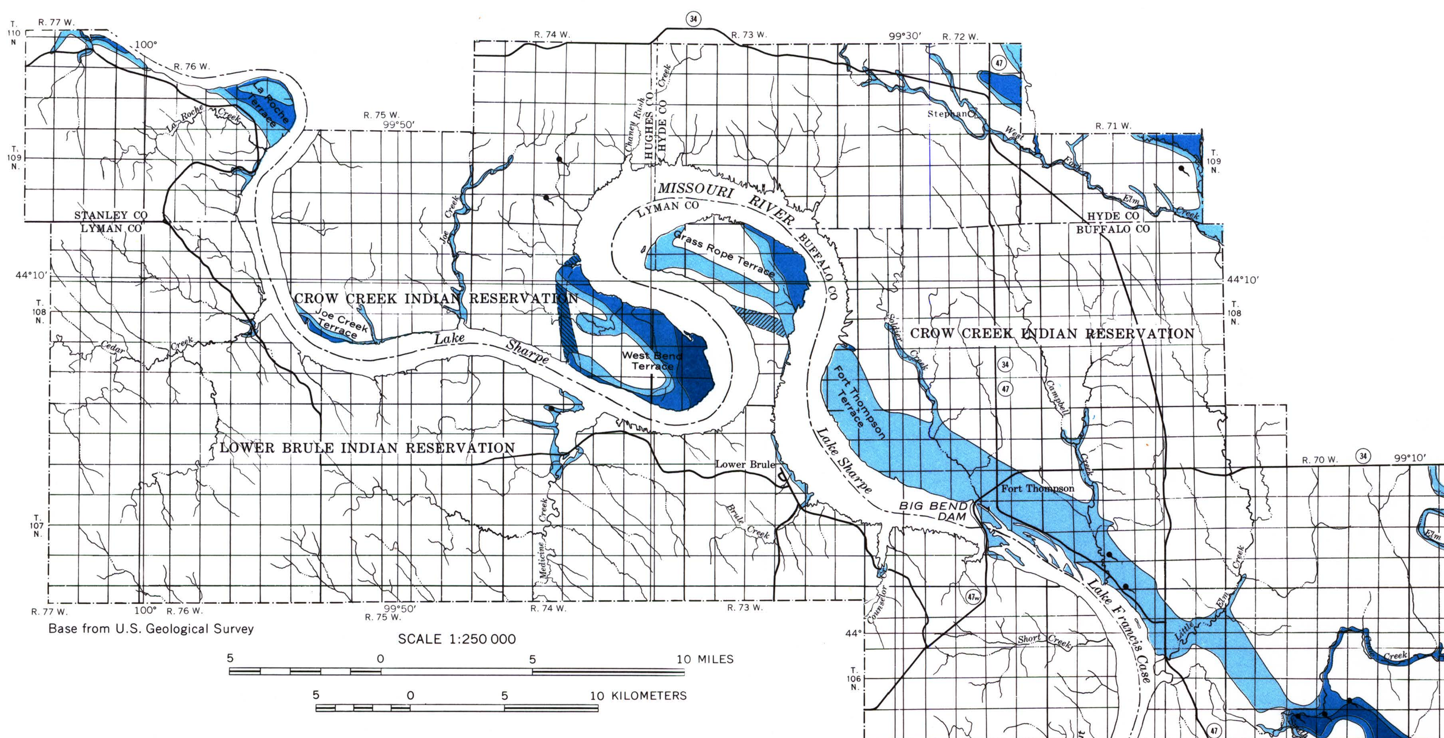
SHALLOW GROUND-WATER RESOURCES



GROUND-WATER AVAILABILITY MAP—SURFICIAL DEPOSITS

EXPLANATION

Potential as sources of supply:

Excellent — *Locally well yields might exceed 500 gallons per minute*

Good — *Patterned where inferred. Well yields may range from 5 to 50 gallons per minute*

Fair to poor — *Patterned where inferred. Locally possible to obtain well yields of 1 to 5 gallons per minute. Water may be of poor quality*

Very poor — *Low probability of obtaining water. Any water found has very poor quality*

Permanent springs and seeps

SHALLOW GROUND-WATER RESOURCES

The possibility of obtaining adequate supplies of good water from surficial deposits is limited to parts of some terraces along the Missouri River, to outwash near Stephan, and to part of a buried ancient drainage channel in southeastern Crow Creek Reservation. In these areas deposits of permeable sand and gravel either extend below the level of Lake Sharpe or are sufficiently "dammed" by impermeable boundaries to form subsurface reservoirs of water.

Pierre Shale, at or near the surface in much of the area, has almost no potential as a source of potable water. The Pierre usually will not yield water to wells, but where water can be obtained, generally the quantity is meager and the quality is very poor. Colluvium and alluvium along streams draining areas where shale is at the surface commonly are composed of clay or silty clay and are relatively impermeable; where water can be obtained, the quality is usually very poor. Many small springs and seeps occur along contacts between the Pierre and overlying deposits. The shale, a barrier to the downward movement of ground water, causes the water to move laterally to points of discharge at contact springs. The quality of water from these contact springs ranges from fairly good to very poor. Most springs and seeps are temporary and go dry by late summer.

Glacial till, both end moraine and ground moraine, is little better than Pierre Shale as a potential source of water. Locally, thin beds or lenses of gravel, sand, or silt may yield meager or small supplies of water, commonly of poor quality.

Alluvium along several streams, particularly Joe, Soldier, Elm, Smith, and Campbell Creeks, and at the mouths of others such as Cedar and Medicine Creeks, might yield small supplies of water, commonly of poor quality. Alluvium under the flood plain of Crow Creek, however, probably can yield small to moderate supplies, locally as much as 50 gpm (gallons per minute), of poor- to good-quality water. Although commonly low in dissolved solids (less than 1,000 mg/l), water from the Crow Creek alluvium can contain appreciable selenium; as much as 0.02 mg/l has been found.

