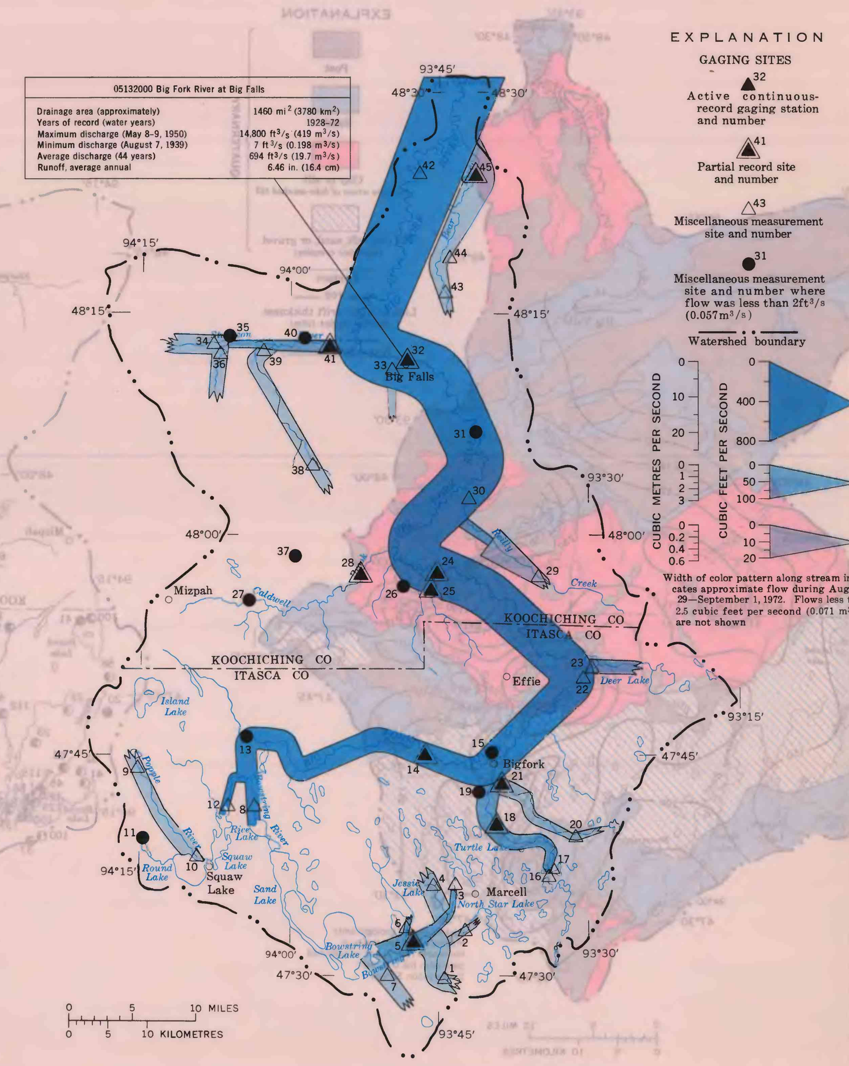
SURFACE WATER

Map key	Station number	Gaging station, partial record, or miscellaneous discharge measurement site	Approximate drainage area (mi²)	Measurement period August 30-September 1, 1972: Discharge (ft³/s)	Specific* conductance	Yield (ft³/s/mi²)	Base-flow period July 28-30, 1970: Discharge (ft³/s)	Specific* conductance	Yield (ft³/s/mi²)	7-day minimum discharge 10-year recurrence interval (ft³/s)
1	—	Bowstring River near Suomi	—	10.4	240	—	—	—	—	—
2	—	Potatoe Creek near Marcell	—	3.97	220	—	—	—	—	—
3	—	Turtle Creek near Marcell	—	12.5	220	—	—	—	—	—
4	—	Little Turtle Creek at Talmoon	—	8.62	245	—	—	—	—	—
5	05131600	Bowstring River near Talmoon	90	49.1	230	0.55	14.2	268	0.16	<1
6	—	Jessie Brook near Talmoon	—	16.8	235	—	—	—	—	—
7	—	Grouse Creek near Talmoon	—	9.35	60	—	—	—	—	—
8	05131650	Bowstring River at Shogren Dam near Dora Lake	—	128	200	—	—	—	—	—
9	—	Popple River at Alvwood	—	8.32	225	—	—	—	—	—
10	—	Popple River at Squaw Lake	—	9.20	256	—	—	—	—	—
11	—	Round Lake tributary near Squaw Lake	—	1.06	280	—	—	—	—	—
12	05131720	Popple River near Dora Lake	—	71.6	208	—	—	—	—	—
13	—	Moose Brook near Dora Lake	—	1.88	—	—	—	—	—	—
14	05131750	Big Fork River near Bigfork	585	240	210	0.41	122	238	0.21	17
15	—	Big Fork River tributary at Bigfork	—	1.30	120	—	—	—	—	—
16	—	Rice River at outlet of Clubhouse Lake near Marcell	—	10.8	220	—	—	—	—	—
17	—	Rice River tributary at outlet of East Lake near Marcell	—	16.4	175	—	—	—	—	—
18	05131760	Rice River near Bigfork	76	56.0	255	0.74	23.9	290	0.31	<1
19	—	Rice River tributary near Bigfork	—	0.12	170	—	—	—	—	—
20	—	Gale Brook near Marcell	—	4.52	125	—	—	—	—	—
21	—	Gale Brook near Bigfork	—	10.4	180	—	0.10	302	—	0
22	05131770	Big Fork River near Craigville	—	382	210	—	—	—	—	—
