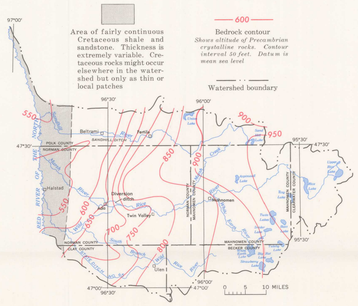
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS, SOILS, AND MINERALS

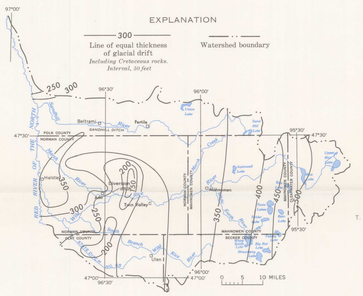
HYDROLOGIC INVESTIGATIONS
ATLAS HA-339 (SHEET 2 OF 4)

GROUND WATER

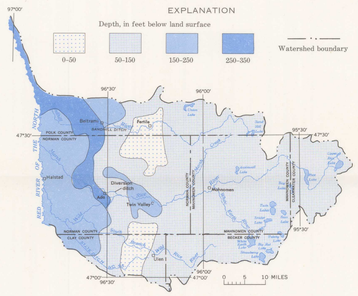


CONTOURS ON THE PRECAMBRIAN CRYSTALLINE ROCKS, WHICH FORM THE BASE OF THE GROUND-WATER RESERVOIR, SHOW RELIEF OF MORE THAN 400 FEET WITHIN THE WATERSHED.—*The general slope of this surface is toward the west. Bedrock valleys of low relief occur southeast of Ada. Cretaceous sediments occur mainly in the western part of the watershed. Thickness varies but is generally less than 50 feet and progressively thins toward the east. These deposits occur elsewhere in the watershed, but only as thin discontinuous deposits.*

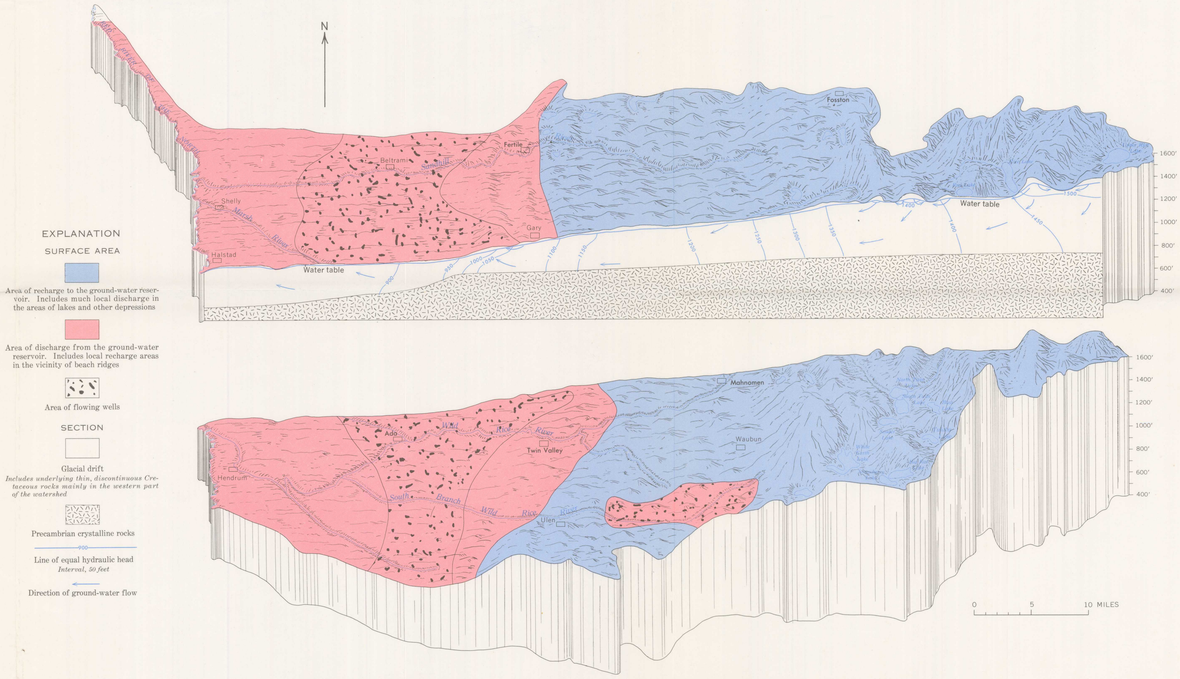
The Cretaceous sediments consist largely of shale, but thin layers of fine to coarse sand are commonly found. Yields of wells tapping the sand lenses are usually less than 50 gallons per minute.



