	......	40	......	1,310	978	642	3	....	....	a
517	......	853	67	1.2	1.6	......	1,840	167	0	89	....	....	b
515	......	820	72	.2	5.7	......	1,688	764	342	44	....	....	b
710	......	14	495	1.3	5.3	......	1,497	130	0	90	....	....	b
537	0	1,236	27	......	2.0	......	2,405	1,600	1,160	11	....	....	a
463	......	978	22	.2	6.7	......	1,986	1,175	795	11	....	....	b
405	......	1,082	178	0	8.8	......	2,304	1,505	1,173	12	....	....	b
410	......	697	188	.4	4.4	......	1,869	1,239	903	7	....	....	b
520	0	763	44	......	2.9	......	1,650	614	188	52	....	....	a
647	0	479	126	......	1.6	......	1,487	233	0	80	....	....	a
300	......	1,058	328	1.4	6.7	......	2,365	537	291	71	....	....	b
327	......	1,116	354	4.0	4.0	......	2,572	192	0	90	....	....	b
392	......	435	96	0	1.3	......	1,169	686	365	25	....	....	b
426	......	621	28	.2	1.0	......	1,323	409	60	61	....	....	b
274	......	848	265	.6	.35	......	2,037	580	355	62	....	....	b
314	......	914	275	3.6	7.1	......	2,117	390	133	76	....	....	b
327	......	959	282	1.3	.18	......	2,178	371	103	79	....	....	b
351	......	832	228	1.4	.44	......	1,938	421	133	73	....	....	b
190	0	510	178	......	80	......	1,297	869	713	15	....	....	a
571	......	482	152	0	3.1	......	1,580	478	10	61	....	....	b
283	......	672	22	.2	1.3	......	1,268	386	154	60	....	....	b
529	......	618	22	.2	.5	......	1,338	474	40	59	....	....	b
403	0	856	14	......	2.5	......	1,601	962	632	23	....	....	a
393	......	1,056	73	0	3.5	......	2,029	953	631	38	....	....	b
366	......	1,031	392	0	425	......	2,950	1,605	1,305	29	....	....	b
0	0	775	705	.1	0	......	....	475	475	74	....	....	c
478	0	783	218	0	13	......	....	545	153	50	....	....	c
321	0	458	121	.1	17	......	....	677	414	15	....	....	c
451	0	790	106	0	48	......	....	1,230	860	11	....	....	c
342	65	507	118	.6	7	......	....	88	0	90	....	....	c
399	0	3,790	206	0	52	......	....	3,580	3,253	22	....	....	c
178	0	1,080	320	.1	217	......	....	1,150	1,004	27	....	....	c
218	0	884	240	.1	0	......	....	665	486	57	....	....	c
309	36	48	488	0	0	......	....	130	0	88	....	....	c
164	0	2,080	50	0	26	......	....	1,370	1,236	15	....	....	c

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1949							
137-60-4bab...	Barnes	160	Jan. 13...	......	....	1.4	540	346	531	....
137-60-25aad.	...do........	87	...do......	......	....	1.0	104	37	379	....
137-60-25aca.	...do........	90	Jan. 10...	......	....	.3	888	260	184	....
137-60-30baa1	...do........	44	...do......	......	....	.6	196	51	104	....
137-69-26......	Stutsman....	18	....	......	16....	3	187	170	42	....
137-69-26.....	...do........	22	....	......	27	1.1	260	169	103	....
137-69-26bac9	...do........	25	Nov. 21..	......	....	.35	180	150	690	....
			1950							
137-69-26bca5	...do........	22	Dec. 29..	......	....	......	60	120	140	....
137-69-26bdd9	...do........	20	...do......	......	....	......	120	200	250	....
			1946							
137-84-1dd...	Morton......	17.6	Sept. 17..	......	....	.2	64	37	382	
138-55-13......	Cass........	30	....	......	39	0	556	281	165	....
138-56-18......	Barnes......	34	....	......	42	1.2	114	38	421	....
138-56-18.....	...do........	13	....	......	29	2.0	224	124	321	....
138-56-18.....	...do........	28	....	......	32	.9	206	104	291	....
138-56-18.....	...do........	15	....	......	27	0	260	108	257	....
138-56-18.....	...do........	18	....	......	28	0	207	99	310	....
138-56-18.....	...do........	16	....	......	30	.1	177	91	140	....
138-56-18.....	...do........	14	....	......	24	2.0	248	118	234	....
138-83-14ab..	Morton	28.9	Sept. 17..	......	....	.1	458	111	324	
			1947							
139-96-12ab..	Stark........	25	July 18..	......	20	7.2	215	120	245	10
139-97-10dd..	...do........	40	...do......	......	13	.45	325	113	178	7.6
139-97-14da..	...do........	30	...do......	......	25	......	313	97	134	11
140-54-30.....	Cass........	30	....	......	19	.9	220	73	328	....
140-55-19.....	...do........	22	....	......	35	.4	531	323	44	....
140-56-19.....	Barnes......	25	....	......	34	.4	245	160	75	....
141-49-6......	Cass........	200	....	......	28	1.4	52	20	468	....
			1921							
141-49-6c.....	...do........	149	June 24...	......	35	1.4	51	15	363	
142-50-2......	...do........	185	....	......	14	......	91	8.5	749	....
142-50-2a.....	...do........	135	June 24...	......	32	.53	83	24	710	
142-59-31.....	Barnes......	29	....	......	30	.3	185	114	41	....
142-59-31.....	...do........	20	....	......	28	.4	99	64	251	....
			1946							
142-61-6cad..	...do........	60	Sept. 15...	......	....	.2	200	44	90	....
142-72-3......	Kidder......	55	....	......	32	2.1	180	56	190	....
142-72-3......	...do........	65	....	......	30	1.4	147	43	168	....
143-50-3......	Cass........	207	....	......	25	2.0	158	63	866	....
143-56-17.....	Barnes......	25-30	....	......	31	1.4	474	210	118	....
143-56-17.....	...do........	25-30	....	......	25	.3	157	106	83	....
143-56-17.....	...do........	26	....	......	32	2.2	620	309	197	....
143-59-19.....	...do........	24	....	......	20	.4	162	153	25	....

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
488	0	2,920	290	0	30	......	....	2,780	2,380	29	....	....	c
344	0	452	342	0	2	......	....	410	128	67	....	....	c
494	0	748	1,780	0	4	......	....	......	......	11	....	....	c
398	0	475	78	0	0	......	....	700	374	24	....	....	c
710	......	411	79	.2	177	......	1,511	1,171	589	7	....	....	b
570	......	631	242	.2	133	......	1,929	1,350	883	14	....	....	b
570	......	1,340	280	......	390	......	....	1,070	603	58	....	....	c
340	17	590	47	......	56	......	....	650	342	32	....	....	c
270	24	1,110	210	......	43	......	....	1,140	878	33	....	....	c
886	0	266	95	1.6	.2	......	1,400	312	0	73	2,030	7.6	a
568	......	2,146	174	.2	6.6	......	3,842	2,589	2,123	12	....	....	b
587	......	425	312	.2	3.1	......	1,667	452	0	67	....	....	b
735	......	580	411	0	6.2	......	2,148	1,093	490	40	....	....	b
535	......	660	321	.2	.88	......	2,001	950	511	40	....	....	b
381	......	331	613	0	177	......	2,024	1,105	793	34	....	....	b
573	......	667	304	.2	5.3	......	1,988	923	453	42	....	....	b
495	......	547	104	0	2.2	......	1,456	818	412	27	....	....	b
600	......	617	347	.2	.9	......	1,999	1,117	625	32	....	....	b
808	0	1,130	327	.1	2.0	......	3,030	1,600	936	31	3,370	7.4	a
505	0	1,100	10	.5	1.5	0.26	2,160	1,030	616	34	2,340	7.3	a
554	0	1,140	12	.1	18	......	2,300	1,280	826	23	2,320	7.1	a
413	0	970	95	.4	1.2	......	2,560	1,180	841	20	2,950	7.3	a
451	......	873	210	.6	1.8	......	2,026	862	492	46	....	....	b
194	......	2,315	118	.4	29	......	4,041	2,664	2,505	3	....	....	b
475	......	818	137	0	3.8	......	1,888	1,274	884	11	....	....	b
427	......	211	464	.8	7.9	......	1,481	215	0	83	....	....	b
390	0	193	328	......	7.1	......	1,194	189	0	81	....	....	a
317	......	435	830	.8	6.4	......	2,415	262	2	86	....	....	b
212	0	410	890	......	15	......	2,298	306	132	84	....	....	a
418	......	375	202	.2	2.7	......	1,238	931	588	9	....	....	b
327	......	377	284	.2	.4	......	1,358	516	248	52	....	....	b
464	......	418	17	......	......	......	....	680	300	22	....	....	c
424	......	629	67	0	1.8	......	1,438	686	338	38	....	....	b
512	......	424	35	0	4.4	......	1,118	545	125	40	....	....	b
322	......	897	946	.8	11	......	3,196	660	396	74	....	....	b
351	......	1,872	85	.2	1.8	......	3,299	2,103	1,815	11	....	....	b
381	......	613	39	.2	4.4	......	1,324	825	513	18	....	....	b
369	......	2,621	156	.2	.4	......	4,701	2,825	2,522	13	....	....	b
385	......	588	73	.2	71	......	1,469	1,034	718	5	....	....	b

