PREPARED AS PART OF THE PROGRAM OF THE
DEPARTMENT OF THE INTERIOR
FOR DEVELOPMENT OF THE MISSOURI RIVER BASIN

INTRODUCTION

Figure 1. – Index map of South Dakota showing location of Cheyenne River Indian Reservation. The area discussed in this report is outlined in blue.

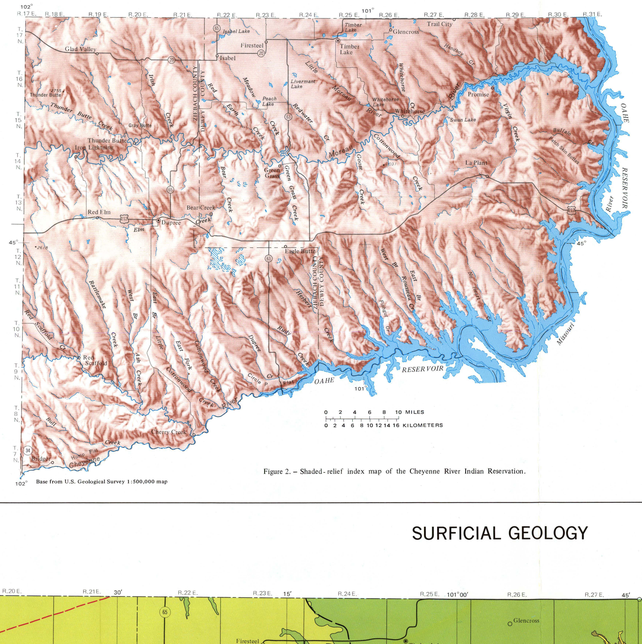


Figure 2. – Shaded-relief index map of the Cheyenne River Indian Reservation.

Base from U.S. Geological Survey 1:500,000 map

INTRODUCTION

Effective improvement of economic and social conditions of Indians living on the Cheyenne River Indian Reservation has been hampered by lack of adequate and reliable information about the quantity and quality of water supplies available for development. Compounding the problem is the recent filling of Oahe Reservoir, which flooded about 105,000 acres of Indian land, and the consequent relocation of many residents. This report summarizes the results of a water-resources study made at the request of the U.S. Bureau of Indian Affairs. It is intended to provide some of the needed information on water supplies that could be used to alleviate the problems mentioned.

The cooperation and courtesy extended by many farmers, ranchers, and residents of the area contributed greatly to the success of the study. Special thanks are due to Mr. John Wall, U.S. Public Health Service, Eagle Butte, and to the personnel of the Land Operations and Conservation Units of the U.S. Bureau of Indian Affairs, Eagle Butte.

LOCATION AND SETTING

The Cheyenne River Indian Reservation occupies about 4,230 mi² in Dewey and Ziebach Counties. As the combined area of the counties is only 4,420 mi², and the land ownership pattern is complex, all of both counties is included within the area discussed in this report. Thus, for simplicity of discussion, the terms "Cheyenne River Indian Reservation" and "Dewey and Ziebach Counties" are used interchangeably.

The Cheyenne River Indian Reservation is in the Missouri Plateau division of the Great Plains physiographic province.

The topography basically is a high rolling upland cut by the deep, meandering trenches of the Missouri River and its two major tributaries in the area, the Cheyenne and Moreau Rivers. Erosion has cut deeply into the upland to sculpture a badlands type area known locally as "the breaks." An extensive system of terraces extends along the Cheyenne and Moreau Rivers; at least seven terrace levels can be observed in some areas.

Except for part of the rolling upland (primarily that in the area underlain by the Hell Creek and Fox Hills Formations, see map of surficial geology, figure 5) much of the land is unsuitable for large-scale crop production because of rugged topography or poor soils. Even on the best land, crop production usually is low because of erratic and inadequate rainfall. The soil and range data (U.S. Bureau of Indian Affairs, 1959; U.S. Soil Conservation Service, unpub. data) indicate that only about 7 percent of the area is arable land suitable for production of cultivated crops; an additional 2½ percent is suitable for the production of a crop of wild hay every 2 or 3 years. Thus, much of the area is rangeland, with scattered fields of hayland and cultivated crops that are raised mostly for livestock feed. In 1974 more than 87 percent of the land was used for grazing, including the more than 1½ percent of the report area that is rated as barren wasteland not suited for grazing.