The sand and gravel deposits underlying the major terraces are good sources of water only where thick enough to extend below the surface of the Missouri River reservoirs. Thus, the buried ancient channels across LaRoche and West Bend terraces, and the eastern edges of West Bend and Grass Rope terraces are potentially good sources of water. Locally, yields of 50 gpm might be obtained from wells, except for the eastern tip of West Bend terrace, where yields of 500 gpm or more may be attainable. The quality of the water ranges from excellent to poor, depending upon the source of the water and the permeability and local composition of the deposit. The best quality water comes from Lake Sharpe through coarse, clean gravel; the poorest quality water probably infiltrates through clayey material and may flow along the Pierre Shale bedrock surface beneath the terrace.

Where the base of a terrace is above the reservoir surface, the high permeability of the sand and gravel and the steep slopes of the underlying bedrock surface permit rapid discharge to the Missouri of infiltrating precipitation. This is why Fort Thompson terrace, for example, does not contain large or dependable supplies of water, though it locally is from 60 to 100 feet thick. Much of Grass Rope, West Bend, and LaRoche terraces, and most or all of Joe Creek and Fort Lookout terraces have the same configuration. If wells were completed in the deeper parts of buried drainageways on the bedrock surface, they might obtain small to moderate supplies of good to poor-quality water; but such wells might go dry by late summer or fall.

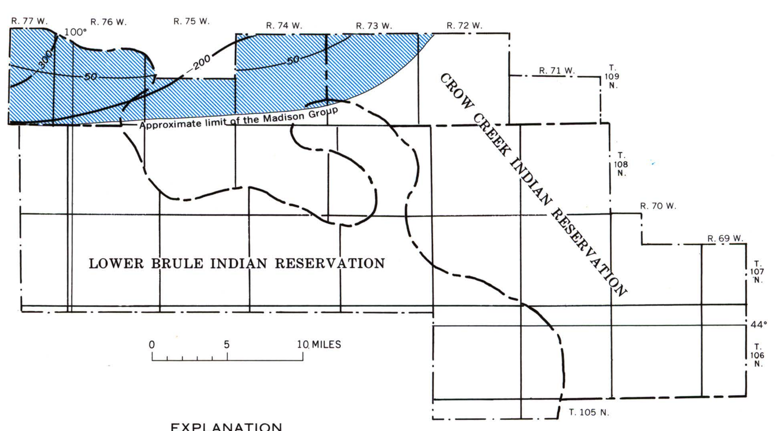
The outwash deposit northeast of Stephan yields good-quality water to several stock and domestic wells. The deposit may contain as much as 10,000 acre-feet of water underlying an area of 9 square miles; only about 2 square miles of this is within the reservation. This aquifer could not support heavy pumping from high capacity wells but should continue to be an excellent source of stock water.

Outwash and fill in the buried ancient channel in southeastern Crow Creek Reservation contain an estimated 10,000 acre-feet of water in Buffalo County and can supply good-quality water to high-capacity wells. The quantity of water that can be pumped from this aquifer on a sustained-yield basis is not very large, however. Analysis of data from an aquifer test made with the irrigation well in section 28, T. 106 N., R. 70 W., showed that, although the transmissivity is about 130,000 gallons per day per foot and the storage coefficient is at least 0.05, only about 400,000 gallons per day moves through the aquifer into the test area when the well is pumped 900 gpm. Thus one well pumping at 900 gpm can withdraw water from the aquifer at about three times the natural recharge rate. Also, drawdown at the test site is large enough to limit continuous pumpage to 25 days or less. This natural limit on its pumpage prevents the irrigation well from adversely affecting nearby stock and domestic supply wells.

Very few permanent springs or seeps were found during this study. Most of those found, and most of the springs and seeps mapped by the Bureau of Indian Affairs soil and range surveys (1964 and 1965), are temporary and go dry by late summer or are seepage from nearby stock reservoirs. Some seeps have no outflow because the water evaporates before reaching a stream. All permanent springs, except those on the lower reaches of Crow Creek, have flows of less than 5 gpm. The Crow Creek springs have an aggregate flow, in late summer, of more than 80 gpm and maintain a small base flow in the lowest reach of the stream.

The quality of water in surficial deposits varies widely, often within short distances. For example, water from a well in section 28, T. 106 N., R. 70 W., was of calcium bicarbonate type and had a specific conductance of only 887 μmhos per cm (micromhos per centimeter) whereas water from a well a quarter mile farther west was of sodium sulfate type and had a specific conductance of 4,500 μmhos per cm. Such variations make it difficult to predict water quality reliably when selecting well sites. The differences in water quality have many causes including: local variations in soluable minerals in aquifer material; differences in residence time of water in the soil and the aquifer; possibility of receiving fertilizer or feed-lot drainage; and local pollution. In general, the cleaner, coarser, more permeable aquifer material tends to yield the less saline, better quality water.

GEOHYDROLOGY OF THE BEDROCK AQUIFERS



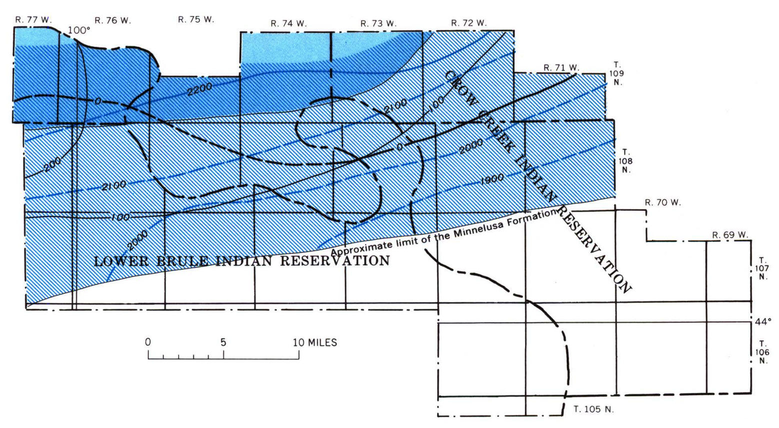
EXPLANATION

Area where aquifer in Madison Group probably is in contact with aquifer(s) in overlying formations