THICKNESS OF THE GLACIAL DRIFT IS BETWEEN 200 AND 500 FEET THROUGHOUT MOST OF THE WATERSHED.—*The extreme thickness in the eastern part is due to a large north-south trending moraine forming the eastern boundary of the area. Drift thickness is an important factor when considering availability of water from glacial deposits (see availability map, this sheet). Cretaceous sediments were included with the glacial drift in the computation of drift thickness because of the difficulty in distinguishing the contact from drillers' logs. However, where the Cretaceous sediments have been definitely identified (see bedrock map above) the thickness is extremely variable and probably is not more than 50 feet at most places.*



WATER FOR DOMESTIC AND FARM SUPPLY CAN USUALLY BE OBTAINED WITH A WELL LESS THAN 150 FEET DEEP IN MOST OF THE WATERSHED.—*However, it has been necessary to drill deeper than this locally. The area where most wells are less than 150 feet deep is the part of the watershed where till is at or near the surface (for water-bearing characteristics of glacial till see availability map). Wells in the western part of the watershed are deeper because a considerable thickness of clay must be drilled through before reaching the glacial till, which contains permeable sand lenses. Wells less than 50 feet deep are most common in the area of beach ridges.*



WATER ENTERS THE GROUND-WATER SYSTEM LARGELY IN THE ROLLING UPLANDS OF THE MORAINAL AREA.

Most water in this area moves to and is discharged in adjacent depressions, commonly occupied by lakes, streams, or swamps. Some water, however, moves deeper into the ground-water reservoir where it becomes part of the regional flow system. Much of this water is discharged in the eastern and central part of the lake plain, as indicated by the zone of flowing wells, but the water deeper in the reservoir moves upward in the vicinity of the Red River of the North.

Within the regional discharge area, which is essentially the lake plain, small flow systems commonly are developed within the beach-ridge area where water enters the beach ridge and is discharged to nearby streams or adjacent swampy depressions.

Where the Cretaceous sediments are continuous with those in North Dakota the hydraulic head in Cretaceous sediments is generally greater than that in the glacial drift. This results in water moving upward and mixing with water in the drift.

EXPLANATION

SURFACE AREA

Area of recharge to the ground-water reservoir. Includes much local discharge in the areas of lakes and other depressions

Area of discharge from the ground-water reservoir. Includes local recharge areas in the vicinity of beach ridges

Area of flowing wells

SECTION

Glacial drift
Includes underlying thin, discontinuous Cretaceous rocks mainly in the western part of the watershed

Precambrian crystalline rocks

700
Line of equal hydraulic head
Interval, 50 feet

Direction of ground-water flow

EXPLANATION

Fine-grained lake deposits

Lithologic characteristics: Stratified lacustrine silts and clays occur in the western part of the area and fine sand occurs in the eastern. Thickness of the lake sediments ranges from more than 120 feet of silt and clay in the west to only a few feet of sand in the east

Water-bearing characteristics: The lake sediments generally are not a source of water. However, large diameter dug wells or cattle ponds in the clay and silt intercept enough permeable stringers of silt to maintain watering ponds for livestock

Beach Ridge aquifers

Lithologic characteristics: Predominantly fine to medium sand, containing much coarse sand and some fine to medium gravel. The deposits range from less than 10 to more than 30 feet in thickness at their highest point. The ridges are tens of miles long and their width ranges from a few hundred feet to more than a mile

Water-bearing characteristics: Saturated in the lower half to two-thirds the larger deposits can yield more than 20 gpm (gallons per minute) to individual wells. The lower beach ridges are unreliable as a source of ground water because wells would commonly go dry in the late summer and fall

Outwash and ice-contact aquifers

Lithologic characteristics: Medium to coarse sand, containing fine gravel. Medium gravel occurs locally. Thickness of the aquifer varies considerably, but generally is thicker in the central and northern parts. Test holes in the southern part showed 5 to 40 feet of sand, whereas in the central and northern part the thickness ranges from 15 to more than 80 feet

Water-bearing characteristics: The aquifer was not test pumped but the permeability and available head suggests that individual wells could probably yield at least several hundred gpm. The water table is very near the surface and parts of the aquifer are covered with peat lands. (see soils map, sheet 1). Recharge to the aquifer is probably quite high as indicated by the water-table contours (see sheet 4), and by the sandy nature of the till to the east of the aquifer