Individual livestock water supplies are fairly small and widely dispersed, a necessity for successful ranching under existing climatic and topographic conditions. The low precipitation, generally low soil fertility, and moderately high relief support a fairly sparse plant growth that must be carefully managed to prevent overgrazing and yet make optimum use of available range resources. The soil and range studies found an average range capacity of 3 acres per animal month (the maximum was more than 20 acres), or about 24 acres per animal each grazing season. Rangeland requirements of this magnitude necessitate low livestock population densities, frequent shifting of stock between pastures, or both. Availability of adequate supplies of water close to feeding areas is critical to success in livestock production. Long travel between food and water can result in livestock weight losses rather than weight gains. Thus, to maximize stock production and to make best use of rangeland requires many, dispersed water supplies. For most ranchers the least expensive way to improve water supplies is to capture and hold spring runoff and occasional summer storm flow by building dams or by excavating dugouts in ephemeral streams and drainageways.

SURFACE-WATER RESOURCES

SURFACE-WATER RESOURCES

The Missouri River and its impoundment, the Oahe Reservoir, both in volume and in potential for development vastly overshadow all other sources of surface water available on the Reservation. Lake Oahe stores more than 22 million acre-ft. The average annual flow of the Missouri through the area is more than 16.2 million acre-ft; compared to this, the average annual surface-water runoff of 0.1 million acre-ft or even the average total annual precipitation of 3.8 million acre-ft are relatively minor. Yet, in 1974, other surface-water sources such as stock ponds and dugouts were far more important to the economy than the Oahe Reservoir. For much of the region they probably will remain so in the future, because most of the area is suitable only for rangeland and because the cost of distributing Missouri River water for stock use throughout the two counties probably would be prohibitively expensive.

The surface-water hydrology of the area is summarized in the accompanying diagram, which shows the approximate average annual hydrologic budget.

The Missouri River is the only stream that has had a record of continuous flow since the area was first settled, though the Cheyenne River has had year-round flow except in years of unusually severe drought. Most local streamflow is from snowmelt and from spring rain. In most years more than 95 percent of the streamflow reaching the Cheyenne, Moreau, and Missouri Rivers occurs in March, April, and May. Runoff from summer storms usually evaporates or is intercepted by stockponds before it reaches the rivers. Springs and seeps are common in spring and early summer except where the Pierre Shale is at or very near the surface, but discharge usually is small. Most springs and seeps dry up by midsummer, although some streams do have more or less permanent natural "water holes" – 5 to 100 foot segments that intercept the local water table.

The estimated average annual flows of selected streams are shown in the accompanying table.

The Oahe Reservoir on the Missouri River is an almost untapped water resource. Aside from power generation and flow-regulation function, and considering the use of the reservoir as a water supply only, development by the end of 1974 was negligible. Within the boundaries of the Reservation no water was diverted for irrigation, less than 3 acre-ft was used for public supplies, and some, probably less than 200 acre-ft, was consumed by livestock. The reservoir also provides outstanding recreational use for fishermen, boaters, and others interested in camping, water sports, and waterfowl hunting.

The severe drought that began in 1973 had, by the summer of 1974, resulted in a water shortage of crisis proportions in the two-county area. As stock ponds dried up many ranchers began hauling water for livestock from the Missouri and Cheyenne Rivers. By fall of 1974, less than 4 percent of stock ponds were reported to contain usable quantities of water. To help alleviate the water shortage and to improve the chemical quality of domestic water supplies, the Fox Ridge Water District was organized. The first stage of the Water District's plan, to be in operation by early 1975, has been construction of a pipeline to Eagle Butte from the Cheyenne River arm of the Oahe Reservoir (the intake is about 14 mi downstream from South Dakota Highway 63 bridge). Ranches and homes near the pipeline will be served. The Water District hopes to extend its area of service to most communities between the Cheyenne and Moreau Rivers as far west as Faith, in Meade County, 2 mi west of the Reservation. As many ranches as possible will be included.

The chemical quality of surface water ranges from very good to very poor (see table 4), depending upon the water source and the time of year. The system of large reservoirs on the Missouri River has stabilized the quality of the river water to a year-round average of about 450 mg/L (milligrams per liter) of dissolved solids. Tributary streams, stock ponds, and dugouts, however, vary greatly in water quality during the year. Water quality is best in spring during snowmelt and is poorest in late summer or fall when pools and ponds usually have been stagnant for several months.

