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Information Pamphlet No. 50

MAJOR AQUIFERS IN SPINK COUNTY, SOUTH DAKOTA

by

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Prepared in cooperation with the
South Dakota Geological Survey,
Spink County, the James River Water Development District, and the
Mid-Dakota Water Development District

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ABSTRACT

Aquifers in glacial drift deposits in Spink County store nearly 3.3 million acre-feet of fresh to slightly saline water at depths of from near land surface to more than 500 feet below land surface beneath an area of about 760 square miles. Yields of properly developed wells in the more productive aquifers exceed 1,000 gallons per minute in some areas. Withdrawals from the aquifers, mostly for irrigation, totaled about 15,000 acre-feet of water in 1990.

The quality of water from aquifers in glacial drift varies greatly, even within an aquifer. Concentrations of dissolved solids in samples ranged from 151 to 9,610 milligrams per liter, and hardness ranged from 84 to 3,700 milligrams per liter. Median concentrations of dissolved solids, sulfate, iron, and manganese in some glacial aquifers are near or exceed Secondary Maximum Contaminant Levels established by the U.S. Environmental Protection Agency. Some of the water from aquifers in glacial drift is suitable for irrigation use.

Bedrock aquifers in Spink County store more than 40 million acre-feet of slightly to moderately saline water at depths of from 80 to about 1,300 feet below land surface. Yields of properly developed wells range up to 600 gallons per minute. The artesian head of the heavily used Dakota aquifer has declined about 350 feet in the approximately 100 years since the first artesian wells were drilled in the county, but water levels have stabilized locally as a result of decreases in the discharge of water from the wells.

Water samples from aquifers in the bedrock contained concentrations of dissolved solids that ranged from 1,410 to 2,670 milligrams per liter (sum of constituents) and hardness was as much as 1,400 milligrams per liter; these concentrations generally are largest for aquifers below the Dakota aquifer. Median concentrations of dissolved solids, sulfate, iron, and manganese in Dakota wells either are near or exceed U.S. Environmental Protection Agency Secondary Maximum Contaminant Levels. Dissolved solids, sodium, and boron concentrations in water from bedrock aquifers commonly are too large for the water to be suitable for irrigation use.

INTRODUCTION

This information pamphlet is one of a series of reports on water-resources studies of South Dakota counties. It is designed to acquaint the reader with the general distribution, quantity, and quality of ground water available from the major aquifers in Spink County. Information in this pamphlet is based on data collected from well drillers and on data (fig. 1) collected by the U.S. Geological Survey and the South Dakota Geological Survey during 1987 through 1992.

Copies of this publication and other county reports may be obtained as they become available from the South Dakota Geological Survey. Additional information about the hydrology and geology may be obtained from the U.S. Geological Survey in Huron or the South Dakota Geological Survey in Vermillion.

The inch-pound units used in this report may be converted to metric (SI) units by the following conversion factors:

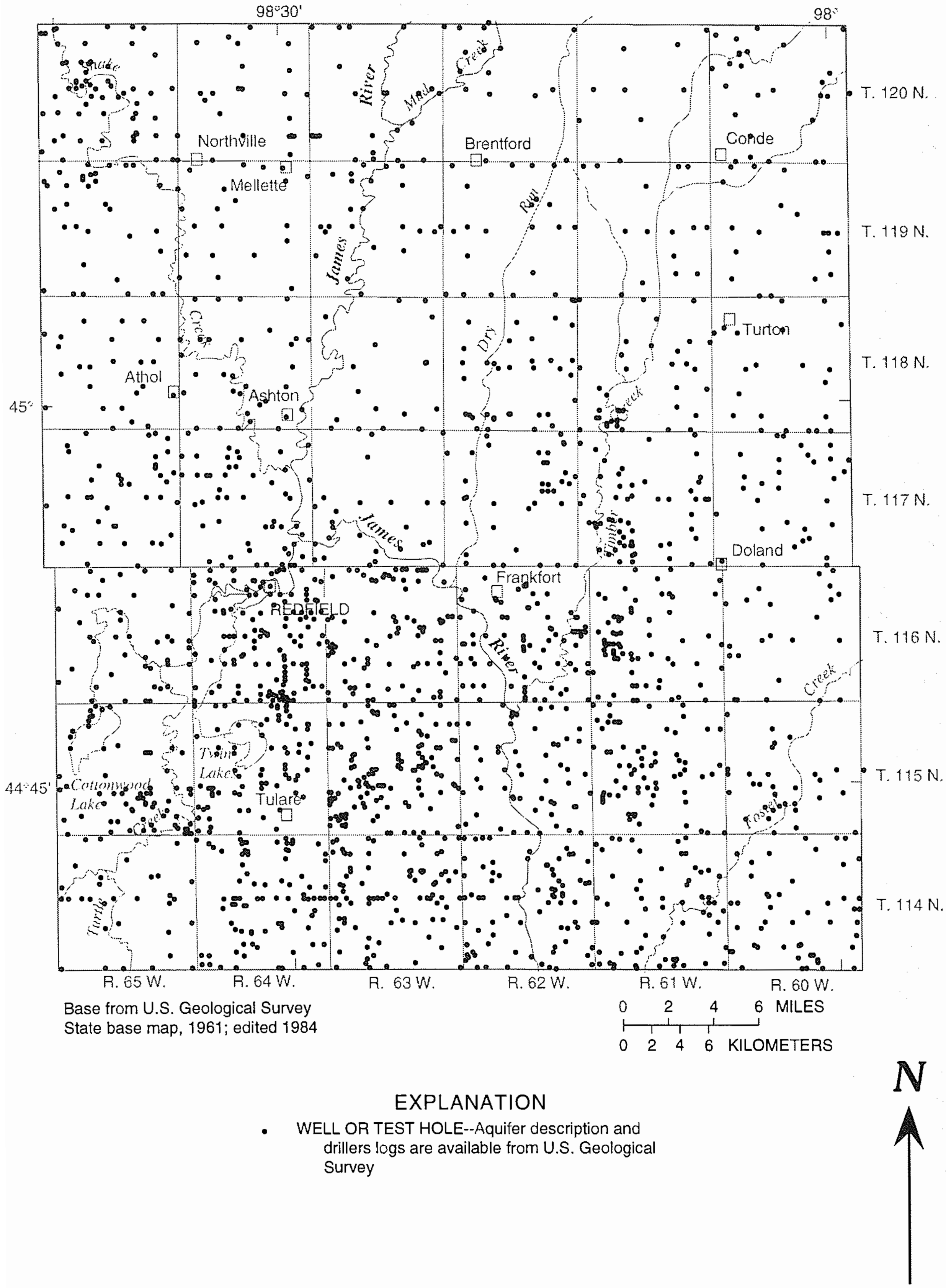


Figure 1. Locations of selected wells and test holes in Spink County.

Multiply inch-pound unit	By	To obtain metric unit
acre-foot (acre-ft)	1,233	cubic meter
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
grains per gallon	17.12	milligrams per liter
inch	25.4	millimeter
mile (mi)	1.609	kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second
pound per square inch	6.895	kilopascal
square mile (mi^2)	2.590	square kilometer

DEFINITION OF TERMS

Aquifer: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Bedrock: A general term for the rock, usually consolidated, that underlies soil, sand, clay, or other unconsolidated material.

Confined aquifer: An aquifer in which the water in a tightly cased well completed in the aquifer usually rises above the top of the aquifer.

Dissolved solids: The sum of all dissolved material in water, expressed as the weight (milligrams) of solute per unit volume (liter) of water.

Glacial aquifer: As used in this report, an aquifer consisting mainly of unconsolidated sand and gravel deposited as outwash from a glacier.

Glacial outwash: Gravel, sand, silt, and clay that was deposited by water from melting ice. In this report, the term is restricted to sand and gravel.

Hardness: Dissolved calcium and magnesium salts in water that decrease the lathering ability of soap and form scale in boilers and pipes. Hardness is reported as the concentration of calcium carbonate and is classified by the U.S. Geological Survey as follows:

Classification	Milligrams per liter	Grains per gallon
Soft	0 - 60	0 - 3.5
Moderately hard	61 - 120	3.6 - 7.0
Hard	121 - 180	7.1 - 10.5
Very hard	More than 180	More than 10.5

Large-capacity well: Defined by South Dakota law as a well capable of yielding at least 18 gal/min on a sustained basis.

Milligrams per liter (mg/L): A unit expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. One milligram per liter is approximately equal to one part per million.

Specific conductance: The ability of water to conduct an electric current. Generally, this is a measure of the dissolved chemical constituents in water.

Till: A general term applied to all unsorted rock material (clay, sand, gravel, boulders) transported by glaciers and deposited directly on land or in the sea.

Water table: That water surface in an unconfined aquifer at which the pressure is atmospheric.

GLACIAL AQUIFERS

The glacial drift of Spink County contains five major aquifers (Hamilton and Howells, 1996). The aquifers, in order of increasing depth, are the Tulare, Elm, Altamont, Middle James, and Deep James.

Most of the glacial aquifers are composed of well-sorted outwash sand and gravel that is very permeable. The sand is mostly medium to very coarse grained, and the gravel is very fine to medium grained. The aquifers underlie about 760 mi^2 (about one-half of the county) and contain about 3.3 million acre-ft of water in storage. The tops of the aquifers are at depths ranging from land surface to more than 360 ft below land surface (table 1). The maximum thicknesses of four of the aquifers is more than 50 ft.

Most of the recharge to aquifers in glacial drift deposits in Spink County is by infiltration of precipitation and by ground-water inflow from adjacent areas. Water seeps downward to the aquifers in unconsolidated deposits through soil and permeable deposits that overlie them and then moves from these areas of recharge toward areas of discharge. Minor amounts of recharge come from aquifers in the bedrock that are in contact with aquifers in the glacial deposits. Also, leakage through ruptured well casings or infiltration of uncontrolled discharge from flowing wells completed in bedrock may recharge aquifers in the glacial deposits. Recharge from precipitation, mainly from rain and snowmelt in spring, varies from year to year and from place to place. Infiltrating water must fill the soil to its moisture-holding capacity before any recharge from precipitation can take place. When the ground thaws in the spring, the amount of water infiltrating from melted snow and from rainfall can exceed the moisture-holding capacity of the soil, and the excess may move downward to recharge aquifers.