Structure contour — *Shows altitude of top of the Madison Group. Contour interval 100 feet. Datum is mean sea level*

Line of equal thickness of Madison Group, in feet

GEOHYDROLOGIC MAP OF THE MADISON GROUP



EXPLANATION

Area where aquifer in Minnelusa Formation probably is in contact with aquifer(s) in overlying formations

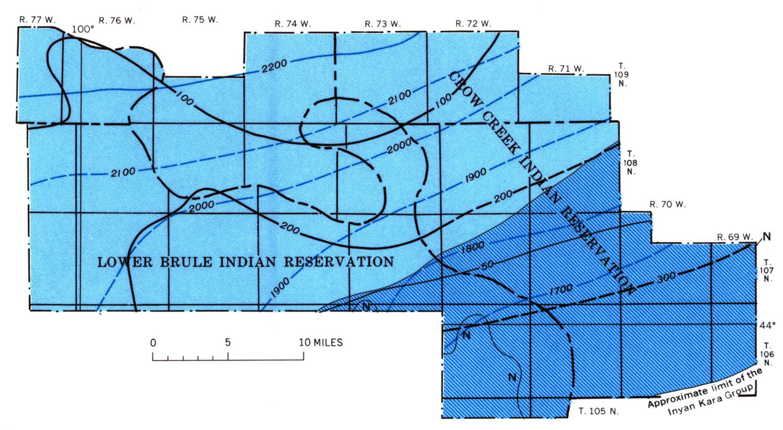
Area where aquifer in Minnelusa Formation probably is in contact with aquifer(s) in underlying formations

Potentiometric contour — *Shows the altitude of the artesian head in the Minnelusa Formation. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level*

Structure contour — *Shows altitude of top of the Minnelusa Formation. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level*

Line of equal thickness of Minnelusa Formation — *Interval 100 feet*

GEOHYDROLOGIC MAP OF THE MINNELUSA FORMATION



EXPLANATION

Area where aquifer in the Inyan Kara Group probably is in contact with aquifer(s) in overlying formations

Area where aquifer in the Inyan Kara Group probably is in contact with aquifer(s) in underlying formations

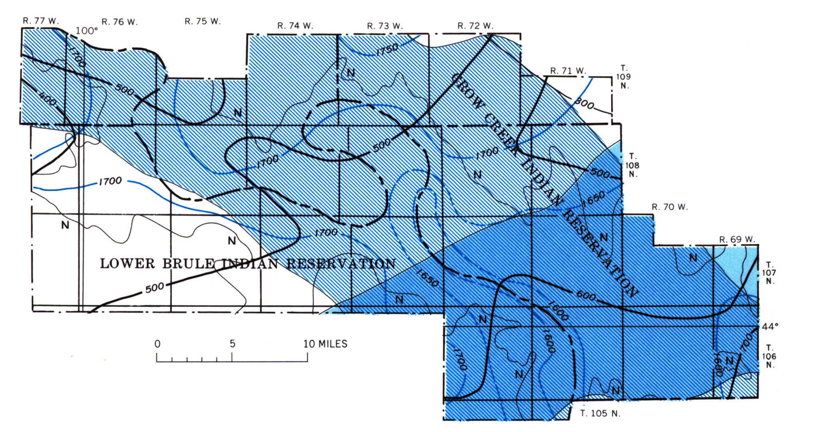
Approximate area where wells tapping the Inyan Kara Group will not flow

Potentiometric contour — *Shows the altitude of the artesian head in the Inyan Kara Group. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level*

Structure contour — *Shows altitude of top of the Inyan Kara Group. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level*

Line of equal thickness of Inyan Kara Group, in feet

GEOHYDROLOGIC MAP OF THE INYAN KARA GROUP



EXPLANATION

Area where Graneros Shale may contain an aquifer at or near the base probably recharged by the Dakota Sandstone

Area where aquifer in the Dakota Sandstone probably is in contact with underlying aquifers

Approximate area where wells tapping the Dakota Sandstone will not flow

Potentiometric contour — *Shows the altitude of the artesian head in the Dakota Sandstone. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level*

Structure contour — *Shows altitude of top of the Dakota Sandstone. Contour interval 100 feet. Datum is mean sea level*

Line of equal thickness of Dakota Sandstone, in feet

GEOHYDROLOGIC MAP OF THE DAKOTA SANDSTONE

GENERALIZED STRATIGRAPHIC COLUMN DESCRIBING THE BEDROCK FORMATIONS, THEIR HYDROLOGIC CHARACTERISTICS, AND QUALITY OF THE WATER

[Some descriptions of the lithology and the water quality are based upon observations made and samples collected outside the area of this study; few wells have been drilled deeper than the Dakota Sandstone and all of those wells are screened in two or more aquifers.]

