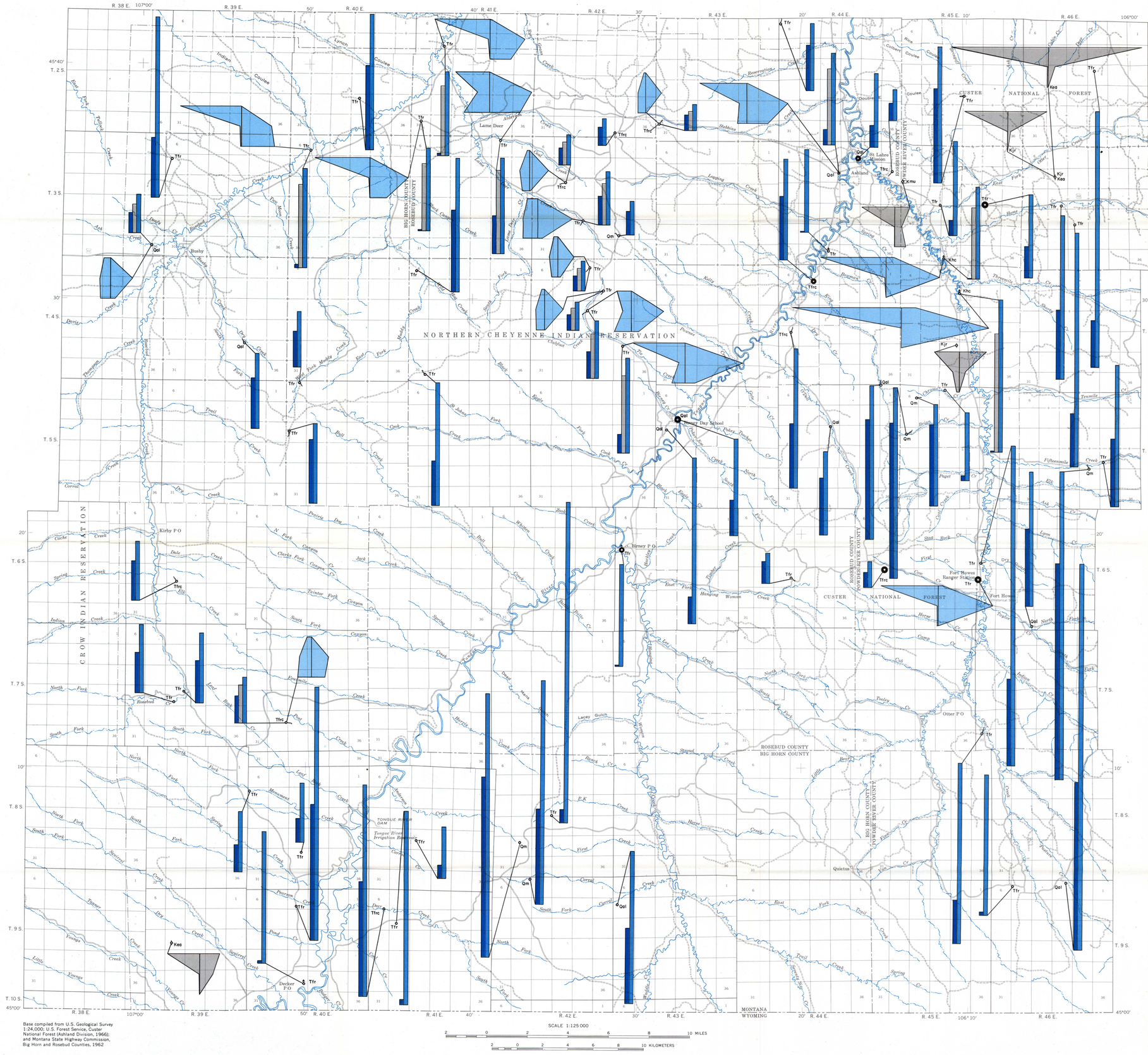
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

HYDROLOGIC INVESTIGATIONS
ATLAS HA-468 (SHEET 2 OF 2)

