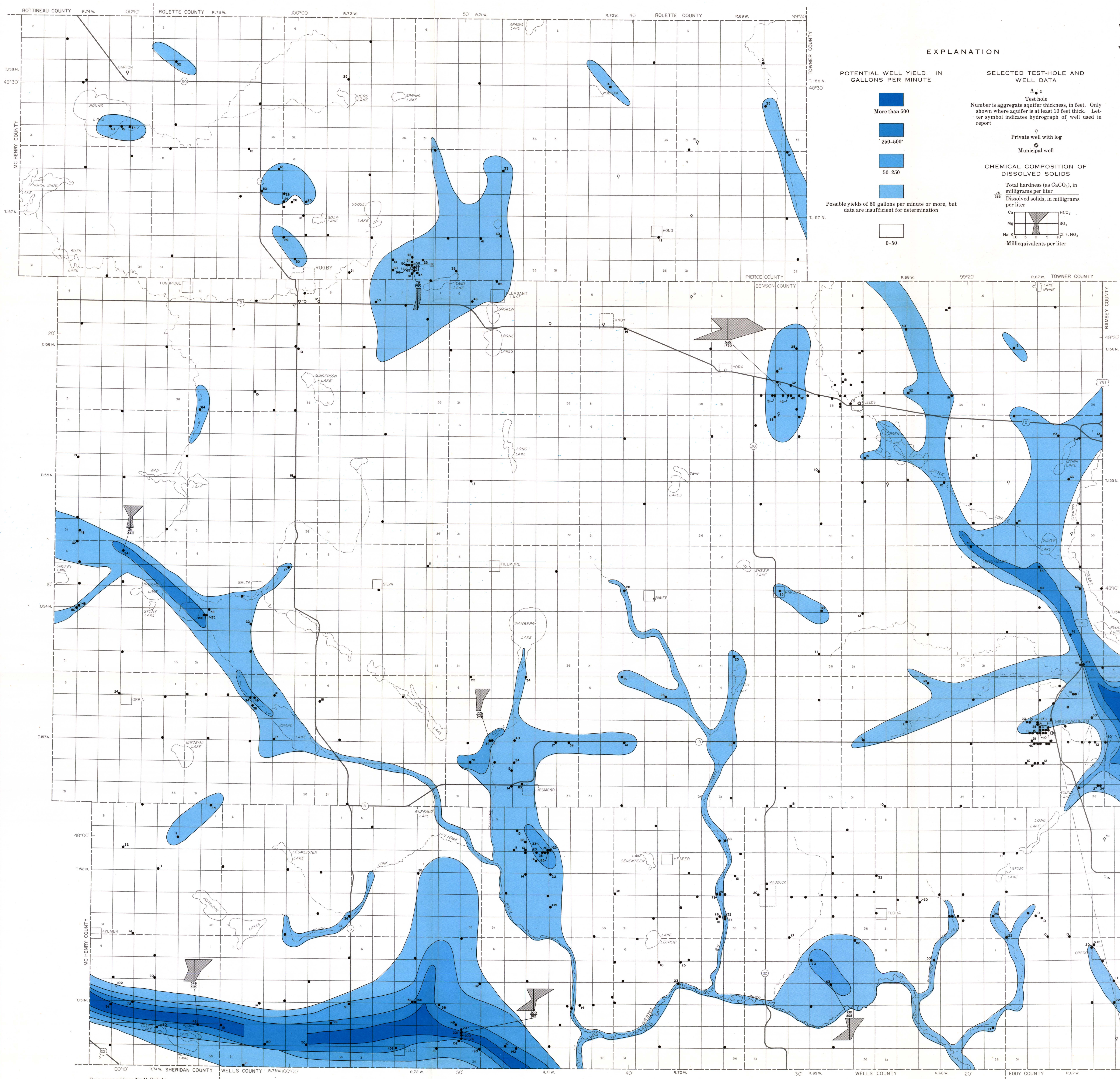
PREPARED IN COOPERATION WITH THE
NORTH DAKOTA STATE WATER COMMISSION
NORTH DAKOTA GEOLOGICAL SURVEY
BENSON AND PIERCE COUNTIES WATER MANAGEMENT DISTRICTS