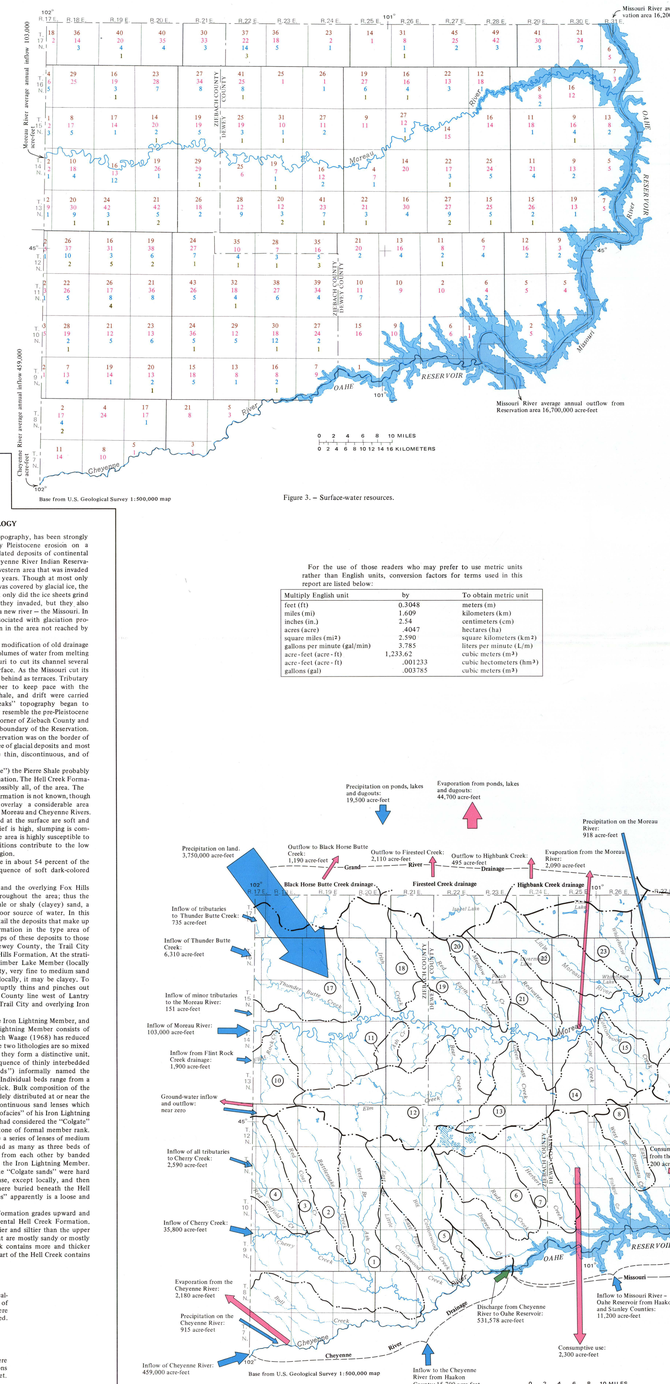
The water samples analyzed for this report were collected mostly in June 1972; however, the Cheyenne River has been sampled each month since September 1972 at Cherry Creek and since November 1972 at South Dakota Highway 63 bridge. Single samples from these and other surface-water sources have been analyzed at various times for public agencies and for individuals.

Water in the Cheyenne River is of the calcium magnesium sulfate type and contains from about 500 to 2,700 mg/L dissolved solids. Its tributaries have a similar or larger range in dissolved solids but differ in the proportions of major ions. For example, Red Scaffold Creek contained sodium bicarbonate type water, while an adjacent tributary, Red Coat Creek, contained calcium magnesium bicarbonate type water. Low dissolved solids content generally is associated with higher rates of flow, though this is not always true.

Daily suspended sediment loads in the Cheyenne River ranged from 80 to 37,000 mg/L during the 1973 water year. Maximum daily load for the period of record is 65,000 mg/L. Water in the tributaries of the Cheyenne commonly is muddy to very muddy.