QUALITY OF GROUND WATER



Base compiled from U.S. Geological Survey 1:24,000; U.S. Forest Service, Custer National Forest (Ashland Division, 1966); and Montana State Highway Commission, Big Horn and Rosebud Counties, 1962

SCALE 1:125 000

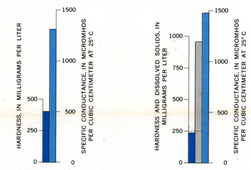
2 0 2 4 6 8 10 MILES
2 0 2 4 6 8 10 KILOMETERS

EXPLANATION

- Domestic or stock well
- Spring
- Flowing well
- U.S. Geological Survey test hole
- Oil-test hole
- Public supply well

Geologic formation yielding water to spring or well

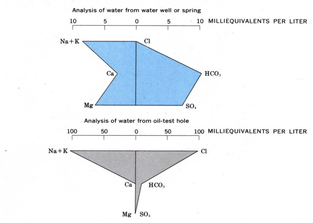
Qal, *alluvium*
Qm, *mantle or surficial deposits*
Tfr, *Tongue River Member of Fort Union Formation*
Tfrc, *clinker from burned Tongue River Member*
Khc, *Hell Creek Formation*
Kjr, *Judith River Formation*
Kea, *Eagle Sandstone*
Kmu, *Muddy Sandstone Member of Thermopolis Shale*



FIELD ANALYSIS OF HARDNESS AND SPECIFIC CONDUCTANCE

LABORATORY ANALYSIS OF HARDNESS, DISSOLVED SOLIDS, AND SPECIFIC CONDUCTANCE

CHEMICAL CONSTITUENTS



QUALITY OF GROUND WATER

FIELD ANALYSES

Field analyses were made to determine approximate values for pH, dissolved iron, hardness, and specific conductance. Hardness is an approximate measure of calcium and magnesium, and specific conductance is an approximate measure of the dissolved solids in the water. Dissolved solids includes the cations that contribute to hardness and those—principally sodium and potassium—that do not. Comparison of hardness to specific conductance, therefore, indicates the amount of sodium and potassium in the water. Hem (1970, p. 99) states that the ratio between dissolved solids, in milligrams per liter, and specific conductance, in micromhos, generally ranges between 55 and 75 percent. Field analyses of ground water are summarized in a table below. Graphic representations of the field analyses are shown on the map.

Summary of field analyses of ground water
(Analyses by U.S. Geological Survey)

Aquifer		Number of samples	Iron (Fe) (mg/l)	Number of samples	Hardness (mg/l)	Number of samples	Specific conductance (micromhos at 25°C)	Number of samples	pH
Alluvium (Qal)	Max.		3.5		2,100		6,000		8.2
	Med.	10	.6	12	670	16	1,800	10	7.6
	Min.		.3		275		460		7.3
Mantle (Qm)	Max.		.4		2,700		4,800		7.2
	Med.	2	.2	5	1,940	5	3,500	3	7.2
	Min.		.1		1,030		1,600		7.1
Clinker (Tfrc)	Max.		1.5		1,440		3,300		8.2
	Med.	5	.3	7	500	8	705	6	7.8
	Min.		.0		185		360		7.1
Tongue River Member of Fort Union Formation (Tfr)	Max.		2.8		1,700		5,500		8.5
	Med.	19	1.0	32	420	49	1,500	23	7.6
	Min.		.2		0		340		6.5
Hell Creek Formation (Khc)	Max.		.....		.....		2,480		....
	Med.		.....		.....	2	2,165		....
	Min.		.....		.....		1,850		....

LABORATORY ANALYSES

Diagrams of analyses (shown on the map) indicate the types of water that are obtained from various sources. Representative analyses are summarized in the table below. Most water from the clinker beds or from alluvium is a "hard" calcium magnesium bicarbonate type. Water from springs that issue from clinker beds contains less dissolved solids than does water from most wells. Water from the Tongue River Member of the Fort Union Formation is a "soft" sodium bicarbonate sulfate type. Water from the Hell Creek Formation, in the valley of Otter Creek, is a sodium bicarbonate type containing minor amounts of sodium chloride. Deeper water-bearing zones contain highly mineralized water of the sodium chloride type and include minor amounts of calcium bicarbonate or sodium bicarbonate.

