SHALLOW GROUND-WATER RESOURCES (CONTINUED)

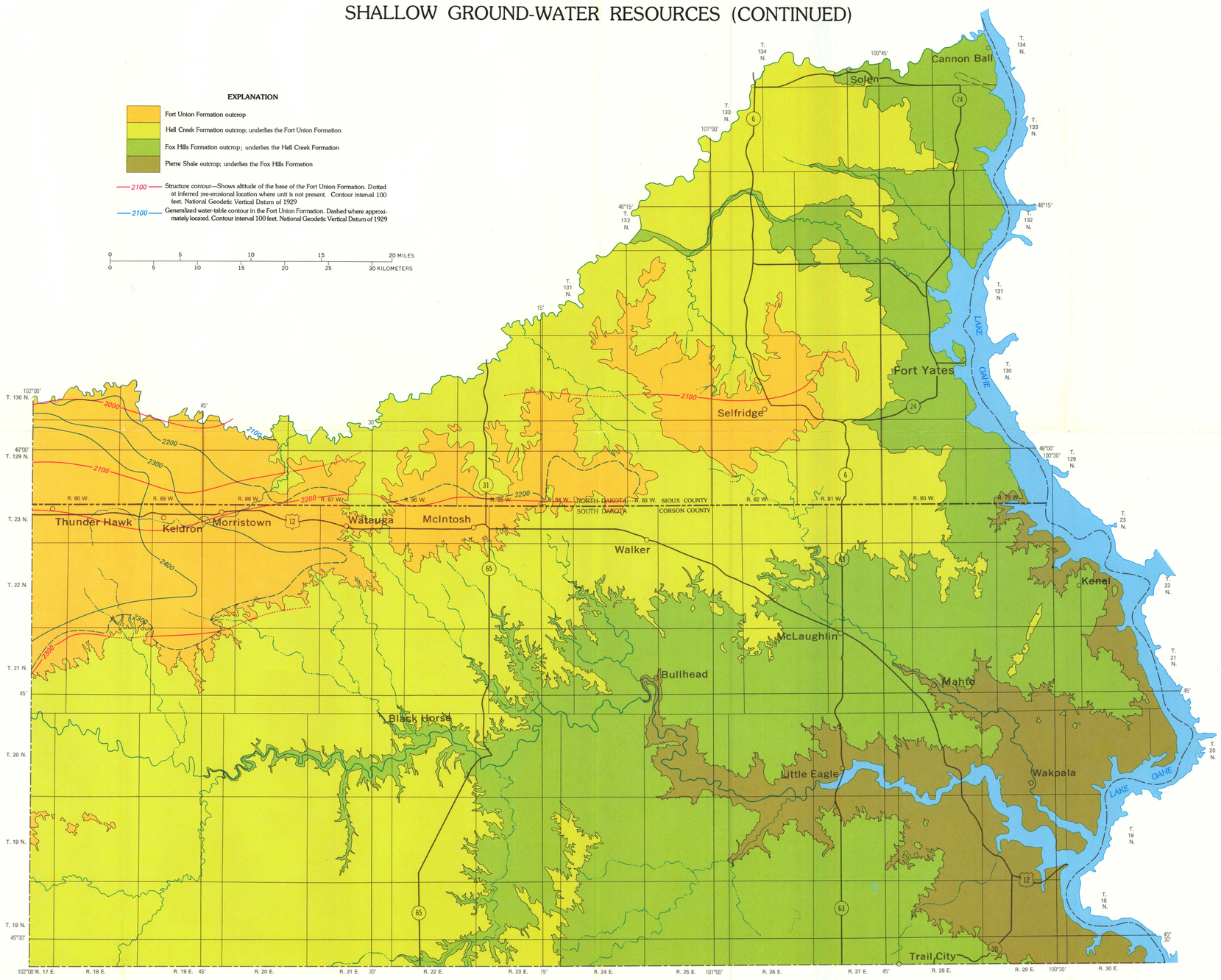

Figure 9.—Geohydrologic map of the Fort Union Formation.