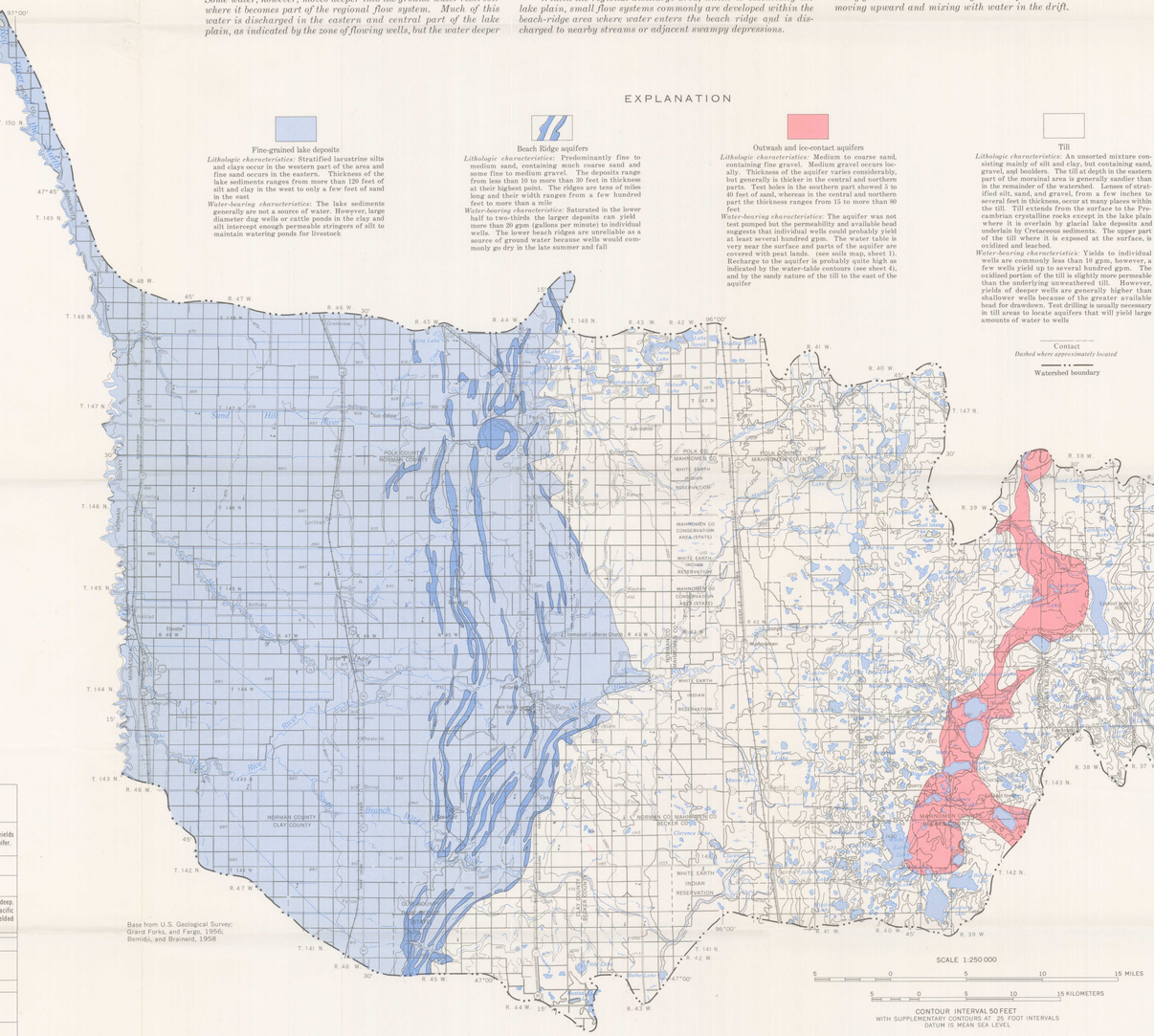
Till

Lithologic characteristics: An unsorted mixture consisting mainly of silt and clay, but containing sand, gravel, and boulders. The till at depth in the eastern part of the morainal area is generally sandier than in the remainder of the watershed. Lenses of stratified silt, sand, and gravel, from a few inches to several feet in thickness, occur at many places within the till. Till extends from the surface to the Precambrian crystalline rocks except in the lake plain where it is overlain by glacial lake deposits and underlain by Cretaceous sediments. The upper part of the till where it is exposed at the surface, is oxidized and leached.