Representative chemical analyses of ground water
(Analyses by U.S. Geological Survey)

Location				Aquifer[1]	Depth of well (feet)	Temperature (°C)	Milligrams per liter														Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH	Color (platinum cobalt units)
10-acre tract	Sec.	Twp. south	Range east				Silica (SiO_2)	Iron (Fe)	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 (residue)	Hardness as ($CaCO_3$)				
SE¼SE¼SW¼	36	3	38	Qal	52	16	13	.....	54	31	36	2.6	336	0	57	2.3	0.2	0.2	0.11	361	262	1.0	610	7.7	3
SE¼SE¼NE¼	9	3	44	Qal	84	.....	25	.....	38	28	267	9.8	626	0	256	12	2.4	.1	.58	950	207	8.1	1,430	8.1	1
SW¼SW¼NE¼	17	3	42	Tfrc	Spring	9	22	.....	48	22	13	5.3	288	0	9.0	1.8	.9	.5	.14	270	213	.4	461	7.8	4
NE¼SE¼NW¼	26	4	42	Tfr	.....	11	15	.....	30	39	298	6.7	871	0	114	5.4	8.7	.3	.15	968	236	8.4	1,490	7.8	5
SE¼SE¼NE¼	9	4	45	Khc	900	15	10	0.64	5.3	1.3	610	2.9	1,360	1	2.5	143	4.6	.1	.29	1,480	19	62	2,360	8.5	7
NW¼SW¼SW¼	7	3	45	Kmu	6,492	.....	4.4	.....	24	15	1,860	64	1,120	0	1,200	1,390	2.8	.3	1.7	5,580	124	73	7,660	8.7	7

[1]Aquifers: Qal, alluvium; Tfrc, clinker; Tfr, Tongue River Member of Fort Union Formation; Khc, Hell Creek Formation; Kmu, Muddy Sandstone Member of Thermopolis Shale.

MAP SHOWING DIAGRAMS OF CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS AND SPRINGS

SURFACE-WATER RESOURCES

SURFACE-WATER RESOURCES

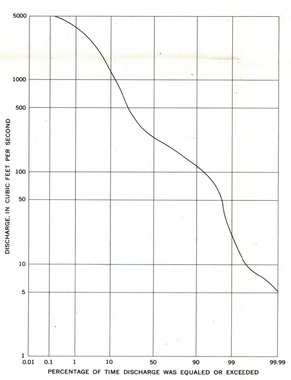
Most of the report area is drained by the Tongue River and its tributaries. About 640 square miles in the northwest part is drained by Rosebud Creek. Most tributaries to the principal streams flow only during spring and early summer. When precipitation during the growing season is insufficient to maintain soil moisture, irrigation water is diverted from the streams.

The Tongue River is gaged and sampled at the Wyoming-Montana State line near Decker, Mont., where it enters the study area. The river drains 1,477 square miles above this station. The percentage of time that streamflow equaled or exceeded given discharge rates; the recurrence interval of low flows of various periods; and the average monthly discharge at the station are shown by the graphs.

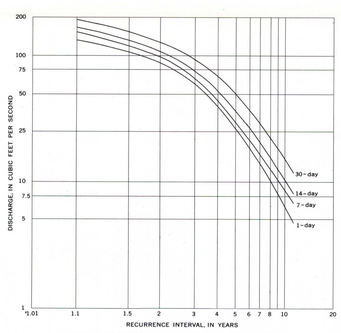
Rosebud Creek drains about 560 square miles above a miscellaneous measurement site in sec. 19, T. 2 S., R. 41 E. The flow as determined by 10 miscellaneous measurements between May 1968 and May 1969 varied from 15 cfs (under ice cover) in February 1969 to about 500 cfs in March 1969 (affected by snowmelt). The discharge measurements are published by the U.S. Geological Survey (1968, p. 264; 1969, p. 274).