GEOHYDROLOGY OF THE DEEP BEDROCK AQUIFERS

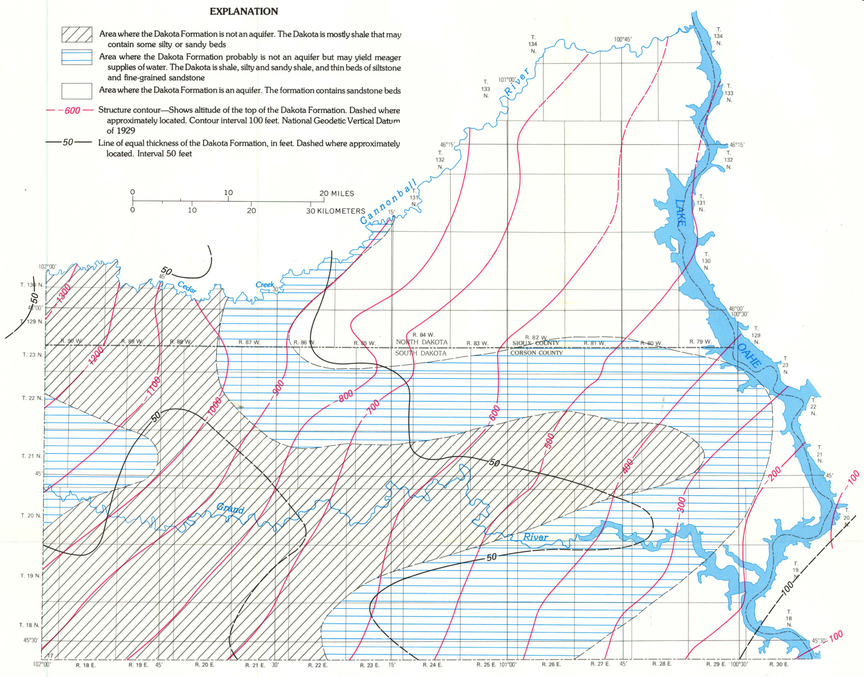

Figure 10.—Geohydrologic map of the Dakota (Newcastle) Formation.

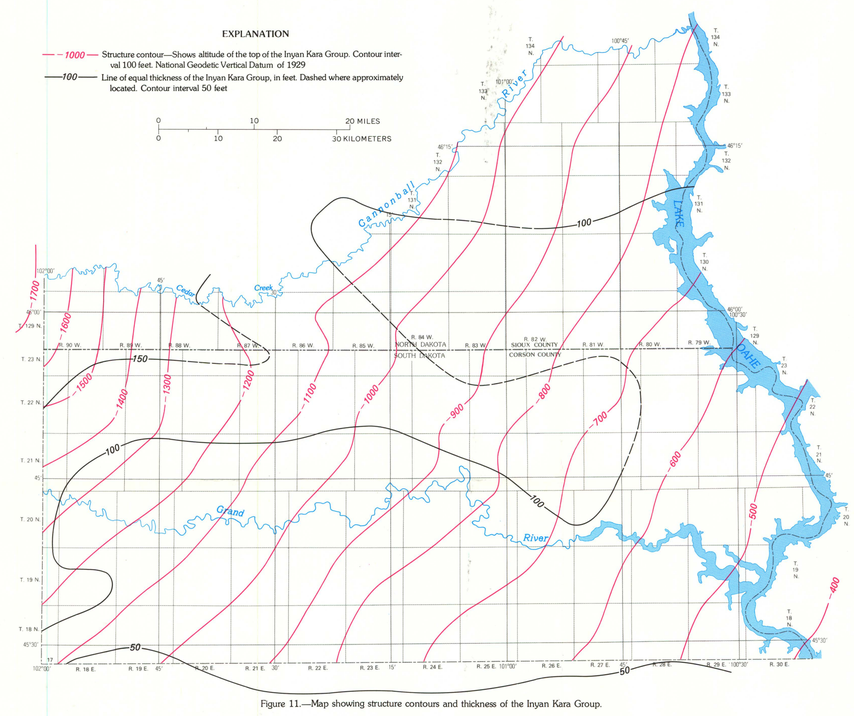

Figure 11.—Map showing structure contours and thickness of the Inyan Kara Group.

