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GROUND-WATER RESOURCES OF MC LEAN COUNTY, WEST-CENTRAL NORTH DAKOTA

By
Robert L. Klausing

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INTRODUCTION

This investigation is part of a statewide program to determine the location, extent, and hydrologic characteristics of the ground-water reservoirs (aquifers); to evaluate the occurrence and movement of ground water within the aquifers, including the sources and areas of recharge and discharge; to estimate the potential yields of wells tapping the major aquifers; and to determine the chemical quality of the ground water.

McLean County encompasses an area of 2,327 square miles in west-central North Dakota. The study, which began in July 1966, was made cooperatively by the U.S. Geological Survey, the North Dakota State Water Commission, the North Dakota Geological Survey, and the McLean County Board of Commissioners. This interim report presents only the major conclusions of the study.

SOURCES OF GROUND-WATER DATA

Many sources of data have been utilized in the study of the ground-water resources of McLean County. A well inventory provided data on depth, construction, and productivity of the private and public wells. A geologic map prepared by the North Dakota Geological Survey provided information on the distribution and lithology of surficial deposits in the county (Bluemle, 1971, pl. 1). Test drilling by the North Dakota State Water Commission, Federal agencies, and commercial well drillers has provided information regarding the thickness and extent of the aquifers underlying McLean County. Chemical analyses of water from selected wells have furnished data on the water quality.

Potential well yields were determined from the thickness and estimated hydraulic conductivity of the water-bearing materials logged at each test hole, and from aquifer pumping tests. Generally, the yield of an aquifer is proportional to its hydraulic conductivity and thickness. The test-hole logs were examined in detail and hydraulic conductivities were assigned on the basis of grain size, apparent sorting, and drilling characteristics of the materials. The test holes were drilled by hydraulic-rotary drilling equipment, which on drilling sand and gravel beds commonly produces samples having less silt and clay than is actually present in the deposit. Allowance was made for this discrepancy. The hydraulic conductivities were further compared with and adjusted to data obtained from aquifer pumping tests.

OCCURRENCE AND POTENTIAL YIELD OF AQUIFERS

Important aquifers occur both in the glacial drift and in the underlying bedrock formations in McLean County. However, the ground-water availability map shows the extent and potential yields of the glacial-drift aquifers only. Although the bedrock aquifers underlie the entire county, the data are inadequate to show spacial variations in potential yields for those aquifers.

The availability map should be used with the understanding that the estimated yields are for fully penetrating, properly screened and developed wells of adequate diameter. The map is intended as a guide in the location of major aquifers, not as a map to locate specific wells. Few, if any, aquifers are so uniform in their water-bearing properties that production wells may be drilled in them without preliminary exploratory drilling. If the map is used with this understanding of its limitations, it should be useful in the future development of the ground-water resources of McLean County.

GLACIAL-DRIFT AQUIFERS

McLean County is almost entirely covered with glacial drift that may be more than 400 feet thick in areas where buried valleys occur.

The glacial drift may be subdivided into two distinct types. The more common type is till, a nonsorted mixture of clay, silt, sand, gravel, cobbles, and boulders. Till was mainly deposited by active glaciers. It has a low hydraulic conductivity, and will normally yield only small quantities of ground water to wells. Glaciofluvial deposits, the less common type of drift, are stratified deposits of sand and gravel that are sorted according to grain size. These materials, deposited by moving water, normally have a high hydraulic conductivity, and are the principal aquifers in McLean County. The major glacial-drift aquifers generally will yield more than 50 gpm (gallons per minute) to individual wells and in places will yield more than 1,000 gpm.

In many parts of McLean County the aquifers occupy narrow and sinuous valleys, but in some areas the aquifers underlie widespread outwash plains. The aquifers are exposed at the surface in some localities, but are deeply buried by till in others. Where the glacial drift is thick, it is not uncommon for two or more major aquifers to be interlayered with confining beds of till or clay and silt. An example of this is in east-central McLean County where a large complex system of interlayered aquifers extends from Lake Audubon to the eastern edge of the county.

Small lenses of water-bearing sand and gravel not shown on the map are common throughout the glacial drift. These deposits generally will yield sufficient quantities of water for average farm use. The thicker deposits may yield as much as 50 gpm for short periods of time; however, long-term yields would be much less because of the limited areal extent of and inadequate recharge to the deposits. Most sustained yields probably would range from 1 to 10 gpm.

BEDROCK AQUIFERS

Three bedrock units—the Fort Union Formation, Hell Creek Formation, and Fox Hills Sandstone—supply water to wells in McLean County. The Fort Union Formation of Tertiary age underlies the glacial drift throughout most of the area, and locally is exposed along stream channels and in areas where the bedrock is topographically high. The Fort Union consists of interbedded clay, shale, siltstone, sandstone, and lignite. The Hell Creek Formation, which underlies the Fort Union and is of Late Cretaceous age, consists of interbedded shale, siltstone, and sandstone. It conformably overlies and is gradational with the underlying Fox Hills Sandstone, also of Late Cretaceous age. The Fox Hills generally consists of interbedded shale and sandstone, but locally consists of clayey sand.