Water in the Moreau River usually is of sodium sulfate type but during periods of high flow may be of sodium bicarbonate sulfate type. When the stream is flowing the dissolved solids concentration ranges from about 100 to 4,100 mg/L. Low dissolved solids concentration generally is associated with high rates of flow, though this is not always true. Those tributaries of the Moreau whose drainage areas are wholly or mostly underlain by the Hell Creek Formation commonly yield water that is less mineralized than is water from tributaries whose drainage area are wholly or mostly underlain by the Pierre Shale.

Daily suspended sediment loads in the Moreau River ranged from about 150 to 20,000 mg/L for the period of record (October 1971 to September 1974). Suspended sediment content usually is highest during periods of high streamflow. Water in tributaries of the Moreau River commonly is muddy to very muddy.



Base from U.S. Geological Survey 1:500,000 map

Figure 3. – Surface-water resources.

EXPLANATION

Stockponds and dugouts, December 31, 1975

	Number	Estimated area, in acres	Estimated storage, in acre-feet
Less than 1 acre	2,440	1,218	5,970
1 to 5 acres	2,105	4,410	20,800
5 to 20 acres	392	3,590	11,000
more than 20 acres	58	5,240	10,480
Total	4,995	14,458	48,250

OAHE RESERVOIR

Normal maximum storage	22,530,000 acre-feet pool altitude 1,617.0 feet above mean sea level
Normal minimum storage	19,300,000 acre-feet pool altitude 1,607.5 feet above mean sea level
Maximum capacity	23,630,000 acre-feet pool altitude 1,620.0 feet above mean sea level
Drainage area above the reservation	208,800 square miles

Table 1. – Estimated average annual flows in selected streams[1]