23	—	Deer Creek near Effie	—	43.1	220	—	—	—	—	—
24	05131870	Big Fork River near Effie	950	472	215	0.50	195	278	0.21	23
25	05131880	Bowerman Brook near Effie	—	0.79	—	—	0.27	204	—	0
26	—	Plum Creek near Effie	—	0.80	—	—	—	—	—	—
27	—	Caldwell Brook near Mizpah	—	0.05	325	—	—	—	—	—
28	05131900	Caldwell Brook near Effie	124	2.34	370	0.019	1.50	280	0.012	0
29	—	Reilly Brook near Craigville	—	6.98	110	—	—	—	—	—
30	—	Reilly Brook near Big Falls	—	30.1	—	—	—	—	—	—
31	—	Big Fork River tributary No. 2 near Big Falls	—	0.47	—	—	—	—	—	—
32	05132000	Big Fork River at Big Falls	1460	570	217	0.39	254	—	0.17	28
33	—	Big Fork River tributary at Big Falls	—	3.60	170	—	—	—	—	—
34	—	Sturgeon River near Margie	—	11.7	148	—	—	—	—	—
35	—	Sturgeon River tributary near Big Falls	—	1.04	174	—	—	—	—	—
36	—	Sturgeon River tributary No. 2 near Big Falls	—	8.41	136	—	—	—	—	—
37	—	Dinner Creek near Gemmell	—	1.23	90	—	—	—	—	—
38	05132050	Dinner Creek at Margie	—	7.74	60	—	—	—	—	—
39	—	Dinner Creek near Big Falls	—	8.09	148	—	—	—	—	—
40	—	Sturgeon River tributary No. 3 near Big Falls	—	1.00	318	—	—	—	—	—
41	05132200	Sturgeon River near Big Falls	322	33.0	144	0.10	20.2	—	0.063	<1
42	—	Big Fork River at Lindford	—	695	180	—	—	—	—	—
43	—	Bear River near Big Falls	—	6.42	120	—	—	—	—	—
44	—	Bear River tributary near Big Falls	—	2.02	55	—	—	—	—	—
45	05132400	Bear River near Littlefork	113	18.4	110	0.16	2.76	162	0.074	0

*In micromhos per centimetre at 25° Celsius

05132000 Big Fork River at Big Falls	
Drainage area (approximately)	1460 mi² (3780 km²)
Years of record (water years)	1928-72
Maximum discharge (May 8-9, 1950)	14,800 ft³/s (419 m³/s)
Minimum discharge (August 7, 1939)	7 ft³/s (0.198 m³/s)
Average discharge (44 years)	694 ft³/s (19.7 m³/s)
Runoff, average annual	6.46 in. (16.4 cm)