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1947							
143-61-21caa	Barnes	30	Aug. 29	......	......	2.1	176	70	264	......
143-61-28bbb	do.	92	do.	......	......	2.2	146	83	394	......
143-61-29cbb	do.	28	May 31	......	......	2.7	192	132	252	......
143-61-29cdc	do.	70	Aug. 29	......	......	10.0	341	115	216	......
143-61-30	do.	40	......	......	23	.1	94	42	728	......
			1946							
143-61-30cda2	do.	51	Sept. 15	......	......	.3	462	213	3,880	......
143-61-30cdb4	do.	77	do.	......	......	.08	176	92	544	......
143-61-30cdc3	do.	28	do.	......	......	.06	216	46	316	......
			1934							
143-61-30cdd2	do.	22	Feb. 7	......	......	.6	74	46	......	......
			1946							
143-61-30dbb	do.	38	Sept. 15	......	......	.1	192	54	287	......
143-61-31bab	do.	45	do.	......	......	.15	192	47	352	......
			1934							
143-61-31bba1	do.	42	Feb. 7	......	......	0	10	25	......	......
			1946							
143-61-32cca	do.	46	Sept. 15	......	......	.1	160	25	203	......
			1947							
143-61-32daa	do.	185	Aug. 29	......	......	.5	194	133	133	......
143-62-8	Stutsman	26	......	......	28	0	300	286	569	......
143-62-8	do.	23	......	......	27	.4	124	94	70	......
143-62-8	do.	83	......	......	32	0	290	307	796	......
143-62-36cdd	Barnes	26	May 15	......	......	.1	136	115	42	......
143-65-34	Stutsman	115	......	......	13	.6	88	38	1,877	......
143-88-4cd1	Mercer	25.5	May 13	......	18	.05	133	65	197	.8
143-88-4cd2	do.	21.1	do.	......	8.4	.02	8.0	6.6	846	44
144-56-1	Steele	55	......	......	12	3	173	96	115	......
			1921							
144-56-1b	do.	45	June 8	......	37	2.4	500	176	100	
144-56-1b	do.	30	do.	......	34	.74	228	79	19	
144-56-1b	do.	30	do.	......	37	.40	341	111	38	
			1946							
144-56-1bad2	do.	34	Sept. 6	......	......	0	291	22	45	
144-56-1bca1	do.	42	do.	......	......	0	560	85		5.1
144-64-12	Stutsman	36	......	......	22	0	382	163	38	......
144-89-23	Mercer	28	......	......	27	20	152	56	89	......
			1921							
145-50-6b	Traill	200	June 24	......	37	1.6	142	54	929	
146-59-24c	Griggs	21	June 9	......	31	.08	198	112	475	

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
360	......	807	62	......	......	......	......	727	432	44	......	....	c
565	......	927	98	......	......	......	......	706	243	55	......	....	c
491	......	1,282	72	......	......	......	......	1,021	619	35	......	....	c
450	......	1,308	59	......	......	......	......	1,372	1,003	26	......	....	c
459	......	1,372	124	0.4	28	......	2,711	418	42	80	......	....	b
923	......	9,020	72	......	......	......	......	2,280	1,524	81	......	....	c
530	......	1,105	205	......	......	......	......	780	345	59	......	....	c
502	......	875	68	......	......	......	......	720	308	49	......	....	c
215	0	[illegible]32	60	......	......	......	......	251	45	......	......	....	c
488	......	800	65	......	......	......	......	700	300	47	......	....	c
386	......	934	112	......	......	......	......	680	363	53	......	....	c
420	0	284	70	......	......	......	......	460	116	......	......	....	c
500	......	383	68	......	......	......	......	490	80	47	......	....	c
451	......	796	91	......	......	......	......	1,027	657	22	......	....	c
471	......	2,249	305	.2	18	......	4,391	1,934	1,548	39	......	....	b
244	......	561	46	.2	3.1	......	1,156	699	499	18	......	....	b
473	......	2,719	310	.2	88	......	5,355	1,996	1,608	47	......	....	b
357	......	549	34	......	......	......	......	814	521	10	......	....	c
669	......	165	2,613	1.6	.8	......	5,250	370	0	92	......	....	b
604	0	438	25	.2	67	0.05	1,240	599	104	41	1,740	7.5	a
1,750	244	21	76	1.2	2.0	.33	2,130	47	0	95	3,280	9.1	a
484	......	483	99	.2	53	......	1,330	833	436	23	......	....	b
398	0	1,600	120	......	1.0	......	2,752	1,972	1,646	10	......	....	a
437	0	422	94	......	24	......	1,164	894	536	4	......	....	a
408	0	720	210	......	......	......	1,700	1,310	975	6	......	....	a
373	......	555	26	......	......	......	......	818	512	11	......	....	c
495	......	1,060	182	......	......	......	......	1,750	1,344	1	......	....	c
362	......	1,299	42	.6	2.7	......	2,349	1,625	1,328	5	......	....	b
500	......	390	16	.2	7.5	......	1,139	649	239	24	......	....	b
305	0	1,241	760	......	......	......	3,431	576	326	78	......	....	a
476	0	1,418	104	......	......	......	2,691	954	564	52	......	....	a

461397 O - 58 - 4

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
146-69-13	Wells	60	...	...	31	1	300	131	111	...
146-71-15	...do	211	...	...	85	14	152	10	204	...
146-73-23	...do	30	...	...	23	3.8	181	58	417	...
146-77-11	Sheridan	22	...	...	25	4.0	49	7.2	454	...
147-56-31	Steele	60	...	...	30	1	300	60	242	...
147-56-31	...do	48	...	...	23	.6	213	66	271	...
147-56-31	...do	50	...	...	35	1.4	166	34	318	...
147-56-31	...do	48	...	...	30	.6	226	104	253	...
147-56-31	...do	36	...	...	24	0	161	33	384	...
147-56-31	...do	48	...	...	28	6	243	83	251	...
147-56-31	...do	60	...	...	28	.7	167	70	354	...
147-56-32b	...do	52	June 9	...	30	.30	408	187	30	
147-56-32b	...do	46	...do	...	30	.53	302	165	141	
147-62-5	Foster	21	...	...	28	3.0	319	133	285	...
147-62-5d	...do	16	June 9	...	28	.8	268	138	40	
147-80-28	McLean	30	...	...	33	.6	440	111	212	...
147-80-28	...do	12	...	...	51	0	348	105	296	...
			1950							
147-88-29aaa	...do	64	Aug. 9	...	31	29	70	30	400	10
			1921							
148-51-1b	Traill	162	June 23	...	36	1.5	168	62	982	
			1946							
148-51-25cc3	...do	10	Oct. 2	...	...	.08	230	46	90	...
148-51-26dda	...do	16	Oct. 8	...	...	.9	172	41	229	...
148-51-36	...do	...	...	...	32	4.8	261	88	1,302	...
148-70-7	Wells	157	...	...	28	1	59	30	450	...
			1921							
148-70-7d	...do	148	June 1	...	32	.59	59	27	378	
148-84-8c	McLean	35	June 18	...	31	.20	187	78	26	
150-72-21	Wells	40	...	...	32	6.4	153	69	221	...
150-78-4	McLean	160	...	...	26	16	257	131	900	...
			1950							
150-91-8dda	...do	118	Nov. 3	46	33	.83	64	27	430	11
151-86-10	Ward	21	...	...	28	.02	36	138	277	...
151-86-10	...do	25	...	...	24	.2	52	202	376	...
151-86-10	...do	16	...	...	19	.2	104	125	186	...
151-86-10	...do	24	...	...	30	1.4	159	148	168	...
151-86-10	...do	48	...	...	23	.7	276	122	...	...
151-86-10	...do	28	...	...	24	.2	256	135	158	...
152-56-7	Grand Forks	30	...	...	29	.4	103	91	138	...
152-56-7	...do	20	...	...	32	.8	145	137	248	...
152-56-7	...do	38	...	...	26	.3	160	166	198	...
152-77-33	McHenry	35	...	...	25	.3	153	77	191	...
152-86-27	Ward	20	...	...	36	0	314	110	48	...

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
532	......	617	321	0.6	6.2	......	1,974	1,296	860	16	......	......	b
688	......	294	34	.8	2.6	......	1,185	479	0	51	......	......	b
658	......	1,002	24	0	1	......	2,131	710	170	57	......	......	b
842	......	117	230	3	3.5	......	1,271	160	0	87	......	......	b
574	......	968	36	0	18	......	2,038	1,003	532	35	......	......	b
571	......	891	35	.6	2.7	......	1,792	815	347	42	......	......	b
569	......	710	30	.8	6.2	......	1,596	563	96	56	......	......	b
549	......	994	40	.4	6.2	......	2,060	992	542	36	......	......	b
500	......	857	50	.8	2.7	......	1,801	541	131	61	......	......	b
523	......	986	36	.8	2.7	......	1,964	963	534	37	......	......	b
484	......	950	68	.2	.7	......	1,888	710	313	52	......	......	b
547	0	998	213	......	80	......	2,522	1,787	1,338	4	......	......	a
464	0	1,232	42	......	10	......	2,339	1,431	1,051	18	......	......	a
496	......	697	593	.6	.9	......	2,411	1,351	944	32	......	......	b
400	0	430	228	......	250	......	1,694	1,240	1,112	7	......	......	a
503	......	1,189	144	0	212	......	2,807	1,562	1,150	23	......	......	b
718	......	526	534	0	71	......	2,502	1,360	771	33	......	......	b
856	0	430	20	.4	3.8	0.20	1,500	298	0	74	2,030	7.4	a
290	0	1,270	860	......	......	......	3,660	674	436	76	......	......	a
402	......	108	375	......	......	......	......	764	434	20	......	......	c
856	0	801	518	......	......	......	......	598	0	45	......	......	c
312	......	1,340	1,551	0	20	......	4,825	1,020	764	74	......	......	b
749	......	359	190	.4	9.7	......	1,494	285	0	78	......	......	b
651	0	309	170	......	......	......	1,321	258	0	76	......	......	a
490	0	422	10	......	2.6	......	1,052	788	386	7	......	......	a
651	......	585	37	.4	2.7	......	1,460	680	146	42	......	......	b
766	......	2,285	111	0	6.7	......	4,271	1,212	584	62	......	......	b
854	0	500	16	......	3.1	......	1,520	271	0	77	2,160	7.8	a
444	......	436	285	0	53	......	1,509	661	297	48	......	......	b
532	......	849	413	0	1.8	......	2,385	965	529	46	......	......	b
462	......	633	42	.8	106	......	1,446	780	401	34	......	......	b
349	......	386	284	.8	354	......	1,931	1,010	724	27	......	......	b
344	......	569	156	.6	44	......	1,461	1,195	913	......	......	......	b
378	......	402	173	0	708	......	2,111	1,200	890	22	......	......	b
556	......	293	50	0	2.7	......	1,128	632	176	32	......	......	b
581	......	732	104	0	106	......	1,851	930	454	37	......	......	b
624	......	668	140	0	.9	......	1,969	1,083	571	28	......	......	b
390	......	596	77	.2	80	......	1,342	699	379	37	......	......	b
495	......	798	67	.2	18	......	1,810	1,243	837	8	......	......	b