Water-bearing characteristics: Yields to individual wells are commonly less than 10 gpm, however, a few wells yield up to several hundred gpm. The oxidized portion of the till is slightly more permeable than the underlying unweathered till. However, yields of deeper wells are generally higher than shallower wells because of the greater available head for drawdown. Test drilling is usually necessary in till areas to locate aquifers that will yield large amounts of water to wells

Contact
Dashed where approximately located

Watershed boundary



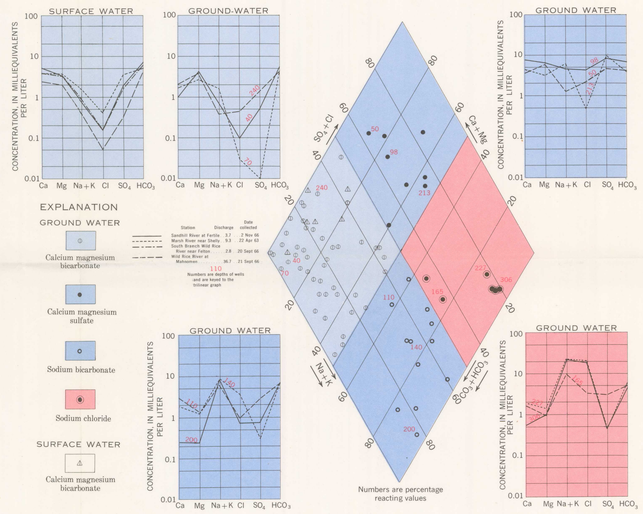
AVAILABILITY MAP SHOWS WHERE GROUND WATER CAN BE OBTAINED WITHIN THE WATERSHED

Ground water for domestic and stock use can be obtained at most places in the area. For larger yield wells the best potential is in the outwash and ice-contact sand and gravel in the eastern part of the watershed. Larger yields of ground water may be obtained in other parts of the area but test drilling is required to locate the sand and gravel bodies.

COMMUNITY WATER SUPPLIES

Community	Well characteristics: Depth (feet)	Diameter (inches)	Operating rate (gallons per minute)	Depth to static water level (feet)	Specific capacity (gpm per ft)	Water quality: Total dissolved solids (mg/l)	Hardness (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Remarks
Ada	255	10	115	25	21			1.2	63	
Well 2	262	12	380	27	19		72		28	Creamery well in town yields 600 gpm from same aquifer.
Well 3	262	12	225	40	31	571	98	0.07	64	
Well 4										
Bejou	98	8	40	13		677	348	0.11	236	
	95	8	45	12	1.9					
Climax	120	6	50-100	20						
	120	8	50-100	20						
Fertile	153	8	125	62	20					
	144	6	150			373	300	0.87	50	Abandoned well, 296 feet deep, owned by Northern Pacific Railway Company, yielded 85 gpm.
Halstad	297	8	175	25	16					
	293	6	200	25	7.5	1,350	207	1.1	207	
Hendrum	300	8	60	11	1.3		170	.23	350	
Mahnomen	93	6	125	20			330	0.42	130	
	93	6	75	20						
	130	8	350	15			380	.68	130	
Nielsville	164	8	24	60			420	4.5	51	
Shelly	258	6	75	29			120	2.9	41	
	247	6	125	29	2		156	.8	14	
	140	4	50	30		678				
Twin Valley	238	10	165							
	240	10	75	26	2.2		260	1.3		
Ulen	110	8	75	11	4	498	392	.46	60	
	111	6	125	11						

WATER QUALITY

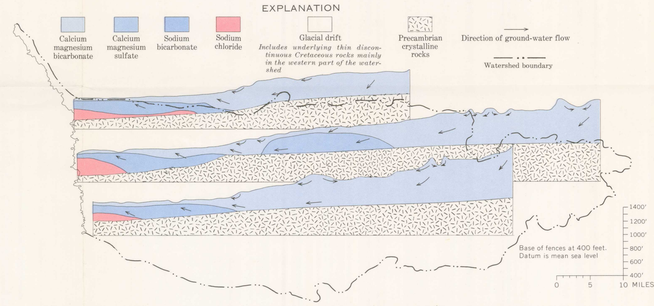


CHEMICAL QUALITY OF GROUND WATER VARIES WIDELY IN THE WATERSHED

Surface-water quality is fairly constant but concentrations of dissolved minerals are generally less at higher flows.