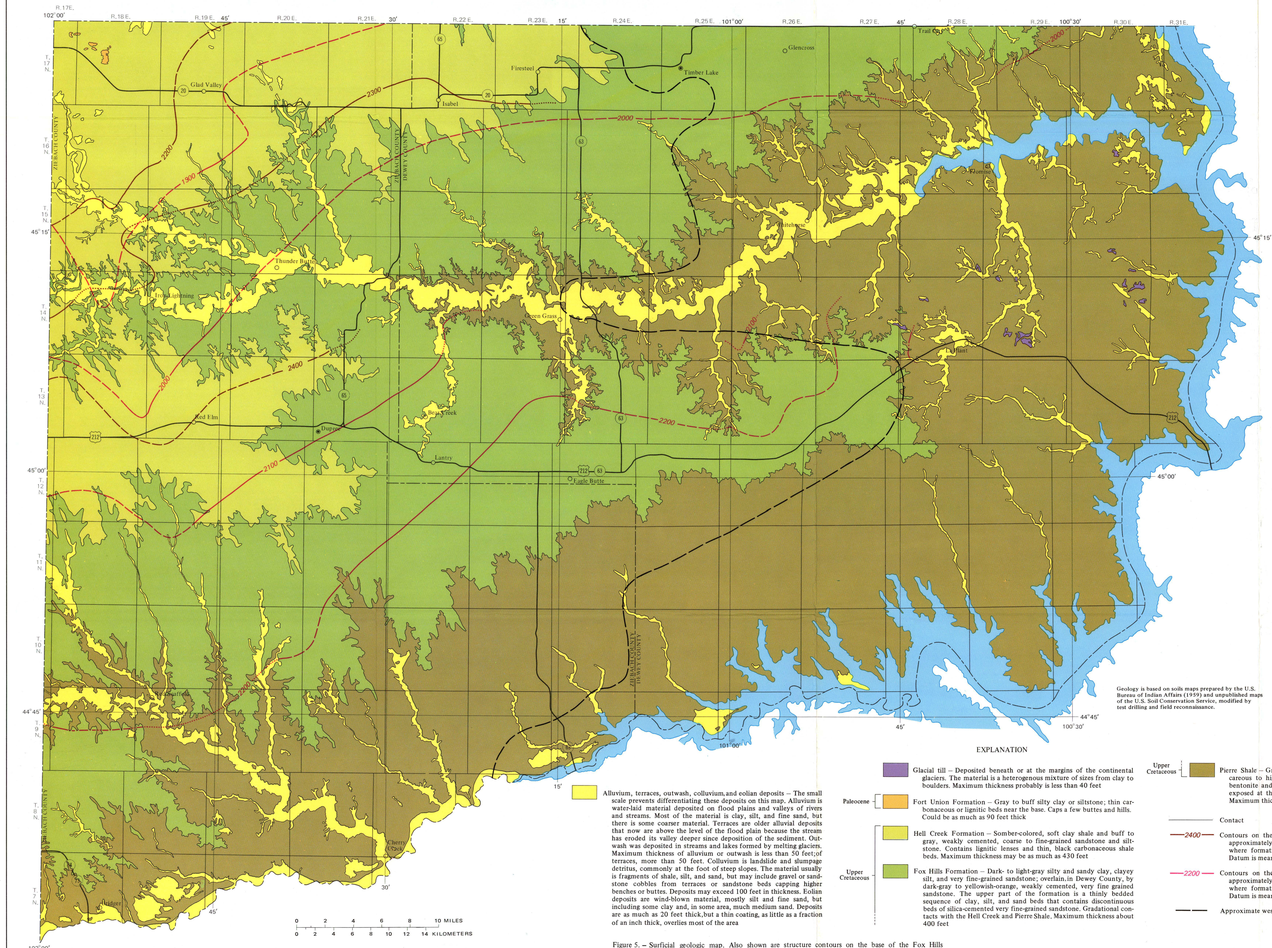
Number shown on hydrologic diagram	Drainage basin	Drainage area (square miles)	Average annual streamflow		
			Acre-feet per square mile	Cubic feet per second	Acre-feet
1	Cherry Creek	2,074	24.5	70.0	50,700
	Cherry Creek, flow originating within the reservation	728	20.5	20.6	14,900
2	Rattlesnake Creek	104	21.0	3.0	2,180
3	Red Coat Creek	45	20.9	1.3	940
4	Red Scaffold Creek	145	20.4	4.1	2,970
5	Big Cottonwood Creek	126	24.1	4.2	3,040
6	Rudy Creek	106	24.5	3.6	2,600
7	Herbert (Asbee) Creek	90	25.0	3.1	2,250
8	Rousseau Creek	47	25.5	1.7	1,200
9	Willow Creek	75	26.1	2.7	1,960
10	Flint Rock Creek	143	20.8	4.1	2,970
11	Ash Creek	18	22.2	.6	400
12	Bear and Elm Creek	234	22.0	7.1	5,140
13	Green Grass Creek	99	25.6	3.5	2,530
14	Goose Creek	85	26.0	3.1	2,210
15	Cottonwood Creek	53	26.6	1.9	1,410
16	Virgin Creek	157	27.2	5.9	4,270
16a	Virgin Creek at LaPlant	65	26.6	2.4	1,730
17	Thunder Butte Creek	546	23.0	16.6	12,700
	Thunder Butte Creek, flow originating within the reservation	253	22.6	7.9	5,720
18	Worthless (Irish) Creek	107	23.0	3.4	2,460
19	Red Earth Creek	94	23.1	3.0	2,170
20	Meadow Creek	48	24.0	1.6	1,150
21	Redwater Creek	62	27.1	2.3	1,680
22	Little Moreau River	124	27.4	4.7	3,400
23	Whitehorse Creek	100	27.2	3.7	2,720

[1] Estimated using the method described by Larimer (1970), except that a regression coefficient of 7.19×10^{-7} was used. This modification provides closer agreement between estimated streamflow and measured streamflow (3.3% percent) at the 18 stream-gaging stations used to validate the method for use in the report area.

For the use of those readers who may prefer to use metric units rather than English units, conversion factors for terms used in this report are listed below:

Multiply English unit	by	To obtain metric unit
foot (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
inches (in.)	2.54	centimeters (cm)
acres (acre)	.4047	hectares (ha)
square miles (mi²)	2.590	square kilometers (km²)
gallons per minute (gal/min)	3.785	liters per minute (L/m)
acre-feet (acre-ft)	1,233.62	cubic meters (m³)
acre-feet (acre-ft)	.001233	cubic hectometers (hm³)
gallons (gal)	.003785	cubic meters (m³)

SURFICIAL GEOLOGY



Base from U.S. Geological Survey 1:250,000 maps

Geology is based on soils maps prepared by the U.S. Bureau of Indian Affairs (1959) and unpublished maps of the U.S. Soil Conservation Service, modified by test drilling and field reconnaissance.