System	Formation or Deposit	Thickness (ft)	Description	Hydrologic Significance	Quality of Water
Cretaceous	Pierre Shale	0-550	Gray, brown, and black, tough, gummy to friable shale, non-calcareous to highly calcareous; contains widely persistent zones of limestone, bentonite, and iron-manganese concretions. Marine.	Relatively impermeable, a barrier to the movement of water. Locally, lenses or streaks of sandy or gravelly material may yield meager supplies of water, usually very saline, often high in selenium.	Specific conductance as high as 15,000 μmhos per cm (micromhos per centimeter). Water may contain selenium; in some areas in western South Dakota selenium contents as much as 5 mg/l (milligrams per liter) have been reported.
	Niobrara Formation	70-160	Tannish to bluish-gray and light to dark-gray highly calcareous shale; contains abundant microfossils. Marine.	Relatively impermeable, a barrier to the movement of water. Apparently contains no water-yielding zone within these reservations, although it is often an important aquifer in the James River valley in eastern South Dakota.	
	Carlile Shale	140-325	Light-blue or light-gray to black shale, generally non-calcareous; contains one or more sandstone or sandy intervals (probably equivalent to the Codell Sandstone Member found elsewhere) in the top half. Marine.	Relatively impermeable, a barrier to the movement of water except that thin sandstone beds, probably equivalent to the Codell Sandstone Member, are reported to yield water in some areas. No wells now in use are known to tap this formation.	Based upon reports from adjacent areas, water from the contained sandstones probably is very saline and of the sodium chloride type (Sp. Cond. more than 4,000 μmhos per cm).
	Greenhorn Limestone	50-100	Buff to bluish, white, or gray, highly calcareous shale; commonly marly and fossiliferous. May be interbedded with thin limestone layers. Marine.	Can yield muddy, saline water to wells in some areas.	Based upon reports from well drillers and samples from wells in adjacent areas, the water is very muddy, of sodium chloride type, and has a Sp. Cond. greater than 5,000 μmhos per cm.
	Graneros Shale	150-320	Medium to dark-gray non-calcareous shale. Calcareous concretions and pyrite and marcasite crystals common. Locally the formation may contain thin lenses and beds of sandstone and may be sandy or silty at the base. Along the crest and slopes of the Sioux uplift basal beds of sandstone or sandy and silty shale may exceed 100 feet in thickness. Marine.	Relatively impermeable, a barrier to the movement of water, except for the basal sandy zone along the crest and slopes of the Sioux uplift. This sandy zone yields very saline, muddy water to flowing and pumped wells. Locally, lenses or streaks of sandy material might yield meager supplies of very saline water to wells.	In the southeast corner yields calcium magnesium sulfate water, Sp. Cond. about 2,200 μmhos per cm, much like that from the Dakota. Becomes sodium chloride, Sp. Cond. greater than 5,000 μmhos per cm within a few miles to the northwest. Also, except in the southeast corner, the water may be malodorous and muddy. Toward the northwest corner, bubbling gas may support a flame. Locally the Sp. Cond. exceeds 10,000 μmhos per cm. Temperature ranges from 15.5° to 26°C.
	Dakota (Newcastle) Sandstone	280-350	White, tan, or light-gray sandstone, very fine to coarse-grained, loose to tightly cemented; interbedded with dark-colored shale. Deltaic or near-shore deposits.	A major aquifer; yields from 2 to 50 gallons per minute of moderately saline to very saline water to pumped and flowing wells. Importance is decreasing because the decline in artesian head has resulted in lower yields and in pumping lifts of as much as 250 feet. The original head (about 1890) was above land surface throughout the area.	Ranges from calcium magnesium sulfate water (very much like that from the Madison Group) in the southeast to sodium chloride water in the northwest. The calcium magnesium sulfate water has Sp. Cond. as low as 2,120 μmhos per cm, hardness as high as 1,400 mg/l, sulfate greater than 1,000 mg/l, fluoride between 2.3 and 3.8 mg/l, and boron generally less than 0.45 mg/l. The sodium chloride water has Sp. Cond. as high as 5,300 μmhos per cm, hardness as low as 50 mg/l, chloride as high as 2,800 mg/l, fluoride between 1.2 and 2.3 mg/l, and boron greater than 3.5 mg/l. Temperature ranges from 15.5 to 32°C.
	Skull Creek Shale	0-130	Dark bluish-gray shale. Marine.	Relatively impermeable, a barrier to the movement of water.	
	Inyan Kara Group	0-80	White to light-gray or tan sandstone, fine to medium-grained; contains beds of gray to black and reddish to buff shale and siltstone. Continental to marginal marine deposits.	A major aquifer; can yield hard, saline water to flowing wells throughout most of its extent in the report area. Probably most, if not all, of the Inyan Kara present is the topmost unit, the Fall River Formation.	Calcium magnesium sulfate water similar to that from the Madison Group. Sp. Cond. ranges from 2,200 to 2,600 μmhos per cm, hardness is greater than 1,200 mg/l, fluoride is between 2.8 and 3.5 mg/l, and boron is generally less than 0.25 mg/l. Temperature ranges from 23.5° to 37.5°C.
Jurassic	Sundance Formation	0-90	White, buff, dark-pink, or red sandstone, medium to fine-grained; may be glauconitic in some areas; contains layers of red to brown, green, and gray shale. Marine.	A major aquifer; can yield hard, saline water to flowing wells throughout its extent in the report area. Water-quality and artesian head are similar to those of the Inyan Kara, but the Sundance pinches out a few miles west or north of the limit of the Inyan Kara.	Calcium magnesium sulfate type water similar in quality to water from the Madison Group. Temperature ranges from about 26.5° to 32.5°C.
Permian and Pennsylvanian	Minnelusa Formation	0-250(?)	White to yellow, buff, or red sandstone interbedded with anhydrite, brick-red to orange, green, or black shale, and white to brown to gray limestone and dolomite. Continental to marine.	A major aquifer; can yield hard, saline water to flowing wells throughout its extent in the report area. Fairly high artesian head, ranging from at least 40 to more than 250 pounds per square inch at land surface. May contain more than one water-bearing zone.	Calcium magnesium sulfate type water similar in quality to that from the Madison Group. Temperature ranges from about 27.5° to 39.5°C.
Mississippian	Madison Group	0-100(?)	White to tan, brown, and gray limestone and dolomite. Locally may contain shale or anhydrite beds. Marine.	A major aquifer; can yield hard, saline water to flowing wells throughout its extent in the report area. Has higher artesian head than any overlying aquifer. The Madison probably recharges the overlying bedrock aquifers and is the source of the calcium magnesium sulfate water found in them. The Madison is recharged in the Black Hills.	Based upon reports from nearby areas, the water is of calcium magnesium sulfate type, has Sp. Cond. of 2,200 to 2,400 μmhos per cm, hardness greater than 1,400 mg/l, fluoride greater than 2.8 mg/l, and boron less than 0.20 mg/l. Temperature is greater than 32°C.
Devonian	Undifferentiated	0-50(?)	Red, green, gray, and black shales interbedded with anhydrite, red to gray, medium to fine-grained sandstone and siltstone, and gray to brown limestone and dolomite. Marine.	Hydrologic potential unknown. The shale beds are barriers to the movement of water but sandstone or limestone beds may be potential sources of water.	No direct information available, but evaporite beds and minerals, such as halite (rock salt), anhydrite, and gypsum probably make the water very saline.
Transgressive	"basal wash"	0-50	White and buff to pink to light reddish-purple sandstone, generally coarse-grained but ranges from fine-grained to gravelly. May be arkosic. Reflects the lithology of underlying or nearby Precambrian rocks. This is a coarse clastic facies that overlies the Precambrian surface throughout much of South Dakota.	A major aquifer; in physical and hydraulic contact with the other aquifers where they pinch out against the Precambrian surface. Also known locally as "granite wash" and "quartzite wash".	Generally the same as water from the Madison Group.
Precambrian	Sioux Quartzite		Pale maroon, pink, red or purple, hard, dense, orthoquartzite. Locally white, locally friable. Contains a few beds of catlinite (pipestone).	Impermeable; locally might yield water from fractures or joints.	No information available; but probably the same as water from whatever aquifer immediately overlies, or is in nearby contact with, the Precambrian surface.
	Igneous and metamorphic rocks		Various colored granite, gneiss, schist, and other igneous and metamorphic rocks.		