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1950							
152-88-21	Mountrail	14	......	......	26	3.0	157	43	382	......
152-88-21	do	85	......	......	38	50	549	211	212	......
153-58-32	Nelson	90	......	......	27	.8	16	4.6	675	......
153-60-27	do	15	......	......	22	.8	178	121	307	......
			1921							
153-60-32d	do	18	May 4	......	29	4.5	254	115	288	
153-61-25	Ramsey	90	......	......	26	.2	52	16	629	......
153-64-2	do	30	......	......	37	.3	434	190	416	......
			1946							
153-66-8ddd	Benson	22	Sept. 1	......	......	1.0	250	97	350	
			1948							
153-66-20bab	do	239	May 4	......	......	.4	110	47	400	
153-66-21aab	do	103	Aug. 17	......	......	1.9	110	72	450	
			1947							
153-67-2dca	do	72	June 12	......	......	0	25	7	750	
			1949							
153-67-2dcb2	do	73	Sept. 30	......	......	.2	26	12	830	
			1946							
153-67-3dcd	do	96	Sept. 1	......	......	43	140	36	230	
153-67-15	do	35-40	......	......	20	1.0	267	102	107	......
153-67-15	do	35	......	......	21	.3	434	561	1,124	......
			1952							
153-67-15cab	do	50	May 14	......	......	.9	280	690	1,990	
			1946							
153-67-15dba2	do	22	July 12	......	......	2.1	440	220	930	
153-67-15dbb2	do	40	do	......	......	1.2	420	170	66	
153-67-15dbd1	do	60	do	......	......	2.8	420	97	380	
153-67-15dcc1	do	25	do	......	......	.4	430	170	110	
153-67-19aaa	do	20	Sept. 1	......	......	2.0	180	61	250	
			1952							
153-67-21aaa	do	50	May 9	......	......	.7	95	84	250	
			1948							
153-67-36bcc	do	200	May 4	......	......	3.5	95	29	550	
154-67-6	do	206	......	......	22	0	76	21	495	......
			1921							
154-100-26a	Williams	Spring	May 29	......	25	1.1	52	33	290	
155-60-27	Ramsey	20	......	......	35	3.6	300	124	105	......
155-60-27	do	20	......	......	25	.7	372	141	129	......
155-79-8aa	McHenry	103	......	......	10	.20	17	5.0	577	......

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
518	......	944	3.0	0.2	0.4	......	1,938	582	157	59	......	......	b
595	......	2,214	2.0	0	.4	......	3,788	2,334	1,846	17	......	......	b
777	......	392	343	.4	0	......	1,808	62	0	96	......	......	b
471	......	1,134	28	.6	4.0	......	2,204	944	558	41	......	......	b
517	0	1,174	40	......	3.6	......	2,261	1,107	683	4	......	......	a
576	......	1,025	10	.4	13	......	2,063	200	0	87	......	......	b
527	......	2,178	50	1.0	.3	......	3,940	1,867	1,435	33	......	......	b
560	0	1,160	140	......	......	......	......	1,020	561	43	......	......	c
590	......	700	80	0	6.4	......	......	470	0	65	......	......	c
550	......	870	150	.03	26	......	......	570	119	63	......	......	c
820	......	400	450	0	......	......	......	90	0	95	......	......	c
770	14	370	610	0	10.8	......	......	110	0	94	......	......	c
440	19	460	140	......	......	......	......	500	107	50	......	......	c
498	......	368	347	0	53	......	1,607	1,092	684	18	......	......	b
512	......	4,445	569	.4	2.7	......	7,776	3,396	2,976	42	......	......	b
600	0	6,570	380	0	......	......	......	3,540	3,048	55	......	......	c
520	0	3,040	360	......	......	......	......	2,000	1,574	50	......	......	c
230	48	1,300	200	......	......	......	......	1,750	1,482	8	......	......	c
350	7	1,680	160	......	......	......	......	1,450	1,152	36	......	......	c
320	25	1,450	260	......	......	......	......	1,780	1,476	12	......	......	c
550	0	710	30	......	......	......	......	700	249	44	......	......	c
370	0	680	86	......	2.1	......	......	580	277	48	......	......	c
600	......	870	110	0	......	......	......	360	0	77	......	......	c
629	......	653	108	1.4	5.3	......	1,703	280	0	80	......	......	b
568	0	428	2.0	......	1.8	......	1,130	265	0	70	......	......	a
444	......	524	356	0	106	......	1,845	1,168	804	15	......	......	b
591	......	494	494	0	124	......	2,165	1,514	1,029	16	......	......	b
1,112	......	7.0	286	4.0	1.3	......	1,476	79	0	95	......	......	b, c

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1951							
155-79-19bb...	McHenry...	30.7	May 30.	43	20	0.29	128	48	198	8.7
			1921							
155-83-14a....	Ward........	200	May 23.	....	29	3.2	125	56	320	
155-83-14b....	...do........	Spring	June 17.	....	35	......	173	58	79	
155-83-14cd1..	...do........	132	May 23.	......	29	2.6	56	27	353	
			1940							
155-83-14cd2..	...do........	158	Feb. 1.	....	30	2.3	56	25	262	....
155-83-14dc1..	...do........	160	...do......	......	26	3.0	52	27	247	....
			1946							
155-83-14dd2..	...do........	145	Sept. 20.	......	....	.10	106	33	290	....
			1921							
155-85-11d....	...do........	30	May 24.	......	19	.11	406	158	105	
156-57-24......	Walsh.......	25	....	......	36	1.1	255	122	143	....
156-57-24......	...do........	18	....	......	34	2.6	287	167	134	....
156-60-28......	Ramsey.....	25	....	......	20	.6	101	31	432	....
156-70-8.......	Benson......	80	....	......	33	3.0	43	7.6	391	....
			1946							
156-79-3dd.....	McHenry...	97.0	July 9.	49	18	......	66	24	457	12
156-79-10aa2..	...do........	121.0	....	......	7.4	.09	5.0	2.3	562	12
156-87-21......	Ward........	30	....	......	31	.6	228	113	32	....
156-88-12......	Mountrail..	60	....	......	36	4.0	318	146	198	....
156-96-15......	...do........	30	....	......	32	.6	347	131	120	....
156-97-9.......	Williams...	48	....	......	30	.3	596	251	127	....
157-58-13......	Walsh.......	15	....	......	27	.2	288	117	151	....
157-58-13......	...do........	14	....	......	28	13	521	465	493	....
157-58-13......	...do........	25	....	......	26	.8	427	171	9.5	....
157-58-13......	...do........	32	....	......	37	18	158	74	208	....
			1951							
157-77-5dc1...	McHenry...	40	June 4.	49	26	.44	462	290	75	12
157-80-22bd2..	...do........	27.0	June 9.	42	23	1.9	232	281	129	8.6
157-94-36......	Mountrail..	18	....	......	31	.2	76	33	342	....
157-95-27......	Williams...	60	....	......	41	1.2	186	98	50	....
158-74-14......	Pierce......	44	....	......	32	11.0	240	92	314	....
158-74-14......	...do........	40	....	......	27	3.0	374	136	557	....
158-78-8dd1...	McHenry...	62.0	June 11.	48	19	1.9	247	132	214	7.5
158-79-22aa...	...do........	13.0	...do......	52	21	2.6	174	47	33	132
			1946							
158-80-13aa3.	...do........	75.0	July 2.	......	18	......	186	68	544	18