Water-level fluctuations in wells are caused by seasonal changes in recharge and discharge. Water levels generally rise in spring due to recharge from snowmelt and rainfall. During summer, levels generally drop because of decreased recharge, increased evapotranspiration, discharge to streams, and increased pumpage. Levels rise again in fall when evapotranspiration and pumpage decrease.

Tulare Aquifer

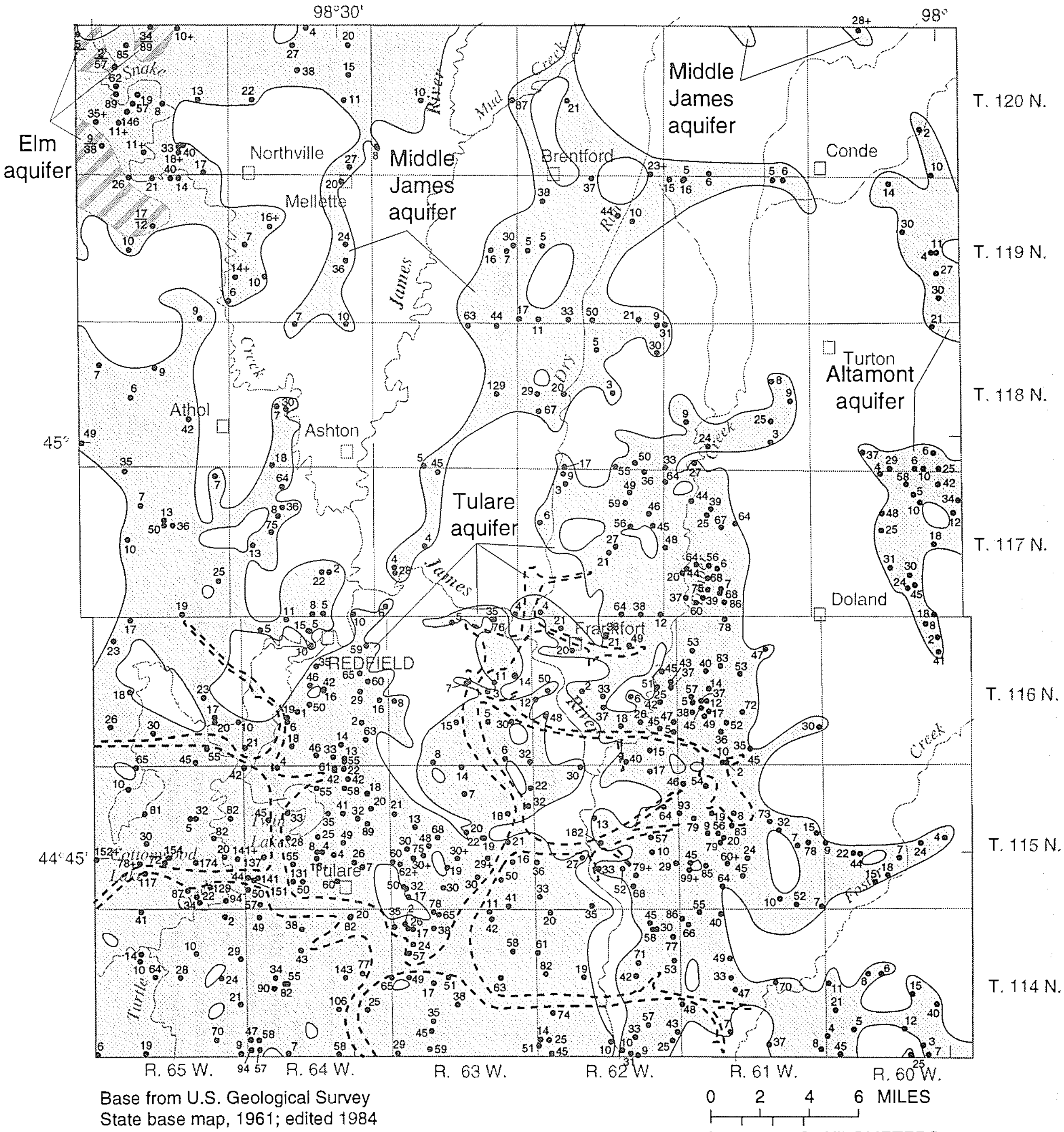
The Tulare aquifer underlies about 510 mi^2 in central and southern Spink County (fig. 2) and contains about 2.4 million acre-ft of water in storage. The deposits that make up the aquifer include not only surface and near-surface irregular sheets of outwash and other fluvio-glacial materials, but

Table 1. Summary of the characteristics of major aquifers in Spink County

[--, data insufficient for an estimate]

Aquifer name	Estimated areal extent (square miles)	Maximum thickness (feet)	Average thickness[1] (feet)	Range in depth below land surface to top of aquifer (feet)	Range of water level (feet below or above (+) land surface)	Estimated amount of water in storage[2] (million acre-feet)	Range of reported and estimated well yields (gallons per minute)	Suitable for irrigation[3]
GLACIAL AQUIFERS								
Tulare	510	220+	37	0 - 100	0 - 50	2.4	2 - 1,200	Yes[4].
Elm	15	35	13	2 - 40	20 - 40	.02	2 - 100	Yes.
Altamont	34	70	22	2 - 80	5 - 60	.10	2 - 900	Yes[4].
Middle James	160	90	30	10 - 100	5 - 30	.61	2 - 500	Yes[4].
Deep James	43	160	36	55 - 364	10 - 45	.20	2 - 1,000	Yes[4].
BEDROCK AQUIFERS								
Niobrara	1,490	200	40[5]	80 - 360	30 - 50	7.6[6]	2 - 600	No.
Dakota	1,500	370	170[5]	740 - 1,000	+90 - 65	32.6[6]	2 - 350	No.
Inyan Kara-Sundance	--	80	--	1,150 - 1,200	+460 - +90	--	--	No.
Minnelusa	--	440	--	1,265[7]	--	--	--	No.