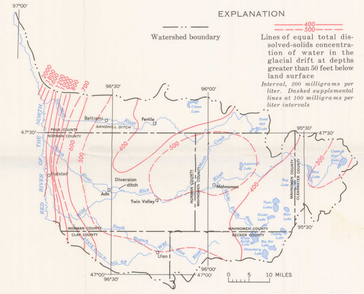
Water can be classified into different types of chemical quality depending on the percentage distribution of the major ions in solution. The water type is controlled principally by the solubility of the minerals within the ground-water reservoir, the time water is in contact with these minerals, and the intermixing of water of different types. Some of the sodium bicarbonate water is due to softening, which is a decrease in calcium and magnesium ion concentration and an increase in sodium ion concentration.

The logarithmic plots show the concentration of the major ions for selected water samples. The concentrations of most ions are between 0.1 and 10 milliequivalents per liter, but in the sodium chloride type the concentration of sodium plus potassium and chloride ions is about 20 milliequivalents per liter in some samples.



CALCIUM MAGNESIUM BICARBONATE, THE MOST COMMON TYPE OF GROUND WATER IN THE AREA, OCCURS MAINLY IN THE RECHARGE AREA

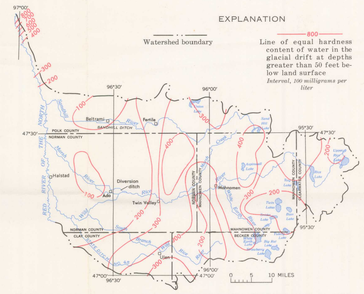
Sodium chloride water occurs in the Cretaceous sediments and in the glacial drift immediately adjacent to them. Ground water generally moves from east to west in the watershed and the mixing of the water from the eastern part of the area with water associated with the Cretaceous sediments causes the presence of the sodium bicarbonate type. Some of the sodium bicarbonate type of water could also be due to softening of the water where it has come in contact with clays and organic matter having ion exchange capacity.



CONCENTRATIONS OF DISSOLVED SOLIDS IN WATER OF THE GLACIAL DRIFT ARE HIGHER NEAR THE RED RIVER OF THE NORTH THAN IN THE EASTERN PART OF THE WATERSHED.—*The higher mineralization of water indicates that the water has been in contact with minerals in the ground-water reservoir for a longer period, and that water movement is probably slower than elsewhere in the watershed.*

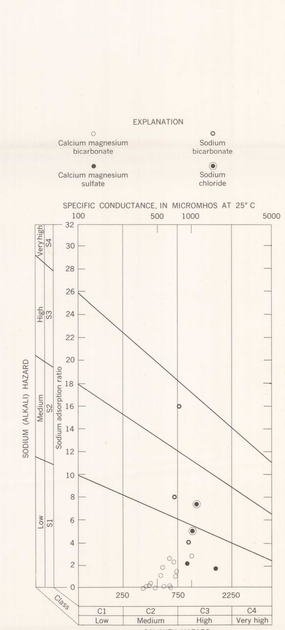
The very high values in the extreme western edge reflect the influence of very poor quality water from the underlying sedimentary rocks which moves upward and mixes with water in the glacial drift.

Water containing dissolved solids of less than 1,000 milligrams per liter is suitable for domestic and stock use. Some water containing 1,000 milligrams per liter or more of dissolved solids contains certain constituents which produce a noticeable taste. Concentration of nitrate in both ground water and surface water is generally less than 1 milligram per liter.



MOST GROUND WATER IN THE WILD RICE RIVER WATERSHED IS VERY HARD, BUT IN GENERAL, THE HARDNESS CONCENTRATION OF WATER IN THE LAKE PLAIN IS LOWER THAN IN THE MORAINAL AREA.—*The lower concentration of hardness in the lake plain is largely due to natural softening of ground water by base exchange.*

Hardness is due mainly to the presence of calcium and magnesium ions which react with soap to form insoluble products. Mineral salts of calcium and magnesium cause hardness and can form incrustation on well screens. Where hardness exceeds 500 milligrams per liter, incrustation of well screens may be rapid in small diameter wells that are heavily pumped.



MOST GROUND WATER HAS A LOW SODIUM HAZARD BUT MEDIUM TO HIGH SALINITY HAZARD FOR IRRIGATION USE.—*The calcium magnesium bicarbonate water generally is suitable for irrigation, but the other types might not be and water from areas where these types of water are found should be analyzed for suitability before they are used. Boron concentration must also be considered when determining suitability of water for irrigation. The highest amount in the samples analyzed was 0.82 milligrams per liter which approaches the lower limit of toxicity to some plants.*

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1970—W69047

WATER RESOURCES OF THE WILD RICE RIVER WATERSHED, NORTHWESTERN MINNESOTA

By
T. C. Winter, L. E. Bidwell, and R. W. Maclay

1970