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
								Calcium, magnesium	Noncarbonate				
398	30	525	17	1.2	20	......	1,210	517	141	45	1,640	8.5	a
742	0	291	232	......	......	......	1,454	542	0	56	......	......	a
537	0	365	6.0	......	......	......	1,093	670	0	20	......	......	a
799	0	68	200	......	......	......	1,135	251	230	75	......	......	a
677	......	67	133	.7	......	......	1,220	245	0	70	......	......	c
648	......	105	153	.5	......	......	1,260	316	0	69	......	......	c
744	......	144	190	......	......	......	1,150	390	0	61	......	......	c
403	0	1,465	26	......	1.5	......	2,548	1,660	1,330	12	......	......	a
371	......	1,032	44	.6	16	......	2,037	1,144	840	21	......	......	b
469	......	1,161	48	.8	44	......	2,286	1,408	1,023	17	......	......	b
542	......	589	187	0	11	......	1,672	390	0	71	......	......	b
739	......	362	6.0	.2	4.4	......	1,244	144	0	86	......	......	b
659	0	3.9	540	.4	1.9	1.8	1,440	263	0	78	2,630	7.8	a
980	......	7.5	340	.3	2.8	......	1,460	22	0	98	......	......	c
523	......	774	14	1.1	.1	......	1,597	1,185	756	6	......	......	b
603	......	1,233	35	0	11	......	2,547	1,406	912	24	......	......	b
564	......	924	174	.2	2.8	......	2,274	1,413	951	16	......	......	b
598	......	1,630	385	0	888	......	3,685	2,526	2,036	10	......	......	b
500	......	502	303	0	213	......	1,951	1,202	792	21	......	......	b
408	......	3,236	92	.4	8.8	......	5,599	2,770	2,435	25	......	......	b
462	......	504	610	.4	44	......	2,161	1,778	1,399	1	......	......	b
498	......	437	25	1.6	354	......	1,721	734	326	39	......	......	b
412	0	408	352	.2	1,550	......	3,800	2,350	2,010	6	4,480	7.6	a
378	0	815	197	.2	830	......	3,040	1,740	1,430	14	3,530	8.1	a
961	......	245	16	0	7.0	......	1,286	327	0	70	......	......	b
805	......	112	133	1.4	18	......	1,116	875	215	11	......	......	b
447	......	1,250	4.8	.1	11	......	2,261	999	632	41	......	......	b
451	......	2,231	11	.1	6.6	......	3,729	1,503	1,133	45	......	......	b
190	0	468	430	.2	478	.05	2,350	1,160	1,000	29	3,060	7.9	a
446	0	222	59	.2	219	......	1,250	628	262	8	1,630	7.7	a
456	0	858	505	.3	6.4	1.8	2,470	744	370	61	3,650	7.6	a

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1948							
158-82-3db	Renville	180	May 28	...	26	8.0	73	24	343	7.2
			1947							
158-82-22cd	do	200	June 14	46	19	7.5	55	22	359	9.6
			1948							
158-82-32ab2	do	275	May 28	...	20	14	168	48	383	7.2
158-87-14	Ward	25	...	...	20	.6	115	94	392	...
158-87-14	do	21	...	...	20	.8	113	96	490	...
158-87-14	do	25	...	...	20	.3	156	66	215	...
158-87-14	do	27	...	...	23	1.3	108	50	313	...
158-87-14	do	20	...	...	28	.6	167	160	590	...
158-87-14	do	21	...	...	26	.7	70	82	271	...
158-87-14	do	15	...	...	20	1.3	75	44	262	...
158-87-14	do	14	...	...	21	.5	152	109	672	...
158-87-14	do	24	...	...	27	.4	129	61	193	...
158-87-14	do	30	...	...	23	.2	84	55	258	...
159-60-27	Cavalier	43	...	...	28	.4	42	21	692	...
159-75-12	Bottineau	10	...	...	29	1.4	143	77	56	...
159-78-22	McHenry	125	...	...	17	0	18	6.6	420	...
			1951							
159-78-22bc3	do	62	June 15	50	26	.48	48	123	156	3.5
159-80-14da2	do	14	June 16	50	24	.16	112	61	69-	66.6
159-80-35bbb	do	25	Aug. 16	...	16	...	170	79	30	
			1948							
159-82-35ad	Bottineau	300	May 28	...	23	7.5	74	22	307	5.2
160-58-20	Cavalier	29	...	...	38	.4	164	70	341	...
160-58-20	do	35	...	...	25	.5	21	7.4	548	...
160-68-5	Towner	20	...	...	19	.05	405	198	142	...
160-69-31	Rolette	42	...	...	29	1.6	152	90	62	...
			1951							
160-79-19db2	Bottineau	90	June 19	46	27	2.0	338	297	138	9.4
160-80-30	do	12	...	...	14	.4	141	79	125	...
160-81-24dd	do	7.0	July 2	40	21	.16	72	142	39	12
			1948							
160-82-17dd2	do	182	May 28	...	26	3.2	81	27	316	8.8
161-52-7	Pembina	86	...	...	20	6.0	442	192	381	...
161-81-35cd	Bottineau	12.5	...	...	27	.3	186	97	175	...
			1921							
162-69-16b	Rolette	16	May 6	...	30	...	159	40	152	
162-72-25c	do	Spring	May 11	...	35	.06	169	19	220	
162-72-30b	do	190	May 12	...	31	...	196	60	63	
162-73-22a	do	Spring	do	43	30	.07	192	65	79	
162-75-7	Bottineau	50	...	...	26	1.0	145	69	120	...

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°)	pH	Source of data
672	0	134	269	0.2	3.0	0.21	1,360	281	0	72	1,920	7.8	a
403	0	417	196	.3	1.5	.48	1,310	228	0	76	2,050	8.3	a
635	0	664	140	.2	3.2	.53	1,840	617	96	57	2,380	7.8	a
937	......	528	133	0	29	......	1,739	675	0	56	......	......	b
820	......	919	37	0	80	......	2,238	680	8	61	......	......	b
520	......	284	209	0	142	......	1,353	660	234	41	......	......	b
898	......	230	107	0	44	......	1,306	500	0	59	......	......	b
721	......	1,181	116	0	425	......	2,898	1,077	486	54	......	......	b
671	......	227	143	.4	142	......	1,225	515	0	54	......	......	b
456	......	295	149	.6	62	......	1,077	372	0	61	......	......	b
917	......	1,264	156	.2	3.5	......	2,899	830	78	64	......	......	b
695	......	300	74	0	13	......	1,128	575	5	42	......	......	b
549	......	260	149	.2	71	......	1,098	436	0	56	......	......	b
364	......	1,292	42	0	.9	......	2,356	200	0	89	......	......	b
421	......	310	90	0	11	......	1,090	680	335	15	......	......	b
810	......	43	194	.6	8.8	......	1,141	77	0	93	......	......	b
264	18	378	193	.4	61	......	1,210	626	379	35	1,720	8.5	a
198	8	135	49	.2	364	.18	1,090	532	357	22	1,330	8.2	a
254	0	525	4.0	2.0	60	......	1,060	748	540	8	1,340	7.6	a
786	0	26	216	.8	1.8	.29	1,080	275	0	70	1,690	7.9	a
383	......	888	140	.8	11	......	1,906	705	391	52	......	......	b
366	......	830	76	.8	6.7	......	1,687	86	0	93	......	......	b
429	......	1,498	160	.6	90	......	2,995	1,836	1,484	14	......	......	b
388	......	464	65	.4	1.3	......	1,148	759	441	15	......	......	b
418	0	740	372	.4	908	......	3,490	2,070	1,730	13	4,030	7.6	a
407	......	495	69	0	4.0	......	1,105	678	344	29	......	......	b
570	0	75	128	.2	200	......	1,240	762	295	10	1,600	8.1	a
782	0	8.8	250	.6	1.5	.14	1,150	313	0	68	1,700	8.0	a
181	......	327	1,595	.4	15	......	3,263	1,992	1,774	30	......	......	b
286	......	527	292	.4	71	......	1,534	872	637	31	......	......	b
493	0	296	98	......	39	......	1,055	562	158	37	......	......	a
481	0	533	8.0	......	3.4	......	1,227	500	106	49	......	......	a
522	5	417	6.0	......	2.0	......	1,102	736	308	16	......	......	a
529	0	428	5.0	......	1.5	......	1,068	746	312	19	......	......	a
607	......	405	5.2	1.4	.09	......	1,138	667	169	29	......	......	b

Table 6.—*Chemical analyses of saline ground water from*

Location	County	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
			1921							
162-75-7......	Bottineau..	50	....	....	30	1.4	229	87	0	....
162-75-7......	...do........	50	....	....	50	.2	223	85	....	....
162-75-15c....	...do........	14	May 16..	....	14	.67	49	19	492	
			1951							
162-81-11bc1..	...do........	30	July 3...	43	20	.10	139	79	31	8.9
			1948							
162-88-34dc...	Burke......	320	May 29...	....	2.9	3.0	271	80	440	7.2
			1947							
162-89-3ad.....	...do........	182	June 5...	50	25	30	93	44	391	17
			1951							
162-90-10cbc.	...do........	22.5	Aug. 28..	....	16	....	407	2,410	2,720	
162-94-3......	...do........	26	....	....	30	.36	228	67	82	....
162-94-3......	...do........	30	....	....	27	0	63	64	309	....
162-94-3ad2..	...do........	26	....	....	30	.36	228	67	82	
163-70-15.....	Rolette.....	16	....	....	20	1.0	154	307	309	....
163-70-15.. ..	...do........	155	....	....	36	1.0	364	159	76	....
163-77-29.....	Bottineau...	45-50	....	....	25	3.0	353	126	47	....
163-80-5dc....	...do........	20	June 25..	44	22	.63	336	143	46	43
163-84-6ad....	Renville....	22	Aug. 1..	....	17	....	337	1,370	1,210	
			1947							
163-88-4bb....	Burke......	120	June 12..	45	12	.60	44	9.8	653	12
163-88-24bb1.	...do........	440	...do......	50	23	....	423	307	215	23
163-89-8ad....	...do........	153	June 5..	50	13	8.0	45	21	729	3.2
			1948							
163-89-25ad..	...do........	200	June 2..	....	2.5	.80	36	21	978	15
163-91-7bb....	...do........	140	Sept. 11..	49	25	16	195	45	217	2.8
163-92-15bb..	...do........	200	June 2..	....	12	....	348	103	402	12
164-53-31cab.	Pembina....	23	Oct. 23..	....	....	1.5	400	320	....	....
164-53-31cbc2	...do........	20	...do......	....	....	.15	400	150	40	
164-53-31ccb.	...do........	13	...do......	....	....	.45	560	230	35	....
164-53-31ccd2	...do........	20	...do......	....	....	.53	420	73	170	....
164-53-31dcc..	...do........	20±	...do......	....	....	.88	180	63	45	....
164-92-34dc2.	Burke.......	345	Sept. 11..	44	8.0	41	33	58	918	12