[1] Arithmetic mean from test hole data.
[2] Storage estimated by multiplying average thickness times areal extent times a specific yield of 0.20.
[3] Based on irrigation-water classification diagram (see fig. 25 of Hamilton and Howells, 1996).
[4] Though generally suitable for irrigation, in some places the water in the aquifer is not suitable.
[5] Average thickness greater than indicated because not all test holes fully penetrated the aquifer.
[6] Minimum value because average thickness greater than indicated.
[7] Based on only one well.



Base from U.S. Geological Survey State base map, 1961; edited 1984

EXPLANATION

- APPROXIMATE AREA UNDERLAIN BY ELM AQUIFER
- APPROXIMATE AREA UNDERLAIN BY TULARE, MIDDLE JAMES, OR ALTAMONT AQUIFERS
- INFERRED LOCATION OF PERMEABLE DEPOSITS IN THE TULARE AQUIFER THAT ARE PART OF THE SAME DEPOSITIONAL EPISODE AS THE DEEP JAMES AQUIFER (see figure 3)
- 34+/89 WELL OR TEST HOLE--Numbers are thickness, in feet, of upper and lower aquifers. A plus (+) indicates a thickness greater than shown.

N

Figure 2. Extent and thickness of the Tulare, Middle James, Elm, and Altamont aquifers in Spink County.

also older, more deeply buried valley-fill outwash and other permeable, hydraulically connected fill in the deep valleys in the bedrock surface. The bedrock valleys that contain the more deeply buried parts of the Tulare aquifer are part of the same buried valley system that contains the Deep James aquifer in northern Spink County (fig. 3), and the Tulare and Deep James aquifers may be hydraulically connected in T. 117 N., R. 62 W. Depth to the top of the upper parts of the Tulare aquifer ranges from 10 to 80 ft in the middle one-third of the county and from land surface to 100 ft in the southern one-third.

The Tulare aquifer is thickest where thicker parts of the surface or near-surface outwash overlie thick or moderately thick valley-fill outwash in the deep valleys in the bedrock surface; maximum thickness exceeds 220 ft. In the surface and near-surface sheets of outwash in the Tulare aquifer, the aquifer is thickest, more than 50 ft, in shallow buried channels in drift that are 1 to 4 mi wide in the southern one-third of the county, and in shallow buried channels in the drift that are less than 2 mi wide in the middle one-third of the county. The average thickness of the Tulare aquifer is about 37 ft. That part of the Tulare aquifer lying east of the James River has no known connection to that part of the aquifer west of the river at shallow depth (above an altitude of 1,100 ft) in Spink County. Any hydraulic connection between the two parts of the aquifer that is within Spink County probably is through permeable deposits in the buried deep bedrock valleys.

Elm Aquifer

The Elm aquifer underlies about 15 mi^2 of northwestern Spink County (fig. 2). The top of the aquifer is at depths of from 2 ft to as much as 40 ft below land surface. The average thickness of the aquifer in Spink County is about 13 ft.