GEOHYDROLOGY OF THE BEDROCK AQUIFERS

Artesian aquifers underlie the entire area. These aquifers are part of a thick sequence of sedimentary beds that extend across the state from the Black Hills uplift to the Sioux uplift and northward into the Williston basin.

Crow Creek and Lower Brule Reservations lie on the northern slope of the Sioux uplift near its western end. The reservations stretch from near the crest of the uplift down onto the shelf and the transition zone between the shelf and the Williston basin.

The geologic formations in the bedrock, and the aquifers they contain, are described in the generalized stratigraphic column.

For the major aquifers (see geohydrologic maps), artesian head increases with stratigraphic depth. Thus, at a given site, higher artesian pressure generally can be obtained by tapping a deeper aquifer (where present) than by tapping a shallower one. Naturally, then, as the artesian head in the Dakota Sandstone has dropped, water users have tended to drill deeper wells. High cost of well construction, low rainfall, and the scarcity of dependable year-round supplies of stock and domestic water have encouraged water users to plan, and to drill, wells tapping high-pressure aquifers below the Dakota Sandstone and to distribute the warm (80° to 100°F or 27° to 37°C) water by pipeline to points more than 2 miles from the wells.

As development intensifies in aquifers below the Dakota Sandstone, the artesian head of these aquifers will decline as did that in the Dakota. The eventual drop in head probably will be large; its size cannot be predicted but will depend upon the excess of withdrawal over recharge before a balance is reached.

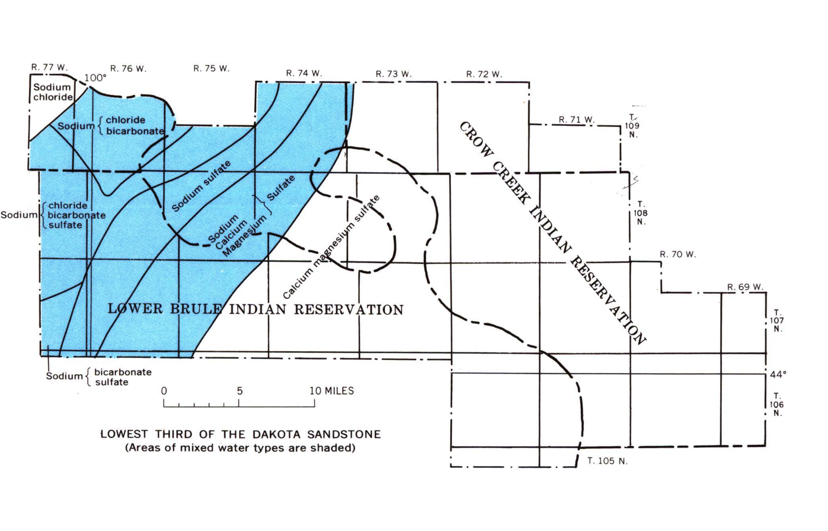
The Dakota is the most intensively developed aquifer in the State; on Crow Creek and Lower Brule Reservations about 46 percent of wells in use tap the Dakota. One of the consequences of heavy development has been a 200- to 300-foot decline in artesian head.

Artesian head in the Dakota Sandstone has been declining during the last 80 years and will continue to do so until recharge balances withdrawals and an equilibrium is reached. Intensive development of deeper aquifers, and the consequent decline in artesian pressure in them, will cause an additional, possibly very large, drop in head in the Dakota. At present, however, the rate of decline of artesian head in the Dakota is less than in the past (less than 1 foot per year in some areas). The artesian pressure may be stabilizing.