GEOHYDROLOGY OF THE DEEP BEDROCK AQUIFERS

Artesian aquifers underlie the entire area. These aquifers are part of a thick sequence of sedimentary beds that occupies a major geologic structure known as the Williston basin. The Standing Rock Indian Reservation is on the eastern limb of the Williston basin and extends to within 30 miles of the edge of the basin.

The geologic formations, and the aquifers that they contain, are described in the generalized stratigraphic column (table 2).

For the major aquifers (see maps, figs. 10 to 19), artesian head increases with stratigraphic depth. Thus, at a given site, higher artesian pressure generally can be obtained by tapping a deeper aquifer than by tapping a shallower one.

Table 2.—Generalized stratigraphic column describing the bedrock units, some of their hydrologic characteristics, and the quality of water.

System	Group, formation, or deposit	Thickness (feet)	Description	Hydrologic significance	Quality of water
Tertiary	Fort Union Formation	0-350	Can be divided into three Members on the reservation: the basal Ludlow Member (continental deposits), the middle Cannonball Member (marine sediments), and the upper Tongue River Member (continental deposits). The Ludlow is a poorly consolidated sequence of buff to cream, very fine to medium-grained sandstone, siltstone, claystone, and shale interbedded with lignite and carbonaceous shale beds and lenses. The Cannonball is composed of poorly consolidated, gray to yellow, very fine to medium-grained sandstone, siltstone, claystone, and dark-gray shale. The sandstone is friable, glauconitic, and noncalcareous. Both shale and sandstone beds contain round to oxoid or lenticular, calcareous concretions that range from a few inches to several feet in longest dimension. This member contains the most persistent, widely continuous sandstone bed in the formation. The Tongue River, found only in the northwestern corner of the reservation, is a sequence of poorly consolidated, interbedded, very fine to medium-grained sandstone, siltstone, claystone, shale, and lignite. The base of this member is a sandstone that contains abundant petrified wood, carbonaceous plant fragments, and lignite. Limestone beds up to four inches thick are found in the siltstone and claystone beds.	The sandstone and siltstone beds in the middle and lower members commonly yield water to wells throughout their extent. The upper unit is too thin and too shallow to supply water to wells in Sioux and Corson Counties. Well yields commonly are low (less than 10 gallons per minute) because the sandstone and siltstone beds are fine-grained and have only moderate to low permeability. Small lenses of water-bearing sand and perched water-table aquifers are common.	Dissolved-solids concentration ranges from about 400 mg/L to more than 3,300 mg/L. Water is calcium, magnesium, bicarbonate type east of Watauga; mostly of calcium, magnesium, sulfate type between Watauga and about 6 miles east of the Perkins County line; and of sodium sulfate type in the western 5 to 7 miles of the reservation. Chloride concentration commonly is less than 15 mg/L. Lithium and strontium decrease to the northwest. Nine of 17 tested wells contained anomalously high nitrate content, thus implying either leakage of surface drainage into wells or local recharge of leachant from fertilizer, sewage, barnyards, or feedlots.
Cretaceous	Hell Creek Formation	0-370	Somber-colored, buff, brown, brownish-gray, and black, soft bentonitic clay shale and buff to gray, poorly indurated, coarse- to fine-grained sandstone and siltstone. Commonly divided into two units: the upper unit contains thin beds of lignite and some lenses of black carbonaceous shale. The lower unit contains less lignite and less carbonaceous shale and is more sandy and silty. Continental.	Can yield supplies of water adequate for stock and domestic use throughout most of its extent particularly where it is more than 100 feet thick. Potential yields from more permeable sand beds should range from 1 to 5 gallons per minute for each 10 feet of aquifer material. Small lenses of water-bearing sand and perched water-table aquifers are common.	Dissolved-solids concentration ranges from about 450 mg/L to more than 3,300 mg/L, but commonly is less than 1,000 mg/L except where depth to the water table is more than 200 feet or where the Hell Creek is overlain by Fort Union Formation. Water is of sodium bicarbonate type except where the nitrate concentration is anomalously high and near the southern border of the reservation. The relative proportions of chloride and bicarbonate increase and sulfate decreases below a well depth of 400 feet.