Altamont Aquifer

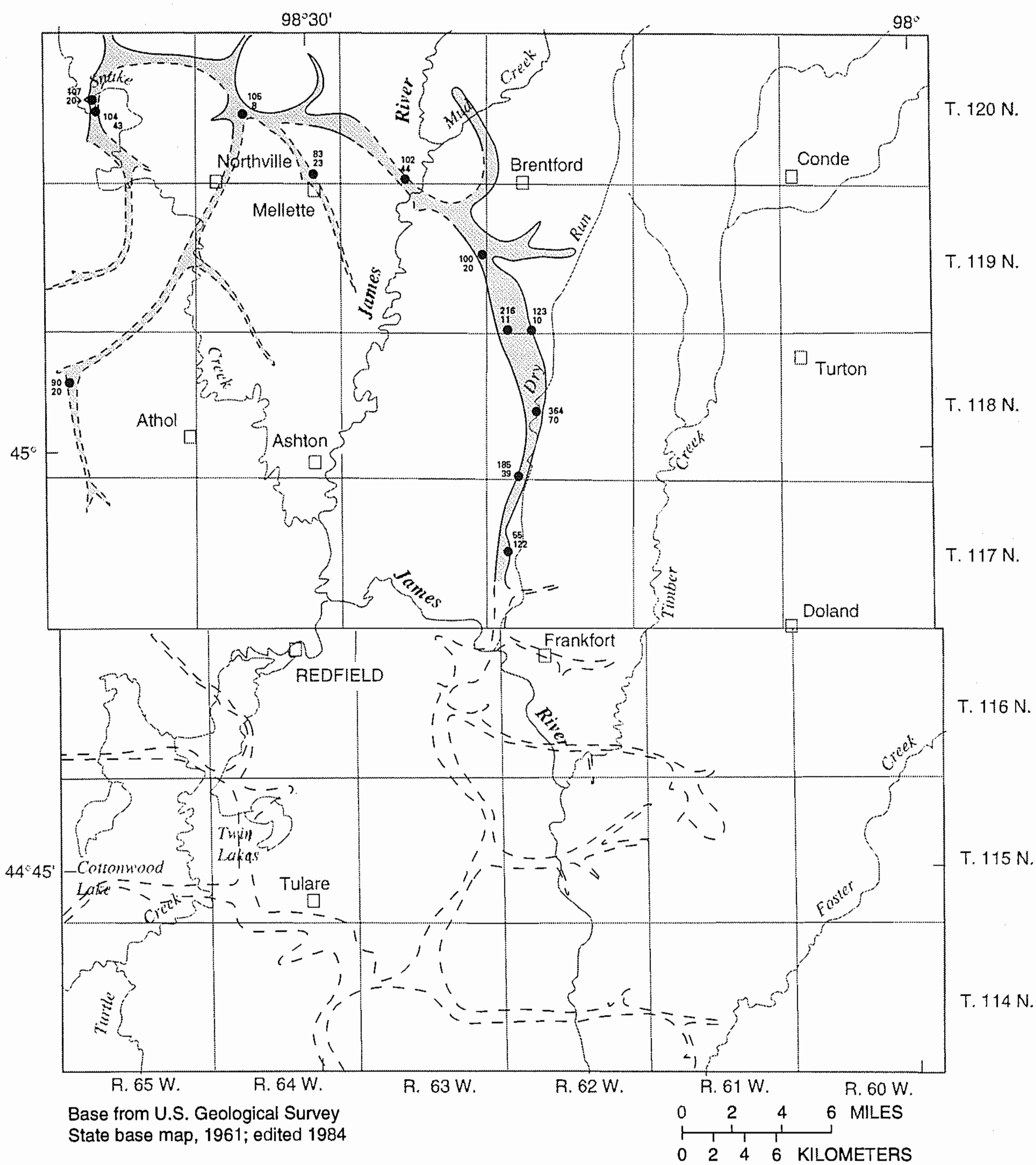
The Altamont aquifer occupies buried channels underlying about 34 mi^2 along the eastern side of Spink County (fig. 2). The aquifer is in two layers. The top of the shallow layer commonly is within 2 to 10 ft of land surface. The depth to the more extensive lower layer ranges from 35 to 80 ft. The average thickness of the Altamont aquifer is about 22 ft.

Middle James Aquifer

The Middle James aquifer underlies about 160 mi^2 of Spink County (fig. 2). Depth to the top of the aquifer ranges from 10 to 100 ft below land surface. The average thickness of the aquifer is about 30 ft.

Deep James Aquifer

The Deep James aquifer, which underlies an estimated 43 mi^2 in northern Spink County (fig. 3), is composed of hydraulically connected deposits in the fill of the buried deep valleys in the bedrock surface. The aquifer area shown in figure 3 is based on available well-log data, but these data are insufficient to fully outline the aquifer. Because this aquifer is made up mostly of deposits of valley-



EXPLANATION

APPROXIMATE LOCATION OF DEEP JAMES AQUIFER--Boundary dashed where location is inferred

INFERRED LOCATION OF PERMEABLE DEPOSITS IN THE TULARE AQUIFER THAT ARE PART OF THE SAME DEPOSITIONAL EPISODE AS THE DEEP JAMES AQUIFER

104
40
WELL OR TEST HOLE IN DEEP JAMES AQUIFER--First number is depth, in feet, to top of aquifer. Second number is aquifer thickness, in feet.

N

Figure 3. Extent, depth, and thickness of the Deep James aquifer in Spink County.

fill outwash, the area shown in figure 3 for the Deep James aquifer also is based on bedrock topography. Materials that now form the Deep James aquifer were later overridden and eroded by glaciers, eroded by streams, and then buried by subsequent glacial deposits; therefore, the deposits that now form the Elm and Middle James aquifers in some places directly overlie the deposits that form the Deep James aquifer and are indistinguishable from them. Depths to the top of the Deep James aquifer range from 55 ft to more than 360 ft below land surface. The thickness of the aquifer averages about 36 ft and ranges from a few feet to 160 ft.

Water Quality in Glacial Aquifers

The chemical quality of water in aquifers in glacial drift deposits varies widely, both within and between aquifers and, in many places, with depth at a given time. Generally, water in the glacial aquifers is very hard, ranging from 84 to 3,700 mg/L. Patterns in water type are not obvious, but some general observations are apparent. Calcium, magnesium, and sodium tend to be co-dominant for many glacial aquifer samples, although calcium is clearly the dominant cation for most samples from the Tulare aquifer. Sulfate tends to be the dominant anion, although bicarbonate is dominant or co-dominant in many samples. Concentrations of dissolved solids in water samples collected during 1962-91 from aquifers in drift ranged from 151 mg/L at a site in the northeastern part of the county to 9,610 mg/L at a site in the central part of the county. Concentrations of dissolved solids tend to be large where aquifers are thin or have low permeability, as in T. 116 N., R. 63 W., T. 117 N., R. 63 W., and T. 120 N., R. 63 W. and R. 64 W. Concentrations tended to decrease with increasing well depth in many areas. Concentrations of sodium generally tended to be highest in areas where the concentrations of dissolved solids exceeded 2,000 mg/L. Sodium concentrations also exceeded 400 mg/L near the James River in T. 115 N., R. 62 W., where the Niobrara aquifer discharges sodium-rich water into aquifers in the drift.