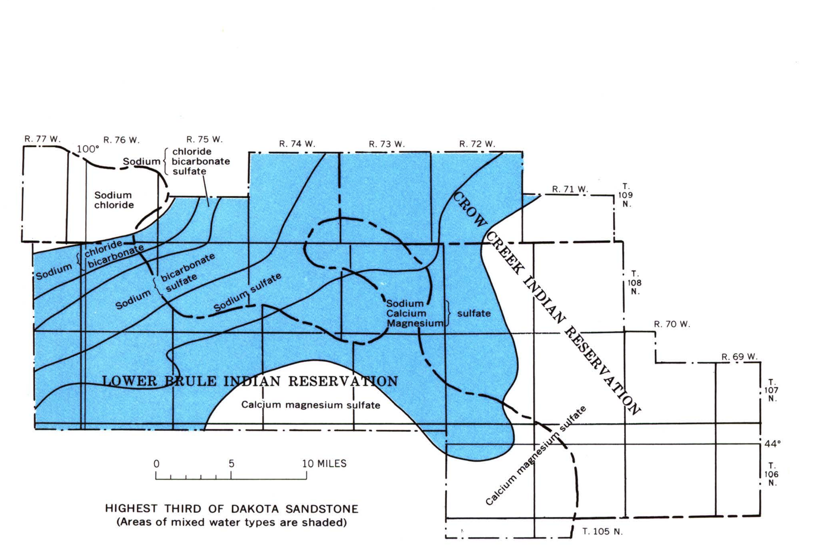
Most well owners are keenly aware of the value of conserving and maintaining artesian pressure and equip their flowing wells with control valves. Even though flow is reduced below the maximum possible rate, many wells flow at greater rates than actually needed. To reduce long term well costs by lengthening useful well life, to conserve pressure, and to maintain original water quality, most wells drilled within the last 10 years are cased with copper or, experimentally, with plastic. Black iron or steel casings tend to deteriorate rapidly and corrode through at permeable beds containing more saline water.

The geochemistry of water in the Dakota Sandstone appears to be complex; within or near the reservations wells tapping the Dakota may yield sodium chloride, sodium bicarbonate, or calcium, magnesium sulfate water. Between the regions where each of these types of water is found are areas of mixed water types such as sodium sulfate or sodium chloride bicarbonate and others. The chemical data support the theory that the Dakota is receiving major recharge from underlying aquifers. Calcium, magnesium sulfate water occupies a larger proportion of the basal third of the formation than in the top third, a natural consequence of its movement into the Dakota from below. Also, the pattern of major ion distribution generally parallels the area where aquifers in the Dakota are in contact with underlying aquifers. The source of predominantly sodium bicarbonate water, found in the Dakota a few miles west of Lower Brule Reservation, is unknown. Sodium chloride water probably is connate (trapped in the Dakota when the formation was deposited).

The proportion of the Dakota Sandstone that yields calcium, magnesium sulfate water probably is increasing. As sodium chloride or sodium bicarbonate water is withdrawn by wells, recharge is induced from underlying aquifers. Some wells (in good condition) in central South Dakota have shown large changes in water quality in the last 10 years. Commonly, these changes have been increases in the proportions of calcium, magnesium, and sulfate.



LOWEST THIRD OF THE DAKOTA SANDSTONE
(Areas of mixed water types are shaded)



HIGHEST THIRD OF DAKOTA SANDSTONE
(Areas of mixed water types are shaded)

GEOCHEMICAL MAPS OF THE DAKOTA SANDSTONE SHOWING WATER TYPES

DEVELOPMENT OF GROUND-WATER SUPPLIES IN 1970

[First number is the number of wells tapping each type of source; number in parentheses is the number of wells or springs that flow; last number is the estimated total flow in gallons per minute.]

Ground water source	Use on Crow Creek Indian Reservation: Irrigation	Domestic	Stock	Domestic and stock	Public supply	Total	Use on Lower Brule Indian Reservation: Domestic	Stock	Domestic and stock	Public supply	Total	Total both reservations
Drift, wells	1(0)	20(0)	34(0)	51(0)	11(1)3	117(1)3	3(0)	2(0)	5(0)	6(0)	16(0)	133(1)3
Drift, springs	-	1(1)1	6(6)100	1(1)8	-	8(8)109	1(1)3	-	-	-	1(1)3	9(9)112
Niobrara(?) Formation	-	1(0)	-	-	-	1(0)	-	-	-	-	-	1(0)
Graneros Shale	-	-	12(11)195	3(2)11	-	15(13)206	-	7(6)24	3(1)10	-	10(7)34	25(20)240
Dakota Sandstone	-	-	31(26)390	19(16)250	4(3)45	54(45)685	-	29(24)365	18(10)260	1(1)30	48(35)655	102(80)1,340
Graneros and Dakota	-	-	-	-	-	-	-	2(2)10	2(1)15	-	4(3)25	4(3)25
Inyan Kara Group and Sundance Formation	-	-	-	2(2)160	-	2(2)160	-	-	-	-	-	2(2)160
Dakota, Inyan Kara, and Sundance	-	-	1(1)30	-	-	1(1)30	-	-	-	-	-	1(1)30
Inyan Kara, Sundance, and Minnelusa Formation	-	-	2(2)80	-	-	2(2)80	-	-	-	-	-	2(2)80
Unidentified[1]	-	-	11(9)122	2(2)22	-	13(11)144	-	20(17)130	5(4)58	-	25(21)188	38(32)332
Total	1(0)	22(1)1	97(55)917	78(23)451	15(4)48	213(83)1,417	4(1)3	60(49)529	33(16)343	7(1)30	104(67)905	317(150)2,322

[1] Probably either sand near base of the Graneros Shale or top of the Dakota Sandstone or both.

GROUND-WATER DEVELOPMENT

An estimated 4,240 acre-feet of water was supplied by wells in 1970. About 3,770 acre-feet was discharged by springs and flowing wells, 230 acre-feet by one irrigation well, and an estimated 240 acre-feet by pumped shallow and artesian wells.

WATER QUALITY

Selected chemical analyses and a summary of trace elements are presented to show the general variation of constituents.

The importance of the various chemical constituents in water depends not only upon the amount of the substance present but also upon the use made of the water. For domestic use, U.S. Public Health Service (1962) suggests that water contain no more than 1,000 mg/l dissolved solids; however, more than half the population of South Dakota drinks water containing more than 1,000 mg/l. Livestock generally has greater salt tolerance than people; pigs, one of the less salt tolerant animals, can drink water containing as much as 4,200 mg/l of dissolved solids. Most crops have less salt tolerance than animals; irrigation water containing 1,200 to 1,500 mg/l of dissolved solids is borderline, if low in sodium, to unsuitable, if sodium constitutes much more than half of the cations.