	Fox Hills Formation	0-340	Dark-gray and greenish-gray to light-gray silty and sandy clay, clayey silt, and very fine sand; overlain, in part, by dark-gray to yellowish-orange poorly-consolidated, very fine-grained sandstone. The upper part of the formation is a thinly-bedded clay, silt, and very fine sand sequence ("banded beds") that contains discontinuous beds of silica-cemented, very fine-grained sandstone. The members of this formation commonly have gradational contacts and are, in part, lateral facies. Marine. The contacts with the overlying Hell Creek Formation and the underlying Pierre Shale commonly are gradational.	Where more than 100 to 150 feet thick it is an aquifer capable of yielding supplies of fresh to saline water adequate for stock and domestic use. Small lenses of water-bearing sand and perched water-table aquifers are common.	Dissolved-solids concentration ranges from about 300 mg/L to more than 4,400 mg/L; in Timber Lake Member it is commonly less than 1,000 mg/L. Dissolved-solids concentration tends to increase with depth. Water is of sodium bicarbonate type except at or near the eastern outcrop and in samples with anomalously high nitrate concentrations. Relative concentrations of bicarbonate and chloride increase and of sulfate decreases below well depths of 500 feet. Chloride, bromide, and iodide tend to increase to the west or northwest.
	Pierre Shale	500(?)-1,500	Gray, brown, and black, tough, gummy to friable shale, noncalcareous to highly-calcareous; contains widely persistent zones of bentonite and limestone or iron-manganese concentrations. Marine. Silty and sandy in its upper part, particularly near the western edge of the report area.	Relatively impermeable; a barrier to the movement of water.	
	Niobrara Formation	100-240	Tannish- to bluish-gray and light- to dark-gray highly calcareous shale; contains abundant micro-fossils.	Relatively impermeable; a barrier to the movement of water. Apparently contains no water-yielding zone in Corson and Sioux Counties, although it does contain an important aquifer in the James River valley of eastern South Dakota.	
	Carlile Shale	470-570	Light-blue or light-gray to black shale, normally noncalcareous; contains one or more sandstone or sandy or silty intervals (probably equivalent to the Codell Sandstone Member found elsewhere) in the top half. Marine.	Relatively impermeable; a barrier to the movement of water. The Codell Sandstone Member, an important aquifer in much of eastern South Dakota, either is missing or (more likely) is represented by relatively impermeable silty and sandy shale.	
	Greenhorn Limestone	120-200	Buff to bluish, white, or gray, highly calcareous shale; commonly marly and fossiliferous. May be interbedded with thin limestone layers. Marine.	Though locally an aquifer in some parts of South Dakota, the Greenhorn is not known to yield water in Corson or Sioux Counties.	
	Graneros Shale	260-410	Medium- to dark-gray, noncalcareous shale. Calcareous concretions and pyrite and marcasite crystals are common. Generally divided into two units by a widely persistent bentonite bed. The upper unit contains many thin bentonite beds; the lower unit is more siliceous and may contain thin sandstone or very sandy or silty beds. Marine.	Relatively impermeable; a barrier to the movement of water.	