glacial drift and alluvium, North Dakota—Continued

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Source of data
376	......	405	8.0	0	1.8	......	1,112	930	622	0	....	......	b
583	......	444	8.5	0	1.8	......	1,141	905	427	......	....	......	b
688	0	656	12	......	....	......	1,648	200	0	84	....	......	a
276	14	180	44	.2	300	......	1,000	672	423	9	1,330	8.3	a
478	0	1,430	42	.4	4.4	0.21	2,680	1,010	618	48	3,010	7.2	a
576	33	593	72	.6	3.0	.55	1,550	413	0	66	2,090	8.1	a
805	0	15,400	107	2.0	1.1	......	24,100	10,900	10,200	35	18,400	7.8	a
487	......	144	320	1.6	22	......	1,109	844	445	17	....	......	b
330	......	659	93	2.2	3.5	......	1,447	422	151	62	....	......	b
487	......	144	320	1.6	22	......	1,109	844	445	17	....	......	c
944	......	532	646	1.0	106	......	2,683	1,654	880	29	....	......	b
561	......	1,221	4.0	.2	1.3	......	2,332	1,568	1,108	10	....	......	b
437	......	738	220	.2	88	......	2,041	1,407	1,047	7	....	......	b
408	0	290	140	.2	895	......	2,430	1,430	1,100	6	2,860	8.0	a
321	0	8,470	24	2.0	11	......	12,900	6,490	6,230	29	10,100	8.0	a
678	33	884	18	.2	3.5	.50	2,020	150	0	90	2,960	8.6	a
305	36	1,110	299	.4	1,180	.23	3,920	2,320	2,010	18	4,600	8.5	a
844	35	872	58	.6	1.5	.46	2,220	199	0	89	3,330	8.4	a
566	5	1,710	34	.6	1.6	.40	3,120	176	0	92	4,070	8.1	a
368	0	754	18	1.4	3.8	.46	1,520	672	370	40	1,860	6.8	a
396	0	1,730	24	.6	14	.42	3,110	1,290	965	40	3,010	7.3	a
570	......	1,840	140	.2	90	......	....	2,300	1,833	......	....	......	c
490	......	1,120	85	.2	6.5	......	....	1,600	1,198	5	....	......	c
500	......	1,920	33	......	....	......	3,280	2,350	1,940	3	....	......	c
580	......	630	310	6.2	170	......	2,350	1,340	864	22	....	......	c
440	......	390	1.0	.5	6.5	......	1,120	700	339	12	....	......	c
412	12	1,880	19	.6	.4	.30	3,170	317	0	86	4,070	8.2	a

SALINE STREAMS AND LAKES

Most of the streams in the Drift Prairie and Red River Valley are not saline. The major streams tributary to the Missouri River in the Missouri Plateau, however, are slightly saline at low flow. These tributary streams drain areas where rocks of Cretaceous and Tertiary age are exposed or lie close to the surface, and they are usually at low (base) flow except during periods of spring runoff and summer rains. The water during low-flow periods is predominantly of the sodium sulfate type.

Table 7.—*Chemical analyses of*

[Analytical results in parts per

Date of collection	Instantaneous discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
										Des Lacs River
Apr. 5, 1949	1,590	8.4	0.15	15	3.0	12		67	0	17
Jan. 17, 1950	.13	26	.....	71	82	325		728	0	530
July 24, 1950	30.4	13	.02	39	26	153		354	0	210
										Little Missouri River
July 23, 1948	340	13	0.00	82	25	129		136	0	450
Dec. 19, 1949	.3	15	.06	46	46	533		656	0	885
Apr. 4, 1950	2,730	8.0	.16	15	3.5	19		68	0	34
										Little Missouri River
Jan. 1 to Feb. 4, 1948	[1]5	18	0.02	123	54	525	11	622	0	1,100
Mar. 19, 1948	[1]5,120	7.3	.06	18	5.3	28		100	0	37
Mar. 11 to Sept. 30, 1947[2]	[1]1,360	8.8	.24	50	15	80	14	175	0	221
Oct. 1, 1947 to Sept. 30, 1948[2]	[1]457	14	.07	44	13	97	3.3	163	0	235
Oct. 1, 1948 to Sept. 30, 1949[2]	[1]596	12	.02	32	14	50	2.5	[3]136	....	133
										Little Missouri River
Mar. 26, 1947	25,400	7.8	0.60	42	8.7	35	3.8	172	0	69
June 8, 1948	670	17	.00	61	24	263		294	0	552
Sept. 8, 1949	13	16	.02	86	40	350		456	0	725
										Knife River north-
Aug. 18, 1950	....	8.0	0.04	34	17	474	6.5	656	0	595

See footnotes at end of table.

Chemical analyses of water from saline streams are given in table 7. For some stations, analyses represent the quality of the water at high, near-average, and low flows. Weighted-average analyses are shown for those stations where samples were collected daily. The averages were computed by weighting each determined concentration with water discharge; they represent approximately the chemical character of the water if all the water passing a station during the period of the weighted average were impounded and mixed. Most of the analyses in table 7 were taken from U. S. Geological Survey Water-Supply Papers 1050, 1102, 1132, 1162, 1187, and 1198.

saline streams in North Dakota

million except as indicated]

Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million: Residue on evaporation at 180°C	Dissolved solids: Parts per million: Sum	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
at Foxholm											
0.8	0.1	3.9	0.01	115	....	0.16	50	0	35	157	7.2
46	....	8.7	....	1,500	1,450	2.04	514	0	58	2,000	7.8
18	.2	2.6	....	682	....	.93	205	0	62	928	7.5
at Marmarth											
4.0	0.2	2.6	0.21	842	....	1.15	307	195	48	1,090	7.8
2.0	.6	.9	....	1,910	1,850	2.60	304	0	79	2,570	8.1
.0	.2	1.9	....	138	....	.19	52	0	44	187	6.7
at Medora											
15	0.4	1.0	0.27	2,200	2,160	2.99	529	19	68	2,800	8.2
2.0	.6	3.0	....	182	....	.25	67	0	48	247	7.3
2.6	.3	1.7	....	484	....	.66	186	42	46	704	......
3.2	.5	2.1	.13	520	....	.71	164	30	56	716	......
.5	.2	1.6	.14	336	....	.46	138	26	44	494	......
near Watford City											
3.8	0.1	3.0	0.12	260	....	0.35	141	0	34	417	7.7
4.1	.3	1.7	....	1,110	1,070	1.51	251	10	70	1,420	7.7
6.5	.4	2.2	.39	1,510	1,450	2.05	379	5	67	2,030	8.1
west of Manning											
4.7	0.6	2.7	0.10	1,500	1,460	2.04	154	0	86	2,150	7.9

Table 7.—*Chemical analyses of saline*

Date of collection	Instantaneous discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
										Crooked Creek
Aug. 21, 1950	....	11	0.10	....	....	608		794	28	900
										Knife River near
July 19, 1946	123	....	0.02	30	13	83		177	10	138
Mar. 25, 1947	1,700	6.6	......	10	4.5	28	7.6	90	0	18
Oct. 19, 1948	6.3	23	.11	41	35	398		664	20	502
										Knife River
Aug. 23, 1950	....	15	0.08	51	34	315	8.2	628	0	433
										Knife River
May 31, 1949	181	10	0.01	50	33	356		632	0	488
May 18, 1950	357	11	.10	47	20	130		278	6	230
Mar. 31, 1951	7,600	4.1	.40	14	2.2	20		66	0	27
										Heart River near
Jan. 12-20, 1948	[1]0.6	23	0.02	38	30	712	9.2	1,070	0	869
Mar. 31 to Apr. 2, 1949	[1]2,060	7.9	.24	10	1.9	15	3.2	48	0	26
May 17 to Sept. 30, 1947[2]	[1]51	14	.08	26	10	72	7.3	[3]171	....	124
Oct. 1, 1947 to Sept. 30, 1948[2]	[1]31	9.8	.23	14	5.0	46	11	[3]107	....	73
Mar. 1 to Sept. 27, 1949[2]	[1]85	11	.28	13	3.1	24	2.8	[3]64	....	39
										Cannonball River
Aug. 19, 1950	....	16	0.24	49	33	322		504	0	515
										Cedar Creek above mouth of
Aug. 29, 1950	....	8.0	0.06	102	61	270		436	0	688
										Duck Creek
Aug. 30, 1950	....	11	0.04	109	97	356		356	0	1,090
										Cedar Creek
Mar. 22, 1947	548	3.6	1.0	14	4.5	11	7.3	76	0	17
Aug. 15, 1950	148	12	.04	54	31	147		224	0	368
Dec. 7, 1950	5.5	15	.04	67	74	366		441	0	845