A large number of wells in McLean County, ranging in depth from 20 to about 500 feet, tap the Fort Union Formation. However, only a few wells tap the underlying aquifers of Cretaceous age. Wells tapping the Cretaceous aquifers range from 150 to 1,310 feet in depth.

The most productive bedrock aquifers consist of sandstone and lignite beds. Wells tapping these aquifers can be expected to yield from 2 to 100 gpm.

CHEMICAL QUALITY OF WATER

The chemical quality of ground water in McLean County varies considerably areally and vertically within a given aquifer. Selected analyses are shown by symbols on the availability map for the glacial-drift aquifers and in the table for the bedrock aquifers. Water from shallow zones in the glacial-drift aquifers is commonly hard and is a calcium bicarbonate type, whereas in the deeper zones it is also hard but is a sodium bicarbonate type. Water from the bedrock aquifers is predominantly soft and is a sodium bicarbonate type. Water from the glacial-drift aquifers generally is harder but less saline and of better quality than water from the bedrock aquifers.

SELECTED REFERENCES

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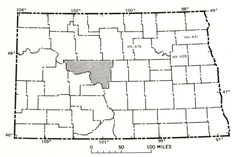

Location of McLean County (shaded) and location of published atlases in this series by atlas number

Base prepared from North Dakota Highway Department county highway maps

GROUND-WATER AVAILABILITY MAP FOR GLACIAL-DRIFT AQUIFERS

SCALE 1:126 720

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

EXPLANATION

POTENTIAL WELL YIELD, IN GALLONS PER MINUTE

- More than 1,000
- 500–1,000
- 200–500
- 50–200
- 0–50

SELECTED TEST-HOLE AND WELL DATA

50-31
●(544)

Test hole or well

Upper numbers indicate aquifer interval, in feet below land surface. Where more than one interval was penetrated, upper and lower limits are given. Plus (+) sign following lower aquifer limit indicates that the test hole did not completely penetrate the glacial drift. Lower number, in parentheses, is aggregate aquifer thickness. Aggregate thicknesses of less than 10 feet are not shown

CHEMICAL COMPOSITION OF WATER FROM GLACIAL-DRIFT AQUIFERS

Number above line at center of circular diagram is carbonate hardness (calcium magnesium hardness as $CaCO_3$), in milligrams per liter; number below line is dissolved solids, in milligrams per liter. The size of the segments of each semicircle is proportional to the quantity of each group of anions or cations to the total anions or cations present

●B

Well completed in bedrock aquifer for which chemical analysis is shown in table

CHEMICAL ANALYSES OF WATER FROM SELECTED BEDROCK WELLS

[Analytical results in milligrams per liter, except as indicated]

Geologic source	Well	Depth	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	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 $CaCO_3$: Sum	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Sodium-adsorption ratio (SAR)
Fort Union.....	A	110	7– 2–68	8	8.7	.....	56	15	1.2	3.2	241	.....	10	2.4	.....	6.1	.....	206	222	203	.....	1	393	8.1	.....
Formation	B	324	5–18–70	7	12	.....	12	3.4	441	3.1	888	43	181	2.7	1.3	1	0.56	1,180	1,140	44	.....	95	1,770	8.6	29
	C	251	7–17–70	8	9.8	9.3	9.6	1.2	752	3.6	1,490	20	24	296	.7	.7	.68	1,940	1,860	29	.....	98	3,050	8.3	61
	D	50	10–11–66	7	9.6	.22	10	5.8	812	4.3	1,020	25	947	12	1.0	.3	.41	2,360	2,330	49	.....	97	3,350	8.5	16
Hell Creek	E	220	7– 1–68	8.3	9.8	2.4	5.4	3.5	454	2.4	952	6.8	180	17	.7	.....	.47	1,140	1,150	28	.....	97	1,780	8.3	37
Formation	F	210	7– 2–68	10.6	4.4	.24	5.1	2.1	366	2.5	747	15	185	1.6	.5	.....	.34	936	951	21	.....	97	1,460	8.3	35
	G	310	6–26–68	8.9	18	.3	4.5	2.7	469	2.0	1,180	18	4.2	31	.4	.....	2.2	1,130	1,130	22	.....	98	1,720	8.3	43
	H	431	4–18–68	7.8	11	.66	7.7	1.7	519	2.2	1,040	.....	66	169	.5	3.0	2.9	1,330	1,300	26	.....	97	2,060	8.2	44
Fox Hills.....	I	605	4–18–68	8.3	12	.82	5.2	2.4	572	2.4	975	.....	4.7	348	3.7	.....	3.5	1,480	1,430	23	.....	98	2,440	8.1	52
Sandstone.....	J	585	7–25–69	10.6	11	.....	4.8	.7	587	2.4	954	.....	9.1	355	4.0	.....	2.0	1,370	1,450	15	.....	99	2,490	7.9	66
	K	1,240	11– 4–69	11.1	17	.....	.....	7.0	.6	648	2.1	1,160	9.1	21	312	.1	1	1.9	1,540	1,590	20	.....	98	2,640	8.4	63
	L	1,310	11–16–67	16	11	.07	3.8	.9	645	2.5	1,180	19	.5	252	4.6	.1	2.85	1,550	1,520	13	.....	.....	2,500	8.5	77

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