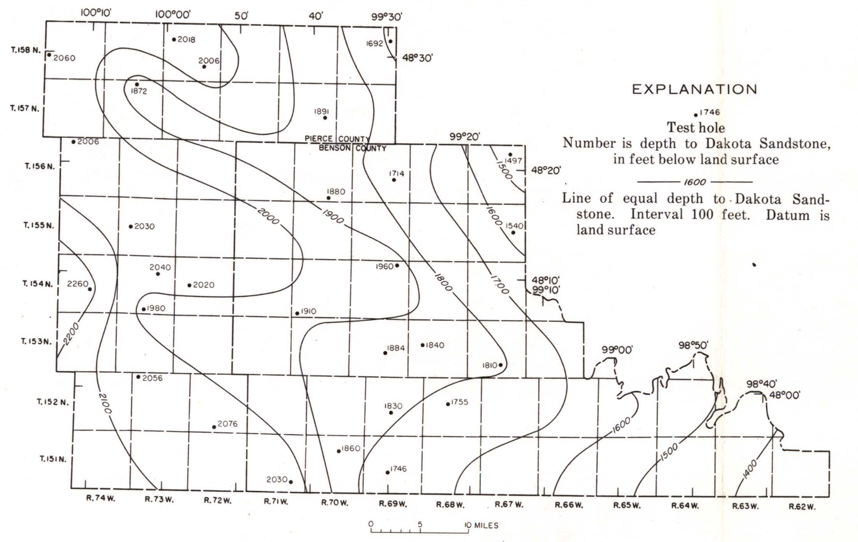
Base prepared from North Dakota
Highway Department county highway maps