See footnotes at end of table.

streams in North Dakota—Continued

Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million: Residue on evaporation at 180°C	Dissolved solids: Parts per million: Sum	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
at Emerson											
5.0	0.6	0.7	....	2,110	....	2.87	321	0	80	2,830	8.3
Golden Valley											
0.9	0.4	1.4	....	412	....	0.56	128	0	58	543	8.2
15	.0	.2	0.06	130	....	.18	43	0	53	193	7.6
6.0	.6	1.0	.14	1,400	1,360	2.16	246	0	78	1,870	8.2
near Zap											
5.0	0.2	1.7	0.30	1,200	1,170	1.63	267	0	71	1,690	8.0
at Hazen											
3.4	0.6	1.6	....	1,350	1,260	1.84	261	0	75	1,870	7.9
1.0	.2	2.8	....	600	....	.82	200	0	59	899	8.2
1.0	.4	2.9	0.12	128	....	.17	44	0	49	170	7.2
South Heart											
7.0	0.7	13	1.1	2,270	2,230	3.09	218	0	87	3,100	8.2
1.0	.6	2.7	.20	112	....	.15	33	0	47	136	7.6
1.3	.1	.6	....	356	....	.48	106	0	58	550	......
.8	.3	1.8	....	233	....	.32	56	0	59	314	......
4.7	.5	2.0	.13	148	....	.20	45	0	52	198	......
near New England											
5.0	0.4	0.2	....	1,200	1,190	1.63	258	0	73	1,740	7.5
Chantapeta Creek											
10	0.6	5.0	....	1,420	1,360	1.93	506	148	54	1,950	7.5
above mouth											
11	0.4	3.3	....	1,940	1,850	2.64	671	379	54	2,490	7.2
near Pretty Rock											
4.0	0.0	0.2	0.04	116	....	0.16	53	0	27	169	7.4
10	.3	2.4	....	748	....	1.02	263	79	55	1,080	7.5
15	.6	2.7	.58	1,610	1,600	2.19	470	108	63	2,100	7.9

Table 7.—*Chemical analyses of saline*

Date of collection	Instantaneous discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
North Fork Grand										
Feb. 1-4, 1952.....	[1]3.0	....	.....	....	....	924		922	33	1,490
Apr. 6-8............	[1]11,080	....	.....	....	....	13		62	0	18
Feb. 25-Sept. 30, 1951[2].............	[1]38.3	8.1	0.08	22	9.0	119	7.4	[3]179	....	198
Oct. 1, 1951-Sept. 30, 1952[2]..	[1]143	....	.....	....	....	32		[3]81	....	49

[1] Mean daily discharge.
[2] Weighted average.

Figure 7 shows salinity-duration curves for the Little Missouri, Heart, and North Fork Grand Rivers. During the periods of record the streams were slightly saline about three-fourths of the time at Medora, South Heart, and Haley.

Except for the high-flow part of the flow-duration curves (see following table), the curves for the period of chemical-quality

Summary data from flow-duration curves

Station	Drainage area (sq mile)	Period of record	Percent of days flow was less than—			
			1 cfs	10 cfs	100 cfs	1,000 cfs
Little Missouri River at Medora..	6,190	October 1945-September 1953..	8	22	60	90
Heart River near South Heart.....	315	June 1947-September 1953.......	55	86	96	99
North Fork Grand River at Haley.	509	October 1945-September 1953..	25	80	95	99

record closely approximate the curves for the period of streamflow record. The flow-duration data for the Heart and North Fork Grand Rivers are considered to be fairly representative of the upper reaches of the major streams tributary to the Missouri River and of the creeks and smaller streams in western North Dakota. The flow-duration data for the Little Missouri River at Medora are considered to be representative of the lower reaches of the major tributaries of the Missouri River in western North Dakota.

streams in North Dakota— Continued

Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million: Residue on evaporation at 180°C	Dissolved solids: Parts per million: Sum	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
River at Haley											
12	....	....	....	3,130	....	4.26	400	0	83	4,020	8.4
1.3	....	....	0.28	112	....	.15	47	0	38	149	7.3
2.0	0.4	3.4	.30	475	....	.65	92	0	72	698	......
1.3	....	....	.24	174	....	2.37	56	0	58	247	......

[3] Includes carbonate as bicarbonate.

SOURIS RIVER BASIN

Chemical-quality data for several sites in the Souris River basin indicate that during periods of very low flow (less than about 5 cfs) the Des Lacs River is slightly saline at Foxholm. The water is of the sodium bicarbonate sulfate type; the maximum observed dissolved-solids concentration in samples taken at intervals of about a month during 1946–51 was 1,500 ppm in January 1950, and the minimum was 115 ppm in April 1949.

LITTLE MISSOURI RIVER BASIN

The chemical quality of the Little Missouri River was determined at Marmarth, at Medora, and near Watford City during 1945–51. Generally, the dissolved-solids concentration was greater than 1,000 ppm at Marmarth when the discharge was less than about 50 cfs and at Medora and near Watford City when less than about 200 cfs.

The slightly saline water of the Little Missouri River is generally of the sodium sulfate type. The maximum observed concentration of dissolved solids was 2,230 ppm (discharge, 5.3 cfs) on January 2, 1951, at Marmarth. The weighted averages for the period October 1947 to September 1949 at Medora represent annual mean discharges similar to the average discharge, 539 cfs, for 9 years of record during 1923–51.

461397 O - 58 - 5

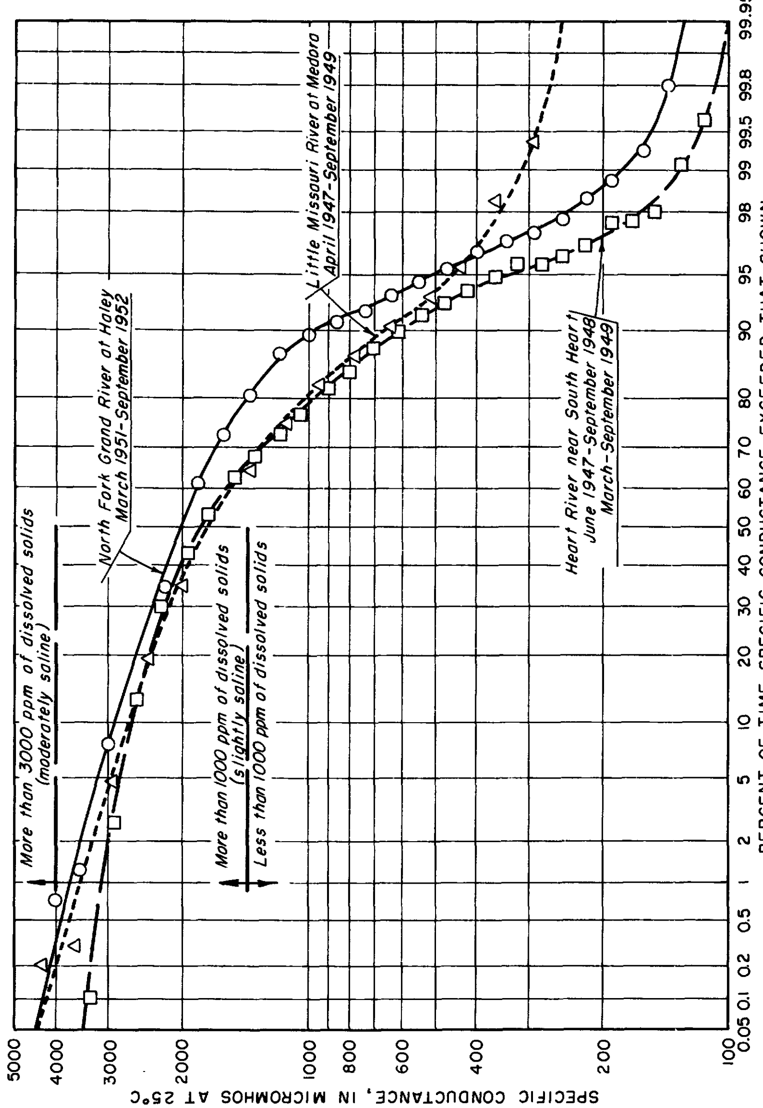


Figure 7. — Salinity-duration curves for Little Missouri, Heart, and North Fork Grand Rivers.

KNIFE RIVER BASIN

During the period 1945–51 the chemical quality of the Knife River near Golden Valley and at Hazen was investigated. Analyses of representative samples of high, near-average, and low flows at these sites are given in table 7 along with analyses of water from other sites on the Knife River and from Crooked Creek.

The maximum observed concentration of dissolved solids, which was in a sample from Crooked Creek, was 2,110 ppm. The waters of the basin are only slightly saline at low flow; sodium bicarbonate and sodium sulfate are the major salts in solution. Figure 8 shows the relation between specific conductance and discharge for the Knife River at Hazen. Dissolved solids in parts per million are approximately equal to 0.7 times the specific conductance in micromhos.

HEART RIVER BASIN

An unpublished report by Rainwater[2] summarizes the results of studies of the chemical quality of water in the Heart River basin during 1945–50.

Table 7 shows the analyses of water from the Heart River near South Heart for low and high flows and the weighted averages for May 1947 to September 1949. Generally, the water is saline only at low flows (less than 10 cfs near South Heart) and is of the sodium sulfate bicarbonate type. Table 8 shows maximum and minimum observed concentrations at several stations along the Heart River.