Water samples collected from wells tapping surficial aquifers in Spink County did not exceed the Maximum Contaminant Level (MCL)[1] established by the U.S. Environmental Protection Agency Primary (EPA) Drinking-Water Regulations for any regulated constituent with the following exception: two samples out of 109 collected from the Tulare aquifer and one sample out of 112 collected from minor aquifers in glacial drift exceeded the EPA MCL for nitrate of 10 mg/L (U.S. Environmental Protection Agency, 1994).

The median concentrations of dissolved solids and sulfate in water samples collected from the Tulare, Altamont, Middle James, and Deep James aquifers are near or exceed the EPA Secondary Maximum Contaminant Level[2] (SMCL) of 500 mg/L and 250 mg/L, respectively (U.S. Environmental Protection Agency, 1994). Also, the median concentrations of iron and manganese in water samples collected from the Tulare, Middle James, and Deep James aquifers are near or exceed the EPA SMCL of 300 mg/L (micrograms per liter) and 50 mg/L, respectively. Boron concentrations in water

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[1] Primary Maximum Contaminant Levels are established for contaminants that, if present in drinking water, may cause adverse human health effects; MCL's are enforceable health-based standards. Drinking-water standards established by the State of South Dakota correspond directly with EPA regulations. Federal law requires that drinking-water standards established by the states cannot be less stringent than those established by EPA; the South Dakota Legislature has, in turn, mandated that state drinking-water standards cannot be more stringent than the EPA regulations.

[2] Secondary Maximum Contaminant Levels are established for contaminants that can adversely affect the odor or appearance of water and result in discontinuation of use of the water. SMCL's are nonenforceable, generally non-health-based standards that are related to the aesthetics of water use.

from the Deep James aquifer may exceed recommended limits for irrigation of boron-sensitive crops (U.S. Environmental Protection Agency, 1986).

Bedrock Aquifers

Four bedrock aquifers store more than 40 million acre-ft of water at depths of from 80 to about 1,300 ft below land surface in Spink County. The aquifers, in order of increasing depth, are the Niobrara, Dakota, Inyan Kara-Sundance, and Minnelusa (table 1).

Niobrara Aquifer

The Niobrara Formation is mostly a firm, tan to gray to dark-gray, highly calcareous, silty, chalky shale that yields water, and therefore is an aquifer, in its upper part. The Niobrara Formation is overlain throughout much of Spink County by, in addition to glacial drift, the Pierre Shale, a light-gray to dark-gray to black, calcareous to noncalcareous, greasy, relatively impermeable shale that is as much as 350 feet thick. The Crow Creek Member of the Pierre Shale and one or more 10- to 40-foot-thick layers of calcareous marl in the Gregory Member of the Pierre Shale are often mistaken for the Niobrara Formation. However, even the lowest of the calcareous beds in the Pierre Shale are at least 40 to 100 feet above the Niobrara and none of them yield water to wells.

The Niobrara aquifer, called "chalk" or "chalkstone" by drillers, is in the Niobrara Formation and underlies almost all of the county at depths of 80 to 450 ft below land surface. The altitude of the top of the formation ranges from below 1,060 ft above sea level in buried valleys in the bedrock surface and in the northeastern corner of the county, to more than 1,180 ft above sea level at several places throughout the county. The Niobrara Formation has been deeply eroded locally by pre- and/or interglacial and glacial streams and is thin or absent in some narrow, buried, bedrock valleys.

Where not truncated by Pleistocene erosion, the Niobrara Formation in Spink County is about 80 to 90 ft thick, though well drillers occasionally report thickness of as much as 200 ft. The Niobrara aquifer is very permeable, especially in its upper part where drillers often report a rapid loss of drilling fluid. An irrigation well developed in the aquifer at NW NW NE SW sec. 14, T. 116 N., R. 63 W. is reported to yield 600 gal/min.

Dakota Aquifer

The Dakota aquifer is made up of the permeable siltstone and sandstone beds of the Dakota Formation (Dakota Sandstone), a thick sequence of interbedded shale, siltstone, and sandstone. Beds of permeable sandstone are from 5 to 40 feet thick and compose 30 to 70 percent of the Dakota Formation. The top of the Dakota often is interpreted by drillers as the top of the first 5- to 10-foot-thick sandstone below the Greenhorn Formation. In the past, drillers and water users have divided the Dakota into an upper sandstone, called the "first flow," and a lower sandstone, called the "second flow." Extensive development of the Dakota aquifer and the subsequent decline of artesian pressure has resulted in mixing of water from the two sandstone units to the extent that the artesian pressure and water quality are nearly the same in both.