An iron and manganese content greater than 0.3 mg/l will usually result in staining of laundry, food, and porcelain plumbing fixtures. Calcium and magnesium cause hardness in water and scale formation in plumbing; hardness content greater than 60 mg/l is hard and greater than 180 mg/l is considered very hard. Fluoride in small amounts is beneficial in promoting resistance to tooth decay but excessive fluoride can cause mottling of the teeth; the Public Health Service recommends no more than 1.5 mg/l fluoride on the two reservations. High nitrate content in water usually is an indication of pollution by sewage, feed lot runoff, or fertilizer seepage; the maximum recommended limit of nitrate in drinking water is 45 mg/l because high nitrate can cause a "blue-baby" condition (methemoglobinemia) in infants and young children. Boron is essential to plant growth, but a slight excess may be harmful; sensitive plants may show damage when irrigation water contains more than 0.67 mg/l and even tolerant plants may be damaged when boron exceeds 2.0 mg/l.

SUMMARY

Shallow ground water is not obtainable in much of the area and where it is found, it often is of poor quality. Surface water, with the exception of the Missouri River reservoirs, though a valuable and widely distributed resource, is undependable because of scanty and erratic precipitation. Therefore, some people have drilled deep artesian wells for their basic water needs. Because of the expense of drilling artesian wells, most people will continue to use surface water and shallow ground water, as available, particularly for livestock supplies.

The best chemical quality and largest volume supply of water available within the reservations is from the Missouri River reservoirs. Development of some of the more than 17 million acre-feet of annual flow in the Missouri appears to be an attractive solution to water shortage and a boon to economic improvement, particularly for irrigation. However, financial cost of such development probably will restrict it to large projects or to individual users within a mile or so of the reservoirs; in general, the greater the distance from the reservoir, the higher the cost and the larger the area that probably should be developed.

Surface runoff is widely developed for livestock supplies. Although evaporation losses are high, as much as 38 inches a year, dams and dugouts are a comparatively inexpensive way to hold snowmelt and storm runoff for later use at widely dispersed sites. Use of this type of water resource will continue to grow because of its many advantages.

Shallow ground water of fairly good quality is available in only a few areas. In most of these areas well yields will be less than 20 gpm, although two areas will support well yields greater than 50 gpm. Most future development of shallow ground water probably will be for stock and domestic wells in the few favorable areas. Water quality, of great importance in considering any possible source of supply, is of particular concern for shallow wells because of the ease of pollution from surface sources, possible high nitrate, and the known possibility of high selenium content.

WATER QUALITY

SELECTED CHEMICAL ANALYSES

[Analyses by U.S. Geological Survey Laboratory. Unless otherwise specified, all constituents are reported in milligrams per liter.]

Location (Township Range Section)	Date of collection	Source of water	Depth of well (feet)	Temperature °C	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	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: Calculated	Dissolved Solids: Residue on evaporation at 180°C	Hardness as $CaCO_3$: Calcium Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos)	pH	Percent Sodium	Sodium adsorption ratio (SAR)	Residual Sodium Carbonate (RSC)	Selenium (Se)
107-72-22	4-1-71	Missouri River	-	5.0	5.0	-	-	54	21	70	5.5	196	0	200	13.2	0.6	0.3	0.09	460	474	160	60	710	8.2	40	2.1	0.00	0.00
106-70-10	4-1-71	Crow Creek	-	4	18	-	-	46	19	55	17	172	0	180	13.2	.3	.7	.15	430	476	190	53	665	7.8	36	1.7	.00	.00
107-71-32	4-1-71	Campbell Creek	-	3	26	-	-	170	58	170	13	353	0	690	36.4	.4	.0	.17	1,300	1,440	650	360	1,740	8.0	35	2.9	.00	.00
108-75-13	4-1-71	Joe Creek	-	3	27	-	-	170	45	150	8.4	416	0	530	50.0	.3	.0	.21	1,200	1,260	600	260	1,600	7.8	35	2.6	.00	.00
107-73-22	4-1-71	Brule Creek	-	4	17	-	-	280	85	440	17	302	0	1,400	301	1.0	1.0	.78	2,700	2,890	1,100	810	3,470	8.1	47	5.9	.00	.00
107-74-17	4-1-71	Medicine Creek	-	4	12	-	-	110	27	87	9.5	132	0	440	28.4	.5	.4	.11	780	825	380	270	1,090	7.9	32	1.9	.00	.00
108-76-21	4-1-71	Cedar Creek	-	4	16	-	-	120	28	260	12	212	0	630	123	.7	3.2	.64	1,300	1,380	410	230	1,830	8.0	57	5.6	.00	.00
106-70-27	5-20-69	Spring	-	9.5	28	0.01	0.00	83	26	61	9.2	380	0	95	24.8	.3	28	.31	540	542	310	2	835	7.9	29	1.5	.00	.01
106-70-29	8- -62	Alluvium	25	-	-	.15	-	390	100	420	5.0	719	0	1,500	145	-	0	-	2,900	-	1,400	800	4,500	-	40	4.9	.00	-
107-72-8	5-26-69	Terrace	60	12.5	31	.03	.08	200	73	150	7.6	297	0	730	67.8	.7	2.6	.32	1,400	1,550	800	553	1,870	7.8	29	2.3	.00	-
108-72-29	5-26-69	Alluvium	46	7.0	28	.08	.10	470	170	660	20	677	0	2,500	216	.5	1.6	.16	4,350	4,710	1,900	1,300	5,010	7.3	43	6.7	.00	-
109-72-12	5-26-69	Outwash	40	9.0	20	.03	.00	110	38	61	7.9	351	0	260	9.4	.5	14	.07	700	735	440	147	1,030	7.7	23	1.3	.00	-
109-72-14	5-21-69	Outwash	50	11.5	32	.12	.02	470	180	530	44	500	0	2,400	69.0	.4	73	.09	4,000	4,360	1,900	1,490	4,550	7.8	37	5.2	.00	.21
107-74-5	6-18-69	Terrace	Spring	13.0	26	.04	.00	38	41	85	3.6	398	0	110	13.3	1.0	3.0	.18	520	521	260	0	821	8.0	41	2.3	1.21	.00
108-73-10	6-18-69	Terrace	47	10.5	28	.19	.00	160	140	500	11	452	0	1,300	240	1.2	32	.84	2,600	2,920	960	592	3,600	8.0	53	7.0	.00	.02
109-76-13	6-18-69	Terrace	80	12.5	19	5.5	6.8	510	200	170	12	295	0	2,000	86.0	.8	.5	.26	3,200	3,560	2,100	1,860	3,480	7.6	15	1.6	.00	.00
[1]105-70-11	5-8-60	Graneros	860	20.5	10	2.1	.04	230	55	290	22	175	0	1,200	92	2.5	.1	.77	2,000	2,040	800	652	2,560	7.3	43	4.4	.00	-
106-70-17	6-8-70	Graneros	650	17.5	7.4	2.6	.04	100	30	680	31	242	0	290	976	2.0	.0	3.5	2,200	2,240	370	175	3,740	7.8	78	15	.00	-
[2]106-72-28	6-9-70	Graneros	973	11.0	31	.05	.03	500	220	2,200	73	699	0	4,100	654	.9	1,800	.18	9,900	10,000	2,200	1,590	10,800	7.8	67	20	.00	.20
[1]106-69-15	5-22-68	Dakota	835	18.0	8.8	1.6	.07	380	87	120	20	175	0	1,200	94.2	2.8	.2	.41	2,000	2,230	1,300	1,160	2,490	8.1	17	1.5	.00	-
[2]106-77-3	6-10-70	Dakota	1,473	16.5	24	.17	.10	69	18	400	25	160	0	820	123	2.0	13	.81	1,600	1,590	250	114	2,280	7.7	75	11	.00	.01
109-76-16	6-19-69	Dakota	1,000+	23.5	19	.02	.01	20	8.0	1,100	19	668	0	2.5	1,430	.9	.0	7.5	3,000	3,020	83	0	5,250	8.0	96	53	9.30	-
108-71-15	5-26-69	Inyan Kara and Sundance	1,675	29.5	14	1.0	.10	410	100	69	19	224	0	1,200	88.6	3.4	.0	.16	2,050	2,240	1,400	1,240	2,400	7.4	9	.8	.00	-
109-73-11	5-27-69	Inyan Kara, Sundance, and Minnelusa	2,140	28.0	13	.96	.15	400	94	69	17	191	0	1,300	73.6	2.9	.0	.12	2,060	2,280	1,400	1,210	2,360	7.8	10	.8	.00	.00
[2]108-75-2	6-9-70	Inyan Kara (and Sundance(?))	1,700	23.0	12	2.5	.09	400	89	89	26	174	0	1,200	103	3.2	.1	.25	2,000	2,310	1,400	1,220	2,420	7.8	12	1.1	.00	-
[1]109-77-17	6-10-70	Inyan Kara, Sundance, (and Minnelusa(?))	1,945	35.0	16	.39	.04	410	88	87	27	173	0	1,300	89.5	3.2	.1	.18	2,100	2,280	1,400	1,230	2,390	7.6	12	1.0	.00	-