Analyses of samples collected from the Heart River below Heart Butte Dam near Glen Ullin in August and September 1950 indicated that releases from the reservoir were not saline. The dam was completed in time to impound the above-normal spring runoff of 1950.

CANNONBALL RIVER BASIN

The chemical quality of the Cannonball River near New Leipzig and at Breien and of Cedar Creek near Pretty Rock was investigated during 1945–50. In addition, a salinity survey of the entire basin was made in August and September 1950. These investigations indicated that streams in the basin are slightly saline at

[2] Rainwater, F. H., Chemical quality of surface waters in the Heart River basin, North Dakota: U. S. Geol. Survey Ms. rept.

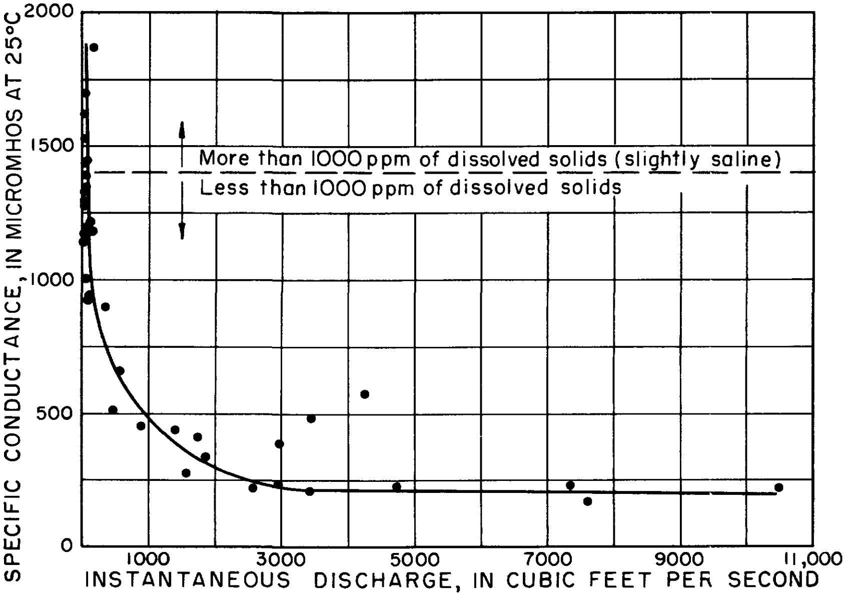


Figure 8. —Relation between water discharge and specific conductance, Knife River at Hazen, May 1946–September 1951.

low flow; the water is of the sodium sulfate bicarbonate type. Several analyses of saline surface waters in the basin are given in table 7.

GRAND RIVER BASIN

The chemical quality of the North Fork Grand River at Haley near the South Dakota State line was studied during the period November 1950 to September 1952. During March 1951–September 1952 water in the North Fork was slightly saline about 80 percent of the time. (See fig. 7.) During spring runoff, dissolved-solids concentrations were as low as 112 ppm. However, concentrations of 2,000 and 3,000 ppm were common during winter months; the maximum observed dissolved-solids concentration was 3,130 ppm for February 1–4, 1952. Sodium sulfate and sodium bicarbonate are the major salts in solution. (See table 7.)

DEVILS LAKE BASIN

Some analyses of saline lakes in the Devils Lake basin are given in table 9. The water in these lakes is of the sodium sulfate type, and the maximum observed concentration of dissolved solids was 116,000 ppm (residue on evaporation) for a partial analysis of a sample collected in June 1949 from eastern Stump Lake.

Table 8.—*Maximum and minimum observed concentrations of mineral constituents and other characteristics, Heart River, N. Dak.*

[Analytical results in parts per million except as indicated]

	Near South Heart		Near Dickinson		Near Richardton		Near Glen Ullin		Near Mandan	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Specific conductance....micromhos at 25°C..	3,100	136	1,990	113	2,270	272	1,920	191	1,650	336
Sodium (Na)[1]	712	12	437	9.2	401	20	373	10	306	21
Bicarbonate (HCO_3)[2]	1,070	46	743	50	780	96	635	100	510	144
Sulfate (SO_4)	869	21	522	9.0	772	43	596	4.9	452	49
Boron (B)	1.1	0.05	....	....	0.50	.03	0.41	0.00	0.48	0.07
Dissolved solids	[3]2,230	112	[3]1,320	87	[3]1,790	180	[3]1,420	131	[3]1,100	214
Hardness as $CaCO_3$	319	31	261	36	596	69	406	69	309	129
Percent sodium	91	35	89	19	74	30	80	10	81	26

[1] Or sodium and potassium calculated as sodium.
[2] Or bicarbonate and carbonate calculated as bicarbonate.
[3] Sum of determined constituents.

Table 9.—*Chemical analyses of saline lakes in*

[Analytical results in parts per

Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
									Devils
June 14, 1949	14	0.20	79	605	2,870	242	708	60	6,380
July 7, 1950	9.5	.04	54	303	1,670	177	548	0	3,480
May 22, 1951	3.6	......	90	286	1,650	160	583	0	3,450
May 15, 1952	7.6	.16	39	350	1,760	175	524	75	3,700
July 16, 1954	11	.04	120	398	2,250	236	666	81	4,780
June 26, 1955	....	......	81	316	1,730	....	558	75	3,650
									East Devils
June 18, 1949	9.2	0.09	26	1,870	10,300	832	1,120	365	23,500
Aug. 1, 1950	14	.06	8.8	1,630	8,750	837	1,030	271	19,800
May 14, 1952	16	.08	7.8	1,880	9,420	811	1,180	283	22,200
									Western
June 16, 1949	14	0.20	152	323	1,330	76	438	0	3,100
Aug. 1, 1950	9.1	.08	96	104	680	70	288	22	1,400
May 23, 1951	15	......	124	207	990	82	356	0	2,170
May 13, 1952	9.4	.20	53	302	1,240	102	354	0	2,700
									Eastern
June 16, 1949	16	0.10	33	5,710	21,900	956	930	220	55,500
Aug. 1, 1950	13	.06	4.0	4,130	14,300	985	711	107	36,200
May 23, 1951	11	......	133	3,970	14,100	860	797	77	35,900
May 13, 1952	12	.08	7.6	4,480	15,000	1,000	849	121	39,500
									Free Peoples
June 20, 1949	38	0.60	80	92	2,810	104	1,410	358	3,600
									Sixmile
June 20, 1949	16	0.02	64	120	488	52	409	0	1,150
									Spring
June 20, 1949	13	0.06	112	280	819	55	406	24	2,300
									Cranberry
June 17, 1949	22	0.02	4.0	5.0	8,220	65	2,250	3,270	9,730
									Stink
June 17, 1949	17	0.09	41	590	6,370	185	464	43	13,000

the Devils Lake area in North Dakota

million except as indicated]

Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million: Residue on evaporation at 180°C	Dissolved solids: Parts per million: Sum	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Lake											
1,330	2.0	19	....	12,500	12,500	17.0	2,680	2,000	68	13,800	8.4
775	.6	1.5	....	6,740	6,740	9.17	1,380	931	69	8,110	7.9
743	.2	5.2	....	6,700	6,680	9.11	1,400	922	69	8,340	8.1
840	.4	2.4	1.1	7,390	7,210	10.1	1,540	986	69	9,140	8.8
1,060	1.0	.5	1.7	9,340	9,270	12.7	1,940	1,260	69	11,200	8.7
788	....	....	....	7,080	....	9.63	1,500	918	68	8,780	8.8
Lake											
3,790	3.4	1.3	....	45,100	41,300	61.3	7,750	6,220	72	38,300	8.7
3,290	2.9	6.8	....	35,900	35,100	48.8	6,720	5,420	71	32,800	8.8
3,590	2.9	....	4.8	39,900	38,800	54.3	7,750	6,310	70	37,000	8.6
Stump Lake											
875	1.0	5.9	1.9	6,470	6,100	8.80	1,710	1,350	62	7,790	8.0
410	2.0	.8	....	3,110	2,940	4.23	667	394	66	4,080	8.4
593	.2	4.2	....	4,400	4,360	5.98	1,160	868	63	5,750	7.6
750	.4	3.1	1.1	5,520	5,340	7.51	1,380	1,090	64	7,150	8.1
Stump Lake											
9,890	1.3	7.3	13	108,000	94,700	147	23,600	22,500	66	63,600	8.3
7,390	2.8	10	....	69,400	63,500	94.4	17,000	16,200	63	48,600	8.3
7,140	2.7	37	....	66,000	62,600	89.8	16,700	15,900	63	52,800	8.3
8,040	2.9	....	8.0	70,900	68,600	96.4	18,400	17,500	62	57,000	8.4
Lake											
800	0.8	3.0	....	8,830	8,600	12.0	578	0	90	11,200	9.0
Bay											
219	0.8	4.1	....	2,480	2,320	3.37	653	318	60	3,370	7.9
Lake											
380	0.4	1.3	....	4,360	4,190	5.93	1,430	1,060	54	5,410	8.2
Lake											
591	....	3.8	....	23,500	23,100	32.0	31	0	99	25,600	9.8
Lake											
1,670	3.4	2.1	....	23,300	22,200	31.7	2,530	2,080	83	2[illegible],900	8.3

Table 9.—*Chemical analyses of saline lakes in*

Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
									Mission
June 20, 1949	13	0.11	26	421	2,290	228	261	70	4,990
									Black Tiger
June 20, 1949	49	0.40	120	708	3,470	216	708	73	7,360

According to Swenson and Colby (1955), the salinity of these lakes is caused mainly by evaporation; surface runoff has been insufficient for many years to cause the lakes to overflow. The lakes lie in the valley of a preglacial river, which, with its tributaries, is partly filled with glacial drift (Upham, 1895, p. 170–171). Surface inflow to Devils Lake is mostly from Mauvais Coulee, which is the largest stream in the basin and is intermittent. The lakes may also receive ground-water inflow from the lower part of the glacial drift, which is underlain by the Pierre shale. Evaporation from a lake surface in the vicinity of Devils Lake has been estimated at about 30 inches per year (Swenson and Colby, 1955), almost twice the mean annual precipitation.