GROUND-WATER AVAILABILITY MAP FOR GLACIAL-DRIFT AQUIFERS

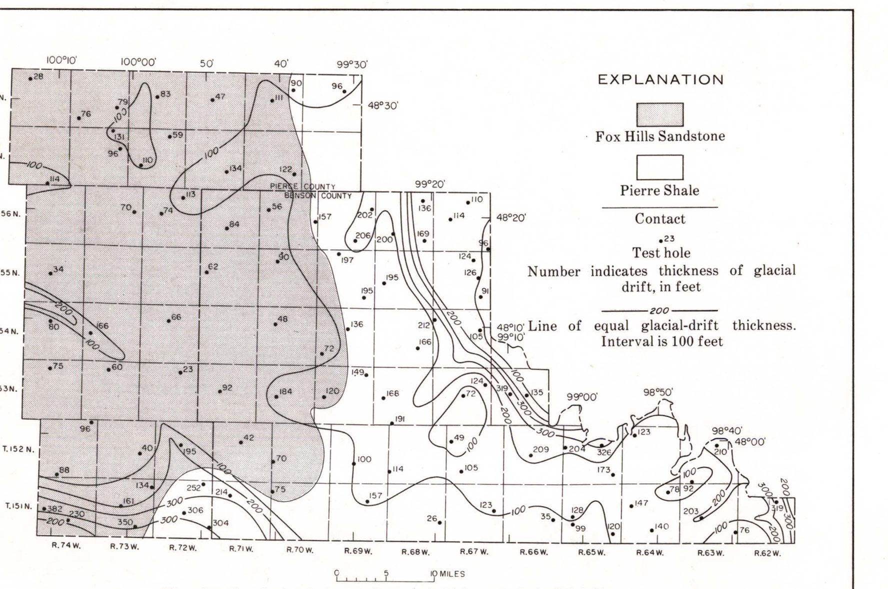
SCALE 1:126 720

2 0 2 4 6 8 10 MILES

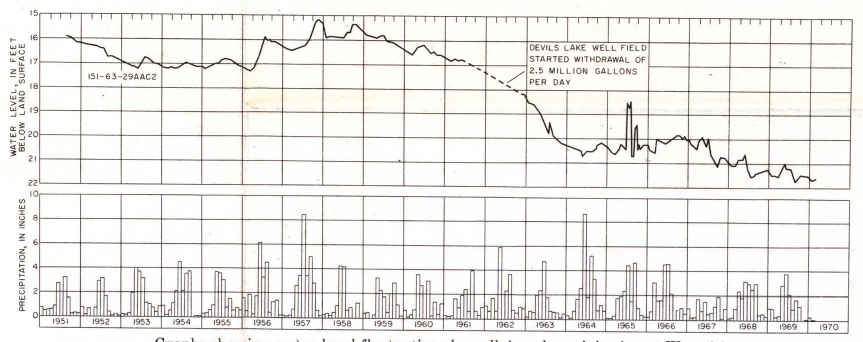
2 0 2 4 6 8 10 KILOMETERS



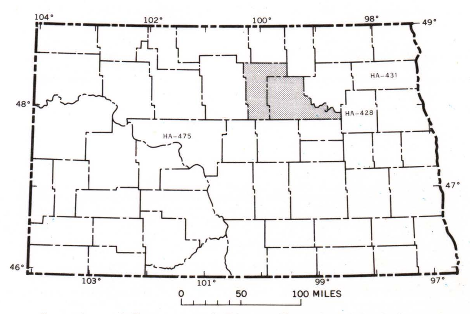
Map showing depth to Dakota Sandstone aquifer



Map showing bedrock formations and thickness of glacial drift



Graphs showing water-level fluctuations in well A and precipitation at Warwick



Location of Benson and Pierce Counties (shaded) and location of published atlases in this series by atlas number.

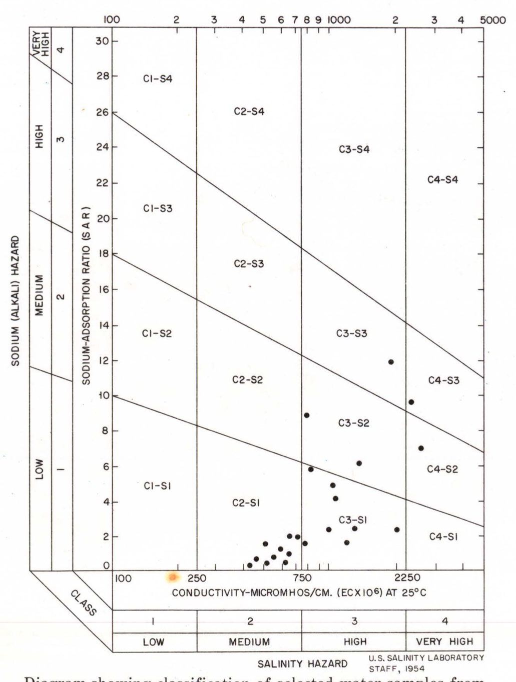
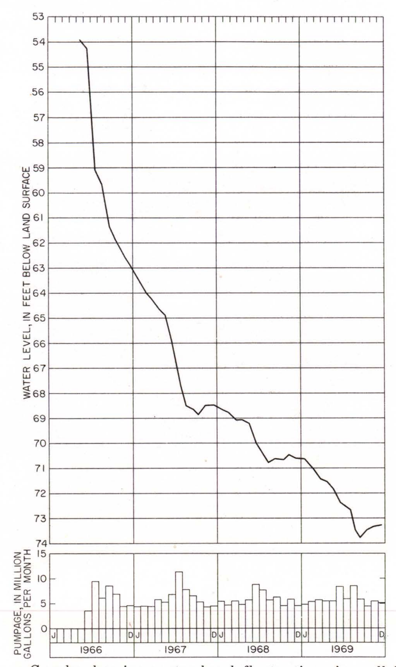


Diagram showing classification of selected water samples from glacial-drift aquifers for irrigation use



Graphs showing water-level fluctuations in well B and pumpage from the Rugby well field

INTRODUCTION

The purpose of this investigation is to provide information about the ground-water resources in Benson and Pierce Counties that is sufficient for planning the safe and intelligent development of water supplies for irrigation, domestic, stock, industrial, and municipal purposes. The investigation is part of a statewide program to determine the location and extent of ground-water aquifers; to evaluate the occurrence and movement of ground water within the aquifers, including sources of recharge and discharge; to determine potential yields to wells developed in the aquifers; and to determine the chemical quality of the ground water.