The Dakota aquifer underlies the entire county at depths of 740 to about 1,000 ft below land surface. The aquifer is confined beneath 700 to 800 ft of Cretaceous shale formations and overlies Precambrian crystalline rocks and, in part of western Spink County, beds of the Skull Creek Shale, Inyan Kara Group, and possibly, the Sundance Formation. Except for sandstones in the Inyan Kara Group and Sundance Formation, both overlying and underlying rocks commonly are relatively impermeable. The altitude of the top of the Dakota increases from less than 360 ft above sea level in the northwestern part of the county to more than 610 ft above sea level in the southeastern part. The formation is more than 200 ft thick throughout most of Spink County and is more than 300 ft thick in some areas; however, it may be less than 200 ft thick in the southeastern corner of the county. The yield of 2-inch-diameter wells with 100- to 200-foot lengths of slotted openings ranges from 4 to 30 gal/min for flowing wells and from 20 to 70 gal/min for pumped wells. A 9-inch-diameter municipal well at Redfield is reported to pump 350 gal/min.

The artesian head of the Dakota aquifer has declined about 350 ft in the last 100 years as a result of withdrawals of more than 400,000 acre-ft of water through wells. However, water levels have stabilized or risen since 1982 because other surface- and ground-water sources have been developed and less use is being made of the Dakota aquifer for stock and domestic water. Also, many farms have recently connected to the WEB Rural Water System and no longer use wells completed in the Dakota aquifer for a domestic water supply. Water levels probably could again decline with the return of severe drought or from industrial and municipal expansion, either of which could cause greater use of water from the Dakota.

Inyan Kara-Sundance Aquifer

The extent of the Inyan Kara-Sundance aquifer in Spink County is not known. The aquifer has been penetrated by wells near the northwestern and southwestern corners of the county. The Inyan Kara aquifer is equivalent to the Fall River Formation of earlier reports for counties to the west (Koch, 1980; Hamilton, 1982). The Inyan Kara-Sundance aquifer at wells SE NW sec. 20, T. 120 N., R. 64 W. and NW NW SW NE sec. 22, T. 120 N., R. 65 W. was penetrated at a depth of about 1,195 ft, an altitude of about 100 ft above sea level. The aquifer is composed of as much as 70 ft of sandstone and sandy shale that is moderately permeable. An artesian pressure of 200 pounds per square inch and an initial flow of 80 gal/min through 2-inch casing were reported by the driller at the second site in 1982. Seven years later, the average flow was 6 gal/min and the partially shut-in pressure at a flow of 2 gal/min was 57 pounds per square inch.

In the southwestern part of Spink County at wells SW NE SE NE sec. 07, T. 114 N., R. 65 W., NE NE SE SE sec. 14 (2), NE NE sec. 26, SE SE NE NE sec. 35 (3), the aquifer was penetrated at a depth of about 1,150 ft, an altitude of about 180 ft above sea level. The aquifer there is composed of as much as 60 ft of shaly, fine to medium sand that is very permeable. Initial artesian pressures of as much as 40 pounds per square inch and flows of as much as 60 gal/min through 2-inch casing were reported by drillers. Yields have since declined as a result of a decrease in pressure.

Minnelusa Aquifer

The extent of the Minnelusa aquifer in Spink County is unknown. The aquifer was penetrated in one water well at a depth of 1,265 ft in the northwestern part of Spink County. The location of the well, which was drilled in 1901 for Ezra Martin by Peter Norbeck, is believed to be SE NW sec. 20, T. 120 N., R. 64 W. The top of the Minnelusa Formation is estimated to be at an altitude of 32 ft above sea level at that location. The bottom of the Minnelusa was reported to lie on very hard rock, probably granite, at an altitude of 403 ft below sea level. The driller's log starting at the top of the Minnelusa Formation, reported 30 ft of "caprock," 230 ft of "shale with water from gravelly clay," 75 ft of "layers of sandrock," 100 ft of "sandstone," and 4 ft of "hard rock." The initial flow reported was 135 gal/min through 5-½-inch casing.

Water Quality in Bedrock Aquifers

Most water in bedrock aquifers is slightly saline, soft to extremely hard, and of sodium sulfate or calcium magnesium sulfate type. Hardness is greatest in the deepest aquifers and may exceed 1,500 mg/L in water from the Minnelusa aquifer. Water that has large concentrations of dissolved solids, particularly sodium, and/or large concentrations of boron, such as all of the aquifers in the bedrock, generally is unsuitable for irrigation use.

Generally, the water of the Niobrara aquifer is soft, with sodium being strongly dominant among the cations. Sulfate generally is the most dominant anion, but chloride and bicarbonate may equal or exceed sulfate in dominance for some samples. Dissolved-solids concentrations for two samples collected from the Niobrara aquifer in Spink County were 1,410 and 1,580 mg/L. Samples collected from the Niobrara aquifer in adjacent counties also generally were about 1,500 mg/L.

Water from the Dakota aquifer generally is a slightly saline, soft to moderately hard, sodium sulfate type. Dissolved-solids (sum of constituents) concentrations in water samples collected during 1937-89 from the Dakota aquifer had a median value of 2,110 mg/L and ranged from 1,620 to 2,670 mg/L. Although the median hardness is 100 mg/L (moderately hard), the highest hardness was 1,400 mg/L and there were a few other samples with hardness exceeding 1,000 mg/L; these levels represent extreme hardness and were found in samples from wells located in the southwestern part of the county. The median concentrations of dissolved solids, sulfate, iron, and manganese in water samples collected from the Dakota aquifer are near or exceed the EPA SMCL's (U.S. Environmental Protection Agency, 1994).