	Dakota Formation (Newcastle Sandstone)	30-120	White, tan, or light-gray sandstone, very fine- to medium-grained, loose to tightly cemented; interbedded with dark-colored shale. Thins to the west where it is mostly shale that contains sandy or silty beds. The shaly phase is almost indistinguishable from the overlying Graneros or underlying Skull Creek Shales. Deltaic to near-shore marine.	Relatively impermeable in western Sioux County and in much of Corson County. In the eastern two-thirds of Sioux County and in extreme eastern and southeastern Corson County the Dakota can yield very saline water. Artesian head in the aquifer ranges from about 1,800 feet above sea level in southeastern Corson County to more than 2,000 feet above sea level in the western part of the area.	Throughout its extent the aquifer yields sodium chloride type water that contains from 6,000 to 10,000 mg/L dissolved solids. Water temperature ranges from about 28° to more than 40°C (82° to more than 104°F).
	Skull Creek Shale	100-245	Dark bluish-gray shale. Marine.	Relatively impermeable; a barrier to the movement of water.	
	Inyan Kara Group	45-180	White to light-gray or tan sandstone and siltstone; contains beds of gray to black and reddish to buff shale. Continental to marginal marine.	An artesian aquifer that can yield saline to very saline water. Minimum artesian head in the aquifer, about 1,900 feet above sea level, is along the Missouri River. The Inyan Kara contains an estimated 10 million acre-feet of water in storage within the reservation.	Near the Missouri River, in Corson County, the aquifer yields water of mixed type (sodium calcium magnesium chloride sulfate) that contains more than 2,500 mg/L dissolved solids; within 10 miles to the west, the dissolved-solids content increases to more than 5,000 mg/L and the dominant ions are sodium and chloride. A few miles west of Little Eagle, the dissolved solids exceed 10,000 mg/L. In the westernmost quarter of Corson County, the dissolved-solids content decreases and is below 5,000 mg/L. Water temperature ranges from about 30° to more than 50°C (86° to more than 122°F).
Jurassic	Morrison Formation	0-50(?)	Green to maroon to medium-gray shale interbedded with thin sandstone layers; some mudstone and siltstone. Fresh water and continental (locally may be marginal marine).	Probably a barrier to the movement of water.	
	Sundance Formation	160-350	Gray, green, and brown shale, interbedded with white, buff, dark-pink, or red glauconitic, fine-grained sandstone and siltstone. May contain limestone concretions and thin beds of coquinoid or oolitic limestone in the upper part. Marine.	The sandstone beds comprise an artesian aquifer that can yield saline to very saline water. Artesian head ranges from 1,900 feet above sea level near the Missouri River to at least 2,500 feet above sea level in the western part of the area. The Sundance Formation contains an estimated 23 million acre-feet of water in storage.	No direct information is available. Near the Missouri River, water in the aquifer probably contains more than 2,500 mg/L dissolved solids. Salinity increases to the northwest and may exceed 10,000 mg/L in the northwestern corner of the reservation. Near the Missouri River, the dominant ions are calcium, magnesium, and sulfate, but within 20 miles to the west sodium and chloride become the major ions. Water temperature ranges from about 35° to more than 50°C (95° to more than 122°F).
	Piper Formation	0-200(?)	Limestone and green or gray shale. Where the formation is thickest, in the western and northern part of the area, beds of gypsum and "red bed" shale may overlie and underlie the limestone and shale unit. The Piper Formation underlies all but the southeastern corner of the reservation.	Hydrologic potential unknown, but probably is low.	No information is available. Any water probably is highly mineralized because the formation contains beds and disseminated grains of evaporite minerals.
Triassic	Spearfish Formation	0-200(?)	Orange, brick-red, green, and gray sandy shale and soft siltstone and sandstone; interbedded with anhydrite, gypsum, and halite (rock salt). Also may contain thin limestone beds. Marine. Underlies all but the southeasternmost one-fifth of the reservation.	Hydrologic potential unknown; but the evaporite and shale beds are barriers to the movement of water and the sandstone and siltstone beds are so fine-grained as to be at best, only poorly permeable.	If any water can be obtained from the Spearfish, such water probably is very saline because of contact with evaporite minerals.