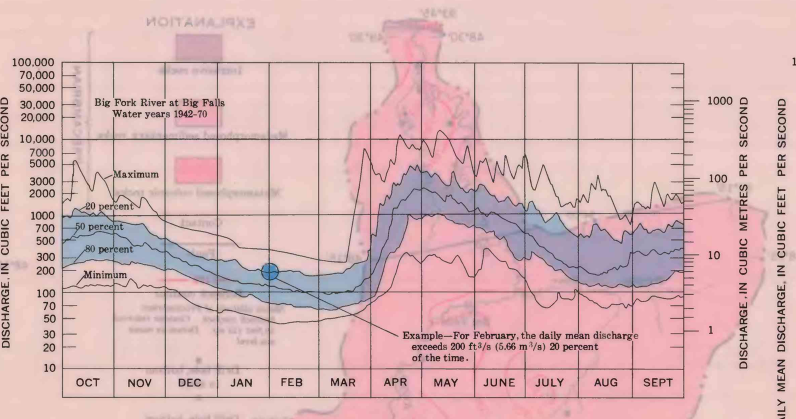


THE FLOW DIAGRAM SHOWS THE DISTRIBUTION OF STREAMFLOW ON AUGUST 29—SEPTEMBER 1, 1972

Flow distribution was determined from discharge measurements made at 50 sites. Some of the flow was runoff from rains in August, so measured discharges do not represent base flow. The discharge of 570 ft³/s (16.1 m³/s) at U.S. Geological Survey gaging station 05132000, Big Fork River at Big Falls, during the measurement period was at the 31 percentile on the flow-duration curve.

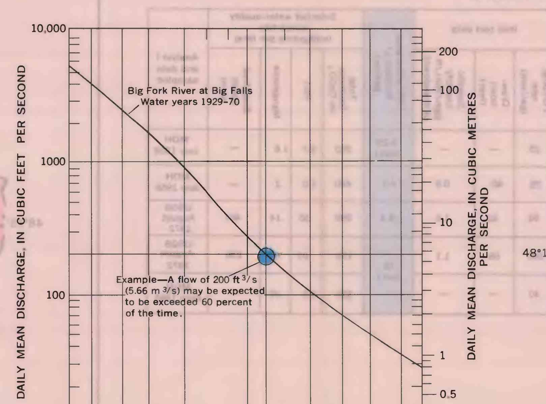
At 10 sites, streamflow was measured several times in past years during base-flow conditions. The base-flow discharges measured July 28-30, 1970, are listed on the adjacent table.

Streams having the highest unit base-flow are in the southern third of the watershed, an area of many lakes. During extended periods of little or no rainfall, streamflow in this area is sustained by ground-water discharge and by slow release of water from the lakes.



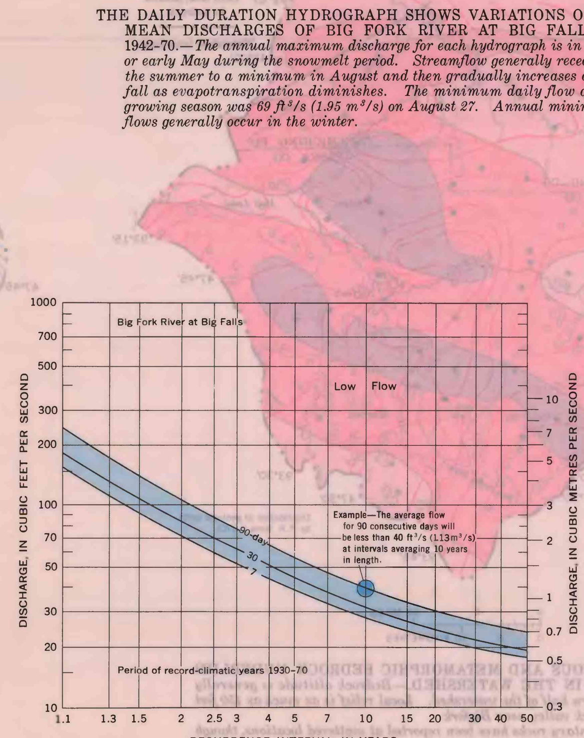
THE DAILY DURATION HYDROGRAPH SHOWS VARIATIONS OF DAILY MEAN DISCHARGES OF BIG FORK RIVER AT BIG FALLS FROM 1942-70.