There are no water-quality analyses in the USGS water-quality data base for samples collected from the Inyan Kara-Sundance aquifer in Spink County. Generally, water from the Inyan Kara-Sundance aquifer in eastern South Dakota is very hard (about 1,000 mg/L) and has concentrations of dissolved solids of 1,000 to 3,000 mg/L (U.S. Geological Survey, 1975).

No water-quality samples were collected from the Minnelusa aquifer in Spink County for this study. Generally, water from the Minnelusa aquifer is an extremely hard, calcium magnesium sulfate type. Based on data from adjacent areas, concentrations of dissolved solids probably are about 2,000 mg/L and the hardness probably is at least 1,200 mg/L and may exceed 1,500 mg/L.

LARGE-CAPACITY WELLS

The best possibilities for obtaining large-capacity wells capable of supplying more than 500 gal/min are in the areas where the aquifers are composed of coarse sand and gravel and are more than 20 ft thick. Before wells are constructed, test holes often are drilled to determine the thickness of the aquifer and to provide samples for determining the grain size of the aquifer material. This information helps in the selection of the proper slot size and length of screen to be used in the construction of a well. Controlled pumping of the well for at least several hours indicates the yield of the aquifer at that locality and provides a representative water sample for chemical analysis. Measurement of the recovery of water level in the well provides information that is useful for estimating the yield of a well during longer pumping periods. If the well is to be used for irrigation, knowledge of the type of soil, subsoil, and topography are also important in selecting the most suitable irrigation system. Increased ground-water development, especially in stream valleys, may decrease streamflow.

WATER USE

Irrigation was the primary user of water (13.3 Mgal/d) in Spink County during 1990. Seventy-one percent of the total amount of water used in the county was for irrigation, and 88 percent of the water used for irrigation was from the Tulare aquifer. Other uses of ground water, most of which came from flowing wells that tap the Dakota aquifer in the bedrock, include more than 4,600 acre-ft for watering livestock, 1,090 acre-ft for rural domestic use, and 348 acre-ft for municipal use. Unused flow from 1,600 flowing artesian wells that tap aquifers in the bedrock is estimated to be 4.6 Mgal/d, or more than 5,000 acre-ft in 1990. Total water use in Spink County during 1985 was 19.6 Mgal/d.

SUMMARY

The glacial drift of Spink County contains five major aquifers (Hamilton and Howells, 1996). The aquifers, in order of increasing depth, are the Tulare, Elm, Altamont, Middle James, and Deep James. These aquifers underlie 760 square miles and store about 3.3 million acre-feet of fresh to slightly saline water at depths of from near land surface to more than 500 feet below land surface. The Tulare aquifer, the most extensive of the aquifers in the glacial drift, has the largest average thickness (37 feet) and occurs mostly in the southern half of the county. Yields of properly developed wells in aquifers in the drift range from 2 to 1,200 gallons per minute. Withdrawals from these aquifers, mostly for irrigation, totaled about 15,000 acre-feet in 1990.

The quality of water from aquifers in glacial drift deposits varies greatly, both within and between aquifers. Concentrations of dissolved solids in samples ranged from 151 to 9,610 mg/L (milligrams per liter), and hardness of the water ranged from 84 to 3,700 mg/L; both dissolved solids and hardness tend to be largest where aquifers are thin and of low permeability. Two of 109 samples from the Tulare aquifer and one of 112 samples from minor aquifers in the glacial drift exceeded the U.S. Environmental Protection Agency (EPA) Primary Drinking-Water Regulations Maximum Contaminant Level (MCL) for nitrate of 10 mg/L. The median concentrations of dissolved solids, sulfate, iron, and manganese in some glacial aquifers are near or exceed the EPA Secondary Maximum Contaminant Levels (SMCL's). Some of the water from aquifers in glacial drift is suitable for irrigation use.

Bedrock aquifers store more than 40 million acre-feet of slightly to moderately saline water at depths of from 80 to about 1,300 feet below land surface. Yields of properly developed wells in bedrock are reported to range up to 600 gallons per minute. The artesian head of the Dakota aquifer has declined about 350 feet during the approximately 100 years since flowing wells were first completed in the aquifer. However, water levels locally have stabilized since 1982 because of a decrease in well use and increased use of water from rural water systems.

The quality of water from bedrock aquifers also varies greatly. Water from the Niobrara aquifer generally is a soft, sodium sulfate chloride type with a dissolved-solids concentration of about 1,500 mg/L. Water from the Dakota aquifer varies from a soft, sodium sulfate type to an extremely hard, calcium magnesium sulfate type. Concentrations of dissolved solids (sum of constituents) in the Dakota ranged from about 1,620 mg/L to about 2,670 mg/L, with a median of 2,110 mg/L; and the hardness was as much as 1,400 mg/L, with a median of 100 mg/L. Median concentrations of dissolved solids, sulfate, iron, and manganese in Dakota wells either are near or exceed EPA SMCL's. Water from aquifers below the Dakota generally is an extremely hard, calcium magnesium sulfate type. Concentrations of dissolved solids in the deeper aquifers (Inyan Kara-Sundance and Minnelusa) are about 2,000 mg/L and the hardness is about 1,000 mg/L or greater. Dissolved solids, sodium, and boron concentrations in water from bedrock aquifers commonly are too large for the water to be suitable for irrigation use.

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