Benson and Pierce Counties cover an area of 2,512 square miles in north-central North Dakota. The study, which began in July 1967 and was completed in June 1971, was made cooperatively by the U.S. Geological Survey, the North Dakota State Water Commission, the North Dakota Geological Survey, and the Benson and Pierce Counties Water Management Districts. This interim report presents only the major conclusions of the study.

SOURCES OF GROUND-WATER DATA

Many sources of data were utilized in the preparation of this report. A well inventory provided data on depth, construction, and productivity of private and public wells in the counties. Test drilling, both public and private, supplied information on the lithology, thickness, and extent of the aquifers. Chemical analyses of water from selected wells furnished data on the water quality.

The potential yields for the glacial-drift aquifers were determined from the thickness and estimated hydraulic conductivity (permeability) of the water-bearing sand and gravel deposits logged at each test hole. Generally, the greater the hydraulic conductivity and thickness of the sand and gravel, the larger the yields. The test-hole logs were examined in detail and hydraulic conductivities were assigned on the basis of grain size, apparent sorting, drilling characteristics, and electric logs of materials. The test holes were drilled with hydraulic-rotary equipment and, consequently, the samples generally contained less silt and clay and displayed a higher degree of sorting than was actually present in the deposit. In assigning hydraulic conductivity values, allowance was made for this discrepancy. The values were further adjusted according to data obtained from 12 aquifer tests and 177 mechanical analyses.

OCCURRENCE AND POTENTIAL YIELD OF AQUIFERS

Ground water is obtainable in Benson and Pierce Counties both from aquifers in the glacial drift of Quaternary age and in underlying bedrock formations of Cretaceous age. The availability map shows only the occurrence and potential yields of glacial-drift aquifers. Although ground water is obtainable from bedrock aquifers practically everywhere in the two-county area, data are inadequate to show spacial variations in potential yields.

The availability map should be used with the understanding that the yields are estimated and are for fully penetrating, properly screened and developed wells of adequate diameter. The map is intended as a general 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 successful production wells may be constructed in them without preliminary exploratory test drilling. If the map is used with this understanding of its limitations, it should serve as a useful tool in the future development of the ground-water resources of Benson and Pierce Counties.

GLACIAL-DRIFT AQUIFERS

Benson and Pierce Counties are almost entirely covered with glacial drift. The thickness varies from a few feet in areas of bedrock highs, to more than 300 feet in areas containing buried valleys, as shown on the glacial-drift thickness map. The glacial drift consists mainly of till and associated glacial melt-water deposits.

Till is an unsorted, unstratified, cohesive, moderately calcareous agglomeration of clay, silt, sand, gravel, cobbles, and boulders. It has a low hydraulic conductivity and will normally yield only small quantities of water to wells. However, in many places thin lenses of sand and gravel are interbedded with the till and will commonly yield adequate supplies for domestic and stock purposes.

The glacial melt-water deposits are sorted and stratified and, where they consist of sand and gravel, contain the major aquifers in Benson and Pierce Counties. These aquifers generally will yield more than 50 gpm (gallons per minute) to individual wells and, in places, will yield more than 500 gpm. Where the glacial drift is thick, it is not uncommon for two or more major aquifers to be interlayered with confining beds of till, clay, and silt.