—*The annual maximum discharge for each hydrograph is in late April or early May during the snowmelt period. Streamflow generally recedes during the summer to a minimum in August and then gradually increases during the fall as evapotranspiration diminishes. The minimum daily flow during the growing season was 69 ft³/s (1.95 m³/s) on August 27. Annual minimum daily flows generally occur in the winter.*



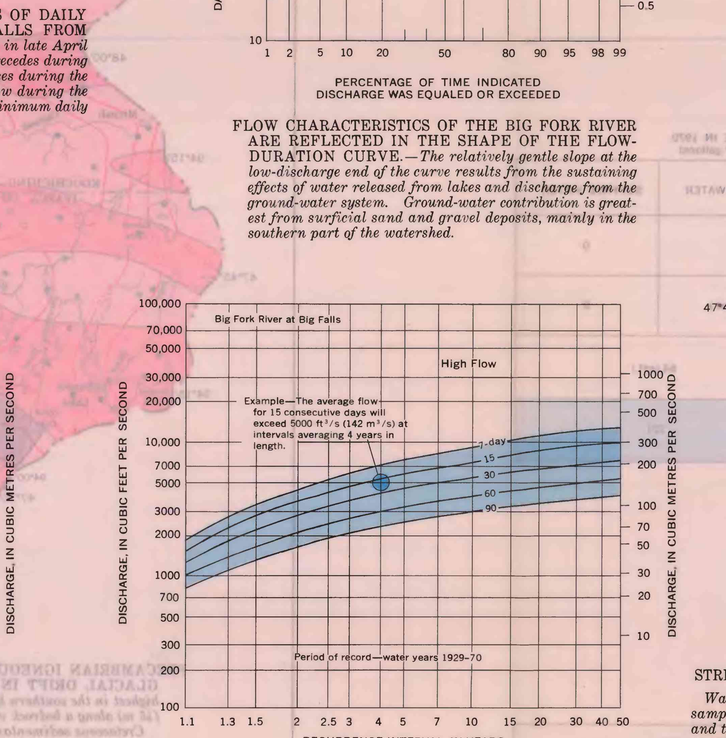
FLOW CHARACTERISTICS OF THE BIG FORK RIVER ARE REFLECTED IN THE SHAPE OF THE FLOW-DURATION CURVE.

—*The relatively gentle slope at the low-discharge end of the curve results from the sustaining effects of water released from lakes and discharge from the ground-water system. Ground-water contribution is greatest from surficial sand and gravel deposits, mainly in the southern part of the watershed.*



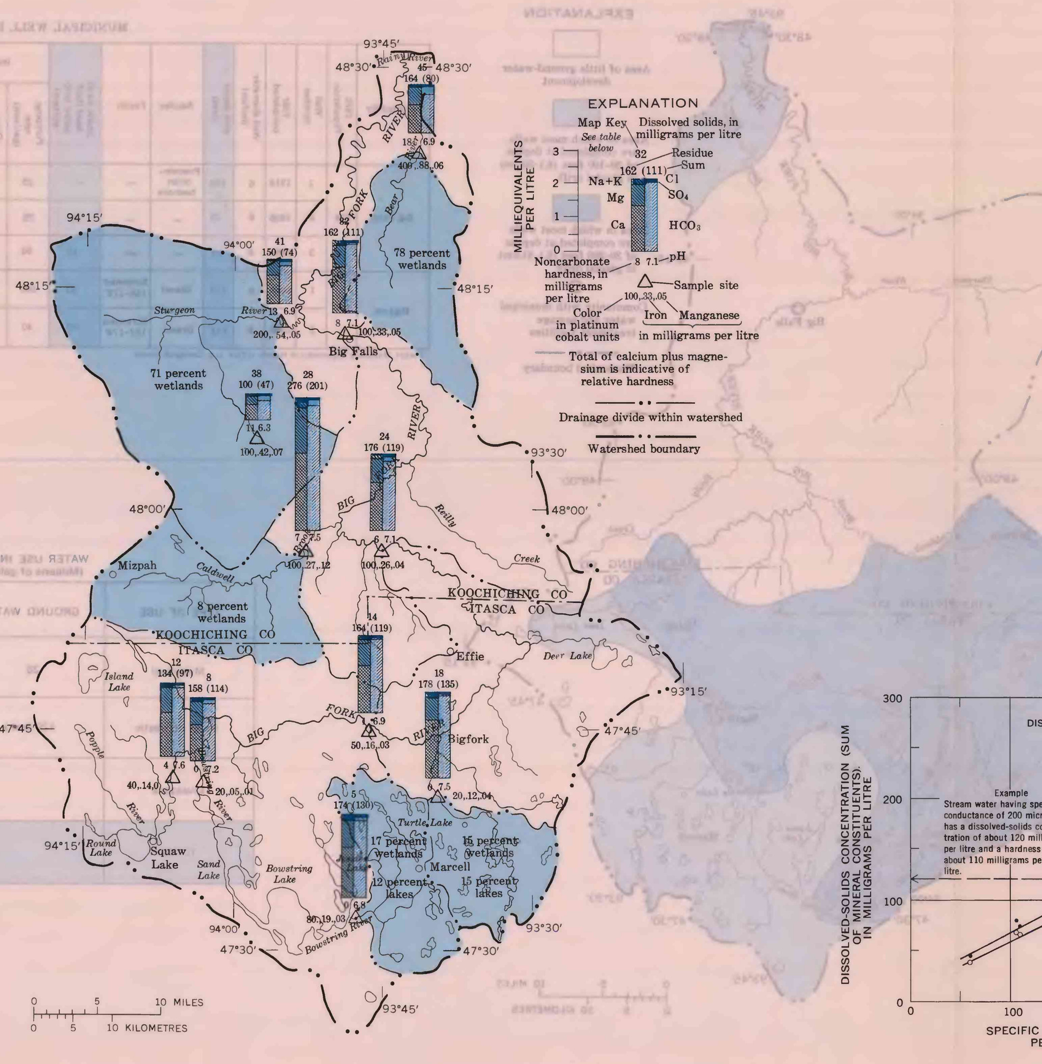
STREAMFLOW IN THE BIG FORK RIVER IS SUSTAINED DURING PERIODS OF LOW FLOW BY DISCHARGE FROM LAKES AND THE GROUND-WATER SYSTEM.