Permian	Minnekahta Limestone	0-38	Gray and white to lavender, fine-grained, dense, thin-bedded dolomitic limestone. Marine. Underlies the westernmost one-sixth of the report area.	Hydrologic potential unknown; probably not an aquifer and may be a barrier to the movement of water.	
	Opeche Formation	0-140	Brick-red to purple and orange, silty shale and fine-grained, soft, slabby sandstone. Marine. Extent is somewhat less than that of the overlying Minnekahta Limestone.	Hydrologic potential unknown; probably a barrier to the movement of water.	
Pennsylvanian	Minnelusa Formation	325-810(?)	A complex sequence of predominantly marine beds. In part of the area, the base is the "basal laterite marker" red shale, overlain by five major sandstone zones separated by limestone, dolomite, shale, and anhydrite beds. Sandstones are white to yellow to red; carbonates are white to brown to gray; shales are brick-red to orange, green, or black. A prominant "red marker" shale above the middle of the formation commonly is interpreted as marking the top of the Pennsylvanian beds; its top is the base of Permian strata.	A major ground-water reservoir. The thicker sandstone beds and some of the carbonate beds form an aquifer that can yield saline to very saline water to wells throughout the area. Minimum artesian head in the aquifer is higher than 2,200 feet above sea level, so most wells tapping the Minnelusa probably would flow. The aquifer may contain more than 50 million acre-feet of water in storage in the reservation.	The only chemical analysis available from the reservation is of a drill-stem test in northwestern Corson County; the water contained more than 140,000 mg/L dissolved solids and might have been in contact with an evaporite zone. However, if that sample is representative of water from the Minnelusa, then the dissolved-solids content decreases to about 60,000 mg/L in southwestern Corson County and to less than 5,000 mg/L near the Missouri River. Dissolved-solids content may be as low as 2,500 mg/L in northeastern Sioux County. The dominant ions are sodium and chloride except in northeastern Sioux County, where they are sodium and sulfate. Water temperature ranges from about 40° to more than 60°C (104° to more than 140°F).
Mississippian	Madison Group (Includes: Charles Formation, and the Mission Canyon and Lodgepole Limestones)	600-1,260(?)	White to tan, brown, and gray limestone and dolomite; interbedded with brown shale and light-blue to white and light-brown anhydrite, some halite. Marine.	May be the most important bedrock aquifer in the region. Can yield extremely hard, saline to very saline water throughout the report area. Artesian head in the aquifer is above land surface throughout most of the reservation. The Madison probably recharges overlying aquifers east and southeast of the report area. The aquifer receives recharge in the Black Hills and in other areas of outcrop farther west. The aquifer is estimated to contain more than 40 million acre-feet of water in storage in Sioux and Corson Counties.	Yields sodium chloride type water in the northwestern half of the report area; elsewhere the water probably is of calcium magnesium sulfate type except where it has been in contact with beds of rock salt. Dissolved-solids content is lowest, about 3,000 mg/L, in the southeast near the Missouri River; and increases to the north and west. In the southwestern corner of Corson County, dissolved-solids content is about 4,200 mg/L, but in the center of southern boundary of the county it is about 6,000 mg/L; in the northwestern corner of the report area it is more than 17,000 mg/L. The salinity may vary widely between various permeable horizons at the same geographic site due to contact between the water and evaporite beds. Where the water is in contact with evaporite beds, the dissolved-solids content may exceed 200,000 mg/L. Water temperature ranges from about 42° to more than 73°C (108° to more than 163°F).