Water levels in most of the glacial-drift aquifers probably are at equilibrium, and aquifer recharge is approximately equal to discharge. However, in at least two aquifers pumpage and natural discharge exceed recharge, and water is being mined. Well A, which is located near the city of Devils Lake well field and taps an aquifer near Warwick, illustrates this condition. The hydrograph of water-level fluctuations in this well shows a decline of about 4 feet since the well field was installed in 1962. Pumpage from the well field, which consists of four wells, has averaged 2.5 million gallons per day. Well B, which is located near the city of Rugby well field, shows a similar but more pronounced decline. As the result of pumpage from the Rugby well field, the water level declined about 20 feet during 1966–69.

BEDROCK AQUIFERS

Three bedrock units of Cretaceous age supply water to wells in Benson and Pierce Counties. These are, in descending order, the Fox Hills Sandstone, Pierre Shale, and Dakota Sandstone. The Fox Hills Sandstone and Pierre Shale directly underlie the glacial drift. The Fox Hills-Pierre Shale contact and areal extent are shown on the bedrock formations and drift-thickness map.

The Fox Hills Sandstone underlies most of Pierce County and the western part of Benson County; it crops out at many locations. The formation is as much as 290 feet thick in western Pierce County, but thins eastward to a featheredge in western Benson County. Numerous lakes and potholes, mostly in Pierce County, are hydraulically connected with the Fox Hills Sandstone and provide a source of recharge. Many domestic and stock wells yield water from depths of generally less than 100 feet, and yields range from 2 to 100 gpm.

The Pierre Shale underlies all of the area and crops out in a few places in southeastern Benson County. Domestic and stock wells yielding from 2 to 8 gpm are developed in a fractured zone in the upper part of the formation.

The Dakota Sandstone underlies all of the area and is reached at depths ranging from about 1,400 to more than 2,200 feet, as shown by the depth map. The Dakota Sandstone is the most extensive aquifer underlying the two counties, but yields are highly variable due to the lenticular nature of the sand beds. Wells in the eastern part of the area generally will flow at rates of from 10 to 150 gpm at land surface elevations of less than 1,500 feet above mean sea level. The water is saline, and is unsatisfactory for most uses except fire protection and sanitary purposes.

CHEMICAL QUALITY OF WATER

Ground water in Benson and Pierce Counties shows a wide range in chemical quality. Water in the glacial-drift aquifers generally is harder but less saline than water in the bedrock aquifers. Shallow drift aquifers commonly yield a hard, calcium bicarbonate type water of relatively low salinity; whereas the deeper drift aquifers commonly yield a calcium or a sodium bicarbonate water of somewhat greater salinity. The bedrock aquifers generally yield a soft, sodium bicarbonate or sodium chloride water of high salinity.

Selected analyses of water samples from the drift aquifers are shown in diagrams on the availability map. In addition, selected analyses are plotted on the irrigation-use classification diagram to compare the relative sodium and salinity hazard. The latter diagram shows that most of the water from glacial-drift aquifers has a medium (C2) to high (C3) salinity hazard, but low (S1) sodium hazard. Water from the bedrock aquifers generally exceeds the very high salinity and sodium hazards (C4–S4), and the analyses could not be plotted on the diagram.

Water with high salinity should not be used on soils with restricted drainage, and even with adequate drainage special management for salinity control may be required and plants with good salt tolerance should be selected. Also, the more sodium an irrigation water contains, the greater the hazard; however, the Department of Agriculture (U.S. Salinity Laboratory Staff, 1954) has shown that calcium and magnesium in the water are important in modifying the effect of sodium on the soil and has introduced the sodium-adsorption ratio (SAR) that expresses relative activity of sodium ions in the exchange reaction with soil. Low-sodium water (S1) can be used on almost all soils with little danger of developing harmful levels of exchangeable sodium. Medium-sodium water (S2) may be used on coarse-textured or organic soils that have good permeability. High-sodium water (S3), typical of most bedrock water, may produce harmful levels of exchangeable sodium in most soils and its use may require special soil management, good drainage, high leaching, and additions of organic matter. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

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GROUND-WATER RESOURCES OF BENSON AND PIERCE COUNTIES, NORTH-CENTRAL NORTH DAKOTA

By
P. G. Randich

1972

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