—*Low flows occur in winter, when precipitation is stored as snow and ice, and in late summer or fall during extended dry periods. Low streamflow during the drought in the 1930's determined the shape and position of the frequency curves at higher recurrence intervals. During 1931-40 there were 498 days when daily mean discharges were less than 40 ft³/s (1.13 m³/s); but, since then (1941-72), the lowest daily mean discharge was 41 ft³/s (1.16 m³/s) on February 6 and 7, 1959.*



FREQUENCY CURVES INDICATE THAT HIGH FLOWS IN THE BIG FORK RIVER ARE SUSTAINED FOR LONG PERIODS OF TIME.

—*Streamflow rises and falls rather slowly because of the large drainage area and the natural attenuating effect of lakes and wetlands.*



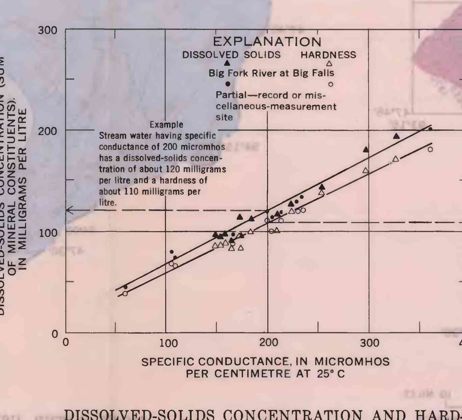
STREAMS IN THE WATERSHED ARE CHARACTERIZED BY WATER OF THE CALCIUM BICARBONATE TYPE

Water type is similar areally, as indicated by analyses of samples collected August 30 to September 1, 1972 (map above and table below). Concentrations of dissolved solids and individual constituents vary considerably and show a relationship to surficial geology. Drainage basins of streams such as Sturgeon River and Bear River are mostly peat-covered wetlands (listed percentages for selected basins were estimated from best available topographic maps). In contrast, Caldwell Brook drains an area whose surficial material is largely clay or silt. Water in streams draining clay or silt areas is more highly mineralized than water from peat areas, where contact with mineral soil is less. Water in streams draining wetlands is generally higher in color and iron and has a lower pH than water from mineral soil areas. Considerable amounts of organic matter in stream water in the northern part of the watershed probably account for the large difference between dissolved-solids residue (includes organic constituents) and dissolved solids as sum of mineral constituents. Lakes in the southern part of the watershed moderate the degree of mineralization of stream water.