EXPLANATION

Alluvium, terraces, outwash, colluvium, and eolian deposits – The small scale prevents differentiating these deposits on this map. Alluvium is water-laid material deposited on flood plains and valleys of rivers and streams. Most of the material is clay, silt, and fine sand, but there is some coarser material. Terraces are older alluvial deposits that now are above the level of the flood plain because the stream has eroded its valley deeper since deposition of the sediment. Outwash was deposited in streams and lakes formed by melting glaciers. Maximum thickness of alluvium or outwash is less than 50 feet; of terraces, more than 50 feet. Colluvium is landslide and slumpage detritus, commonly at the foot of steep slopes. The material usually is fragments of shale, silt, and sand, but may include gravel or sandstone cobbles from terraces or sandstone beds capping higher benches or buttes. Deposits may exceed 100 feet in thickness. Eolian deposits are wind-blown material, mostly silt and fine sand, but including some clay and, in some area, much medium sand. Deposits are as much as 20 feet thick, but a thin coating, as little as a fraction of an inch thick, overlies most of the area

Glacial till – Deposited beneath or at the margins of the continental glaciers. The material is a heterogenous mixture of sizes from clay to boulders. Maximum thickness probably is less than 40 feet

Paleocene — Fort Union Formation – Gray to buff silty clay or siltstone; thin carbonaceous or lignitic beds near the base. Caps a few buttes and hills. Could be as much as 90 feet thick

Upper Cretaceous — Hell Creek Formation – Somber-colored, soft clay shale and buff to gray, weakly cemented, coarse to fine-grained sandstone and siltstone. Contains lignitic lenses and thin, black carbonaceous shale beds. Maximum thickness may be as much as 430 feet

Upper Cretaceous — Fox Hills Formation – Dark- to light-gray silty and sandy clay, clayey silt, and very fine-grained sandstone; overlain, in Dewey County, by dark-gray to yellowish-orange, weakly cemented, very fine grained sandstone. The upper part of the formation is a thinly bedded sequence of clay, silt, and sand beds that contains discontinuous beds of silica-cemented very fine-grained sandstone. Gradational contacts with the Hell Creek and Pierre Shale. Maximum thickness about 400 feet

Upper Cretaceous — Pierre Shale – Gray to brown, tough, gummy to friable shale, noncalcareous to highly calcareous; contains widely persistent zones of bentonite and of iron-manganese or limestone concretions. Where exposed at the surface, the top few feet commonly is weathered. Maximum thickness is about 1,400 feet

Contact

2400 — Contours on the base of the Hell Creek Formation – Dashed where approximately located. Dotted at inferred precrosional locations where formation now is not present. Contour interval 100 feet. Datum is mean sea level

2200 — Contours on the base of the Fox Hills Formation – Dashed where approximately located. Dotted at inferred precrosional locations where formation now is not present. Contour interval 100 feet. Datum is mean sea level

Approximate western limit of glaciation

Figure 5. – Surficial geologic map. Also shown are structure contours on the base of the Fox Hills Formation and on the base of the Hell Creek Formation.

SURFICIAL GEOLOGY

The surface geology (fig. 5), like the topography, has been strongly influenced by continental glaciation and by Pleistocene erosion on a land surface underlain by soft, unconsolidated deposits of continental and marine sandstone and shale. The Cheyenne River Indian Reservation is on the western margin of the midwestern area that was invaded by great ice sheets during the last million years. Though at most only 40 percent of the Reservation apparently was covered by glacial ice, the effects of the glaciers were pervasive: not only did the ice sheets grind away the land surface in the areas that they invaded, but they also changed the courses of rivers and created a new river – the Missouri. In addition, changes in weather patterns associated with glaciation profoundly influenced streamflow and erosion in the area not reached by the ice sheets.

Formation of the Missouri River caused modification of old drainage patterns and creation of new ones. Huge volumes of water from melting glaciers enabled the newly created Missouri to cut in elsewhere several hundred feet into the preexisting land surface. As the Missouri cut its trench deeper, it left remnants of its valley behind as terraces. Tributary streams rapidly cut their channels deeper to keep pace with the Missouri. Large volumes of sandstone, shale, and drift were carried away by erosion and the present "breaks" topography began to develop. The areas that today most closely resemble the pre-Pleistocene surface probably are in the northwestern corner of Ziebach County and along U.S. Highway 212 near the western boundary of the Reservation.

Because the Cheyenne River Indian Reservation was on the border of the glaciated region, much of the area is free of glacial deposits and most of the glacial deposits that are present are thin, discontinuous, and of negligible hydrologic importance.