Devonian	Sedimentary rocks undifferentiated (Includes: Bakken, Three Forks, Birdbear, Duperow, Souris River, Dawson Bay, Winnipegosis Formation and Ashern Formation of Baillie, 1950)	195-505(?)	Gray to brown, rarely pink, limestone and dolomite; interbedded with anhydrite, red to gray, fine to medium-grained sandstone and siltstone, and black, red, gray, or green shale. Marine except where the basal Ashern Formation is found; the Ashern is a weathered residual or soil zone.	Hydrologic potential unknown. Evaporite and shale beds are barriers to the movement of water, but sandstone and carbonate beds probably are artesian aquifers. Permeable strata of Devonian age may contain as much as 15 million acre-feet of water in storage in Sioux and Corson Counties.	No direct information is available. Fifty miles southeast of the report area water from Devonian strata contains 2,200 mg/L of dissolved solids and is of calcium magnesium sulfate type. Drill-stem tests about 15 miles west and 32 miles northwest of the southwest corner of Corson County yielded sodium chloride type water that contained 102,000 and 190,000 mg/L dissolved solids respectively. A drill-stem test 17 miles north of Porcupine yielded sodium chloride type water that contained 189,000 mg/L dissolved solids. Thus, within the reservation, water in Devonian strata probably contains from 4,000 mg/L dissolved solids, near the Missouri River, to more than 30,000 mg/L in the northwestern part. Where the water has been in contact with evaporite beds, the dissolved-solids content may exceed 100,000 mg/L. Water temperature ranges from about 44° to more than 73°C (111° to more than 163°F).
Silurian	Interlake Formation	0-290(?)	Light-tan to brown dolomite, anhydrite, and calcareous sandstone. Marine. Probably underlies all but the southeastern corner of the reservation.	Hydrologic potential unknown, but probably is an artesian aquifer. The Interlake could contain as much as 7 million acre-feet of water in storage within the report area.	No direct information is available, but probably is very saline. Drill-stem tests in Perkins County showed that the water there contained from 6,000 to 8,000 mg/L of dissolved solids. Dominant ions were sodium and chloride in two tests and calcium, magnesium, and sulfate in a third test. In Morton County, 17 miles north of Porcupine, water from a drill-stem test contained 92,000 mg/L of dissolved solids, mostly sodium and chloride. Water temperature ranges from about 45°C to more than 73°C (113°F to more than 163°F).
Ordovician	Stonewall Formation of Kindle, 1914	0-110	Light-tan to yellowish dolomite and sandy shale, locally may contain beds of sandstone. Marine. Underlies all but the southeastern corner of the reservation.	Hydrologic potential is unknown, but the carbonate beds probably are an artesian aquifer.	No information available.
	Stony Mountain Formation	5(?)-100	Brown to gray dolomitic limestone; commonly divided into two units. The lower unit contains sandstone, siltstone, and shale near the base. Marine. Probably underlies the entire report area, but could be missing in a few square miles in the southeastern corner.	Hydrologic potential is unknown, but the limestone and sandstone beds probably are an artesian aquifer.	No information available.
	Red River Formation	450(?)-590(?)	An upper unit of pale-red, pink, buff, or light-brown, fossiliferous dolomite, and a lower unit of light-gray to pinkish, clay-streaked, dolomitic limestone. Can be divided into three units on geophysical well logs. Marine.	A major artesian aquifer. Data is scanty, but oil-well tests seem to show very permeable horizons. Artesian head probably is above land surface throughout most of the report area. The Red River Formation probably contains more than 25 million acre-feet of water in storage in the reservation.	The only chemical analysis available from within the reservation is of a drill-stem test in northwestern Corson County; the water contained more than 130,000 mg/L dissolved solids. Such high mineralization possibly indicates that the water is in contact with an evaporite bed. Drill-stem tests in one well at two horizons of the Red River yielded water that contained 41,000 and 200,000 mg/L of dissolved solids. From the scanty data available, it seems likely that the dissolved-solids content of water in the Red River is least near the Missouri River in the southeast (possibly as low as 2,300 mg/L) but increases to the north and west. In the northwestern corner of the reservation at least one horizon in the Red River may contain water with a dissolved-solids content as low as 40,000 mg/L, but other permeable zones will be more saline. Maximum salinity of the water exceeds 200,000 mg/L. Throughout the reservation the dominant ions probably are sodium and chloride, with the possible exception of a narrow band in the southeast, where they might be calcium, magnesium, and sulfate. Water temperature ranges from about 60° to more than 80°C (140° to more than 176°F). One unverified claim of 102°C (216°F) has been reported in northeastern Dewey County.