[1] Outside of reservation boundaries.
[2] Also analyzed for chromium, lead, barium, nickel, cobalt, and phosphorus but contained less than 0.005 mg/l each.

TRACE ELEMENTS

[Limits, where given, are those determined and recommended by the U.S. Public Health Service. Analyses by U.S. Geological Survey.]

Constituent	Recommended limit (mg/l)	No. of samples	Source	Concentration (mg/l)
Bromide	None	6	Bedrock artesian aquifers	10.0 to less than 0.33
Iodide	None	6	Bedrock artesian aquifers	2.96 to 0.03
Nitrite	None	6	Bedrock artesian aquifers	0.27 to less than 0.005
Phosphorous (total)	None	6	Bedrock artesian aquifers	0.01 to less than 0.005
Arsenic	0.05	7	Streams and Missouri River	Less than [1] 0.0005
		7	Alluvium, outwash, and terrace deposits	0.01 or less
Barium	1.0	6	Bedrock artesian aquifers	Less than [1] 0.0005
Cadmium	0.01	9	Bedrock artesian aquifers	Less than [1] 0.0005
		7	Streams and Missouri River	0.013 to less than [1] 0.0005
Chromium (hexavalent)	0.05	9	Bedrock artesian aquifers	Less than [1] 0.005
Cobalt	None	9	Bedrock artesian aquifers	Less than 0.005
Copper	1.0	9	Bedrock artesian aquifers	0.06 or less
Lead	0.05	9	Bedrock artesian aquifers	Less than [1] 0.0005
Lithium	None	7	Streams and Missouri River	0.21 to 0.05
		9	Bedrock artesian aquifer	0.02 to 1.02
Mercury	0.005	7	Streams and Missouri River	0.0004 to less than 0.0001
Molybdenum	None	6	Bedrock artesian aquifers	0.022 to less than 0.0005
Nickel	None	9	Bedrock artesian aquifers	Less than 0.005
Selenium[2]	0.01	7	Streams and Missouri River	Less than [1] 0.0005
		14	Alluvium, outwash, and terrace deposits	0.28 to less than [1] 0.0005
		1	Graneros Shale	0.20
		13	Dakota Sandstone and deeper aquifers	0.01 or less
Strontium	None	7	Streams and Missouri River	5.8 to 0.58
		9	Bedrock artesian aquifers	1.09 to 16.8
Vanadium	None	6	Bedrock artesian aquifers	0.006 to less than 0.0005
Zinc	5.0	9	Bedrock artesian aquifers	0.61 to less than 0.0005 (8 were less than 0.07)

[1] Detection limit of analysis.
[2] Selenium, in minute amounts, is essential to human and animal nutrition, but even a moderate excess may be harmful or potentially toxic if ingested over long periods of time.

REFERENCES CITED

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