Prior to the Pleistocene Epoch ("Ice Age") the Pierre Shale probably was entirely covered by the Fox Hills Formation. The Hell Creek Formation overlay the Fox Hills over much, possibly all, of the area. The pre-Pleistocene extent of the Fort Union Formation is not known, though deposits of Tertiary age undoubtedly overlay a considerable area north of the Moreau River and between the Moreau and Cheyenne Rivers.

Because the geologic formations exposed at the surface are soft and relatively unconsolidated, and surface relief is high, slumping is common, particularly in the "breaks," and the area is highly susceptible to erosion by wind and water. These conditions contribute to the low agricultural productivity of much of the region.

The Pierre Shale, at or near the surface in about 54 percent of the Reservation (see table 2), is a thick sequence of soft dark-colored marine shales.

The contact between the Pierre Shale and the overlying Fox Hills Formation appears to be transitional throughout the area; thus the lower part of the Fox Hills is sandy shale or shaly (clayey) sand, a relatively impermeable material and a poor source of water. In this report area Waage (1968) described in detail the deposits that make up the three members of the Fox Hills Formation in the type area of the formation and detailed the relationships of these deposits to those in overlying and underlying strata. In Dewey County, the Trail City Member is the basal member of the Fox Hills Formation. At the stratigraphic middle of the Fox Hills is the Timber Lake Member (locally known as the "Timber Lake Sand"), a silty, very fine to medium sand composed of quartz and feldspar grains; locally, it may be clayey. To the west, the Timber Lake Member abruptly thins and pinches out approximately along the Dewey-Ziebach County line west of Lantry where the Fox Hills is divided into the Trail City and overlying Iron Lightning Member.

Waage (1968) named the upper part the Iron Lightning Member, and this name is herein adopted. The Iron Lightning Member consists of two previously used formal members which Waage (1968) has reduced in rank to informal lithofacies because the two lithologies are so mixed that separation is unnatural, but together they form a distinctive unit. The member is predominantly a thick sequence of thinly interbedded sand, silt, and clay layers ("banded beds") informally named the "Bullhead lithofacies" by Waage (1968). Individual beds range from a fraction of an inch to about 3 inches thick. Bulk composition of the material is more than 50 percent sand. Widely distributed at or near the top of the Fox Hills Formation are discontinuous sand lenses which Waage informally named the "Colgate lithofacies" of his Iron Lightning Member. Earlier investigators of the area had considered the "Colgate" to be a continuous, well-cemented sandstone of formal member rank. Waage's studies, however, showed it to be a series of lenses of medium to fine sand up to 60 ft thick; he found as many as three beds of "Colgate sand" at some sites, separated from each other by banded beds of his "Bullhead lithofacies" within the Iron Lightning Member. Although earlier studies indicated that the "Colgate sands" were hard and tightly cemented, such is not the case, except locally, and then mostly at or near areas of outcrop. Where buried beneath the Hell Creek Formation, the "Colgate lithofacies" apparently is a loose and permeable sand.

The predominantly marine Fox Hills Formation grades upward and westward into the predominantly continental Hell Creek Formation. The lower part of the Hell Creek is sandier and siltier than the upper part, though both parts contain zones that are mostly sandy or mostly clayey. The upper part of the Hell Creek contains more and thicker carbonaceous or lignitic beds. The lower part of the Hell Creek contains lenses of "Colgate-type sand."

Base from U.S. Geological Survey 1:500,000 map

[1] Withdrawal in 1974. The Fox Ridge Water District has reserved 3,249 acre-feet per year beginning 1975.

[2] Approximate withdrawal in 1974. Total authorizations on January 1, 1975, are for about 178,260 acre-feet.

Figure 4. – Diagram showing the approximate average annual hydrologic budget for Cheyenne River Indian Reservation; does not include discharge of wells tapping aquifers below the Pierre Shale. Subsurface inflow or outflow and storage changes in the Hell Creek and Fox Hills Formations are assumed to be nil. Consumptive diversions shown are those authorized by the State Water Rights Commission as of December 31, 1974. Numbered drainage basins are those for which estimated annual flow is given in the adjacent table.

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GEOHYDROLOGY OF THE CHEYENNE RIVER INDIAN RESERVATION, SOUTH DAKOTA

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1979

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