	Winnipeg Formation	120(?)-200(?)	A thin upper unit of siltstone; a thick middle unit of green to gray bentonitic shale that contains black phosphate nodules; the lower, or basal unit, is white, well-sorted, medium- to fine-grained quartz sandstone. The basal sandstone is missing throughout most of the reservation. Marine.	Relatively impermeable; a barrier to the movement of water. The basal sandstone, where and if present, is an aquifer.	No information is available; but if any Winnipeg sand is present, the water in it probably is similar in quality to water from the underlying Deadwood Formation.
Cambrian	Deadwood Formation	280-610(?)	White to buff to reddish-orange, light-gray, grayish-red, and brownish-red sandstone, siltstone, flaggy dolomite and limestone, and limestone pebble-conglomerate; contains beds and partings of greenish-gray and gray glauconitic shale. Has sandstone, usually conglomeritic, at the base. Marine. The top of the Deadwood Formation may be Early Ordovician age.	The sandstone and conglomerate beds probably constitute one or more major artesian aquifers. Artesian head probably is above land surface throughout most of the report area. The Deadwood Formation is estimated to contain at least 20 million acre-feet of water in storage.	Only 3 analyses, all from oil company drill-stem tests. One in Perkins County about 15 miles west of the southwestern corner of Corson County, one in the northwestern corner of Corson County, and one in Morton County about 17 miles north of Porcupine. Water from these tests contained 8,700 mg/L, 40,000 mg/L, and 95,000 mg/L dissolved solids respectively. Throughout the reservation water from the Deadwood probably is of sodium chloride type. Dissolved-solids content may be lowest in the southeast (perhaps as low as 3,000 or 4,000 mg/L) and increases to the north and west. Water temperature ranges from about 65° to more than 90°C (149° to more than 194°F).
Cambrian(?) and Precambrian(?)	Transgressive facies of clastic rocks	0-50	Sandstone and conglomerate, generally coarse-grained, but ranges from fine-grained to gravelly. Composition reflects the lithology of underlying and nearby Precambrian rocks. This is a coarse clastic facies that overlies the Precambrian surface throughout the region.	Probably a major artesian aquifer. It is a major conduit for the transmission of water upward through the stratigraphic column because it is in physical and hydraulic contact with other aquifers where they pinch out against the Precambrian surface. Locally known as "wash" and "granite wash". Artesian head probably is above land surface throughout most of the report area.	No information is available, but probably is the same as water from the Deadwood Formation.
Precambrian	Igneous and metamorphic rocks		Various-colored granite, gneiss, schist, and other igneous and metamorphic rocks.	Impermeable. Locally might yield water from fractures or joints.	No information is available, but, where water is found, it probably is the same in quality as water from whatever aquifer immediately overlies, or is in nearby contact with, the Precambrian surface.

[1]Terms used for relative salinity have the following ranges of value for dissolved solids.

Fresh ..... Less than 1,000 mg/L
Saline ..... More than 1,000 mg/L
Moderately saline ..... 2,000 to 6,000 mg/L
Very saline ..... More than 6,000 mg/L

Base from U.S. Geological Survey
Bismarck, 1954–76, and McIntosh, 1953–76,
1:250,000

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GEOHYDROLOGY OF THE STANDING ROCK INDIAN RESERVATION, NORTH AND SOUTH DAKOTA

By
Lewis Howells
1982