Waters are classed as briny in eastern Stump and East Devils Lakes, very saline in Cranberry and Stink Lakes, and moderately saline in Devils, western Stump, Free Peoples, and Spring Lakes.

SUMMARY

Aquifers of Paleozoic age yield as much as 400 gpm of modererately saline to briny water of the sodium chloride type to wells in eastern North Dakota.

The Dakota sandstone, Fox Hills sandstone, and Hell Creek formation of Cretaceous age and the Fort Union formation of Tertiary age yield very small to large amounts of slightly saline to very saline water.

the Devils Lake area in North Dakota—Continued

Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million: Residue on evaporation at 180°C	Dissolved solids: Parts per million: Sum	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Bay											
1,170	1.0	0.9	2.8	10,000	9,340	13.6	1,800	1,470	70	11,600	8.9
Bay											
1,600	1.4	3.0	....	14,700	14,000	20.0	3,210	2,510	68	16,200	8.4

Saline water from the Dakota sandstone is only slightly saline in the southeastern part of the State but is moderately saline farther north. Sodium chloride and sodium sulfate are the principal dissolved salts in the water.

Fresh water is obtained from the Fox Hills sandstone in the southwestern part of the State, and small supplies of slightly saline water of the sodium bicarbonate type are obtained farther east.

The Hell Creek and Fort Union formations crop out in a major part of the Missouri Plateau. Generally, saline water from the Hell Creek formation and upper part of the Fort Union formation is of the sodium bicarbonate sulfate type, and that from the Cannonball member of the Fort Union formation is of the sodium chloride type. Wells in these aquifers produce small to moderate supplies of slightly saline water in the western part of the State.

Glacial drift and alluvium of Quaternary age yield slightly saline water in widely varying amounts throughout much of the State. Because the hydrologic and lithologic characteristics of the drift and alluvial deposits are highly variable, the quantity and quality of the water from these deposits also are variable.

The major streams tributary to the Missouri River in western North Dakota are slightly saline at low flow. Sodium bicarbonate and sodium sulfate are the principal dissolved salts. Some lakes in the Devils Lake basin are briny, and others are very saline to slightly saline.

SELECTED BIBLIOGRAPHY

Abbott, G. A., and Voedisch, F. W., 1938, The municipal ground-water supplies of North Dakota: N. Dak. Geol. Survey Bull. 11.

Akin, P. D., 1952, Ground water in the Litchville area, Barnes County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 18.

Aronow, Saul, Dennis, P. E., and Akin, P. D., 1953, Geology and ground-water resources of the Michigan City area, Nelson County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 21.

Dennis, P. E., 1947a, Ground water in the Aneta area, Nelson County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 7.

———1947b, Ground water near Buxton, Traill County, N. Dak.: N. Dak. State Water Conserv, Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 5.

———1947c, Ground water in the Sharon area, Steele County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 8.

———1948a, Ground water in the Wimbledon area, Barnes and Stutsman Counties, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 10.

———1948b, Ground water in the Hope area, Steele County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 9.

Dennis, P. E., and Akin, P. D., 1950, Ground water in the Portland area, Traill County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. State Geol. Survey, N. Dak. Ground-Water Studies, no. 15.

Dingman, R. J., and Gordon, E. D., 1955, Geology and ground-water resources of the Fort Berthold Indian Reservation, N. Dak. U. S. Geol Survey Water-Supply Paper 1259.

Filaseta, Leonard, 1946, Ground water in the Fessenden area, Wells County, N. Dak.: N. Dak. State Water Conserv. Comm., and N. Dak. Geol. Survey, no. 1.

Kunkel, R. P., 1954, Structure contour map of the base of Mississippian rocks in the Williston Basin and adjoining areas of Montana, North Dakota, South Dakota, and Wyoming: U. S. Geol. Survey Oil and Gas Inv. Map OM 165.

Laird, W. M., and Towse, D. E., 1953, Stratigraphy of North Dakota with reference to oil possibilities: N. Dak. Geol. Survey Rept. Inv. 2.

North Dakota Geological Survey Circulars, 1949–55, Mimeographed logs of oil and gas test holes and wells.

Simpson, H. E., 1929, Geology and ground-water resources of North Dakota: U. S. Geol. Survey Water-Supply Paper 598.

Stiff, H. A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Petroleum Tech. Jour., Tech. Note 84, sec. 1, p. 15–16.

Swenson, H. A., and Colby, B. R., 1955, Chemical quality of surface waters in the Devils Lake basin, North Dakota: U. S. Geol. Survey Water-Supply Paper 1295.

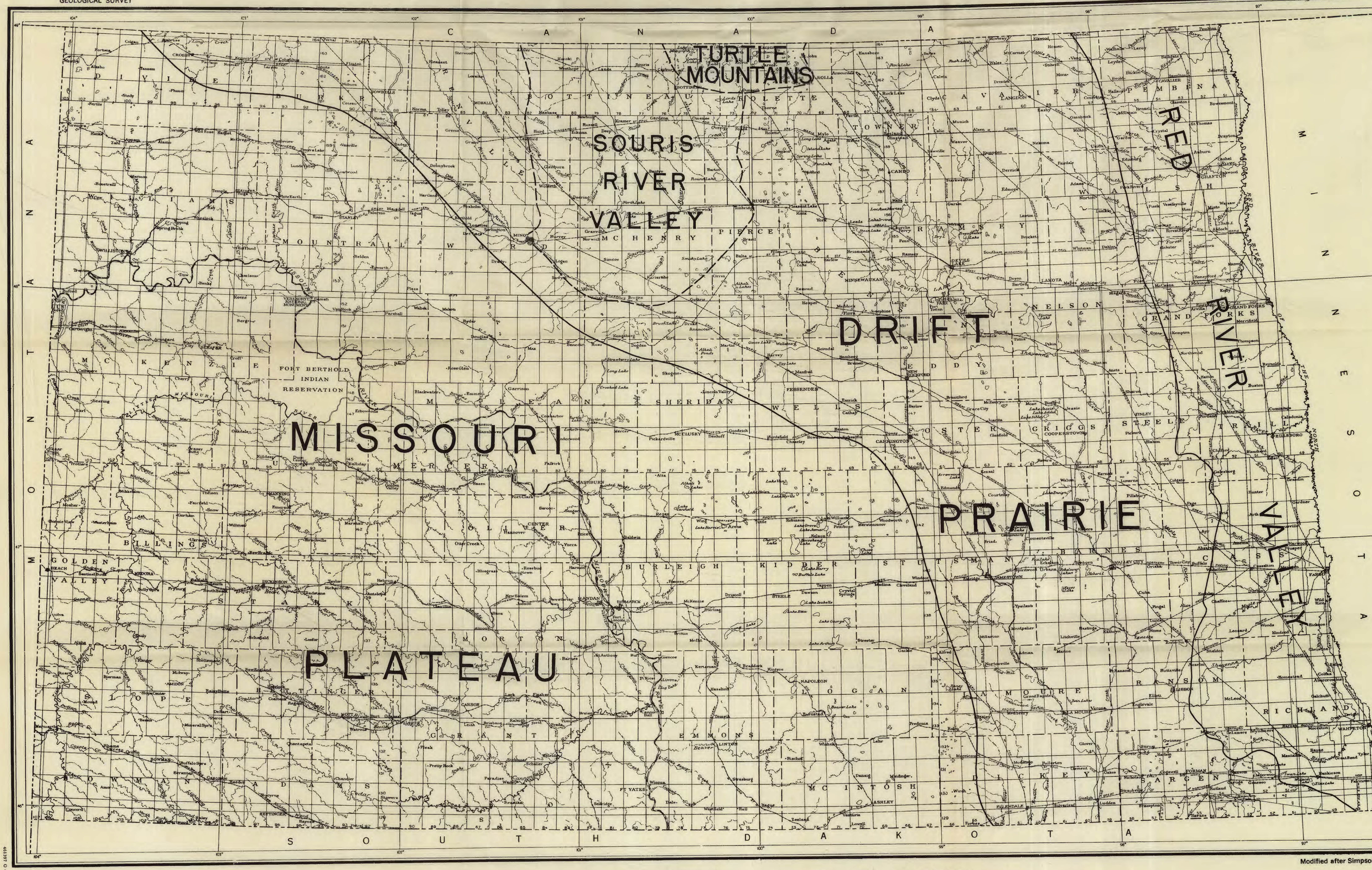
Tychsen, P. C., 1950, Geology and ground-water hydrology of the Heart River irrigation project and the Dickinson area, North Dakota, U. S. Geol. Survey Circ. 34.

Upham, Warren, 1895, The glacial Lake Agassiz: U. S. Geol. Survey Mon. 25.

U. S. Congress, 82d, 1952, An act to provide for research into * * *water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, and for other purposes: 2d sess., Public Law 448.

INDEX

U. S. GOVERNMENT PRINTING OFFICE : 1958 O - 461397



Modified after Simpson, 1929

MAP OF NORTH DAKOTA SHOWING PHYSIOGRAPHIC REGIONS

25 0 100 Miles