The chemical quality of water in the Tongue River at the State line station near Decker was determined from analyses of composite samples. The analyses are shown by Stiff diagrams, (Hem, 1970, p. 259–260) below the mean daily discharge hydrograph. Each sample represents streamflow from periods of from 5 to 37 days, as indicated by brackets.

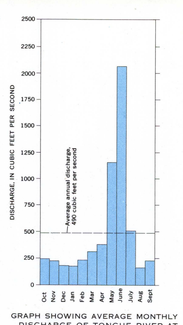
The concentration of dissolved solids in the Tongue River in water year 1968 varied from 674 mg/l (milligrams per liter) in March, when streamflow was low, to 190 mg/l in May and June. The low concentrations coincide with periods of peak runoff from snowmelt and spring rains.



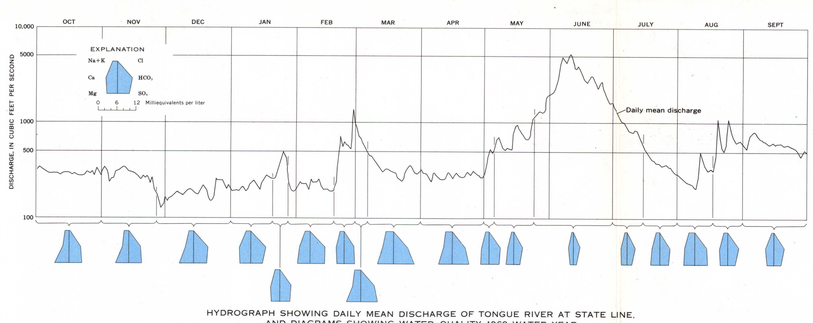
FLOW-DURATION CURVE OF TONGUE RIVER AT STATE LINE, 1961–70 WATER YEARS



LOW-FLOW FREQUENCY CURVES, TONGUE RIVER AT STATE LINE, 1961–70 WATER YEARS



GRAPH SHOWING AVERAGE MONTHLY DISCHARGE OF TONGUE RIVER AT STATE LINE, 1961–70 WATER YEARS



HYDROGRAPH SHOWING DAILY MEAN DISCHARGE OF TONGUE RIVER AT STATE LINE, AND DIAGRAMS SHOWING WATER QUALITY, 1968 WATER YEAR

CONCLUSIONS

Water supplies adequate for domestic and stock uses can be developed throughout most of the project area from the alluvium, surficial deposits, Wasatch Formation, or the Tongue River Member of the Fort Union Formation. Initial yields from wells tapping the alluvium along the Tongue River may be as much as 700 gpm. The quality of water from the alluvium generally is suitable for most uses. Ground-water supplies in the area are inadequate to sustain full development of the coal resources; however, the alluvium is capable of furnishing supplemental water for irrigation or industrial uses.

Surface water in the Tongue River, in the 10-year period of record, equaled or exceeded 100 cfs (cubic feet per second) 93 percent of the time but equaled or exceeded 1,000 cfs for only 12 percent of the time.

REFERENCES CITED

Baker, A.A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806-B, p. 15–67.

Bass, N.W., 1932, The Ashland coal field, Rosebud, Powder River and Custer Counties, Mont.: U.S. Geol. Survey Bull. 831-B, p. 19–108.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill Book Co., Inc., 534 p.

Hem, J.D., 1970, Study and interpretation of the chemical characteristics of natural water [second edition]: U.S. Geol. Survey Water-Supply Paper 1473, 363 p.

U.S. Geological Survey, 1968, Water resources data for Montana, pt. 1, Surface water records: Helena, Mont., Water Resources Division, 271 p.

———1969, Water resources data for Montana, pt. 1, Surface water records: Helena, Mont., Water Resources Division, 283 p.

WATER RESOURCES OF THE NORTHERN CHEYENNE INDIAN RESERVATION AND ADJACENT AREA, SOUTHEASTERN MONTANA

By
William B. Hopkins

1973

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973—W72040