Chemical constituents and hardness, in milligrams per litre

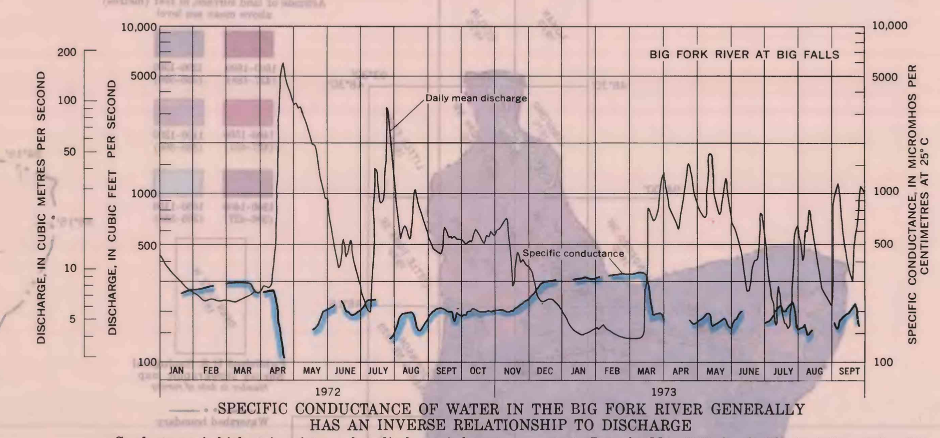
Map key	Station number	Station name and date of collection	Discharge (ft³/s)	Dissolved silica	Iron	Manganese	Calcium	Magnesium	Dissolved sodium	Dissolved potassium	Bicarbonate	Dissolved sulfate	Dissolved chloride	Fluoride	Nitrite & nitrate (N)	Boron	Dissolved solids (sum)	Total hardness as $CaCO_3$	pH	Temperature (°Celsius)	Color (platinum cobalt units)
5	05131600	Bowstring River near Talmoon August 30, 1972	49.1	10	0.19	0.03	30	10	2.9	1.6	141	4.1	1.5	0.2	0.01	0.08	130	120	6.8	20.0	80
8	05131650	Bowstring River at Shogren Dam near Dora Lake August 31, 1972	128	8.7	.05	.01	27	8.8	2.3	1.2	126	2.5	1.1	.1	0	.06	114	100	7.2	21.5	20
12	05131720	Popple River near Dora Lake September 1, 1972	71.6	5.3	.14	0	22	8.6	1.1	0.2	105	6.5	0.8	.2	.01	.07	97	90	7.6	20.0	40
14	05131750	Big Fork River near Bigfork August 30, 1972	240	9.8	.16	.03	28	9.4	2.4	0.9	131	3.1	0.9	.2	0	.08	119	110	6.9	22.5	50
18	05131760	Rice River near Bigfork August 30, 1972	56.0	10	.12	.04	35	8.2	2.7	1.4	148	3.1	1.1	.1	0	.04	135	120	7.5	23.0	20
24	05131870	Big Fork River near Effie August 30, 1972	483	10	.26	.04	29	8.6	2.4	1.1	124	5.0	1.3	.3	.02	.10	119	110	7.1	23.0	100
28	05131900	Caldwell Brook near Effie August 31, 1972	2.34	11	.27	.12	46	17	6.4	1.3	217	10	1.6	.4	.01	.14	201	180	7.5	19.5	100
32	05132000	Big Fork River at Big Falls August 31, 1972	570	10	.33	.05	27	8.1	2.3	0.9	113	5.3	1.2	.3	0	.12	111	100	7.1	21.0	100
38	05132050	Dinner Creek at Margie August 31, 1972	7.74	8.2	.42	.07	9.4	3.5	1.0	0.2	33	6.0	1.1	.3	0	.15	47	38	6.3	20.0	100
41	05132200	Sturgeon River near Big Falls August 31, 1972	33.0	8.6	.54	.05	17	5.9	1.1	0.3	65	7.1	1.2	.4	0	.21	74	67	6.9	20.0	200
45	05132400	Bear River near Littlefork August 31, 1972	18.4	9.4	.88	.06	17	6.5	0.9	0.4	62	11	2.4	.5	.02	.26	80	69	6.9	19.0	400
32	05132000	Big Fork River at Big Falls. Sixteen samples collected during 1967, 1968, 1972, and 1973. Maximum	2,450	13	.52	.09	46	13	4.4	2.2	212	12	3.0	.4	.43	.18	192	170	7.9	21.5	200
		Median	474	9.0	.20	.04	27	8.2	2.3	1.5	118	8.1	2.2	.2	.08	.08	116	100	7.4	7.8	90
		Minimum	119	3.6	.07	0	22	6.7	1.8	0.7	84	5.3	.4	.1	0	.03	92	83	6.5	0.0	17
		Recommended limits for domestic consumption (Minnesota Water Pollution Control Commission, 1967)	—	—	.30	.05	—	—	—	—	—	250	250	1.5	10	—	500	—	—	—	15

(Analyses by U.S. Geological Survey)



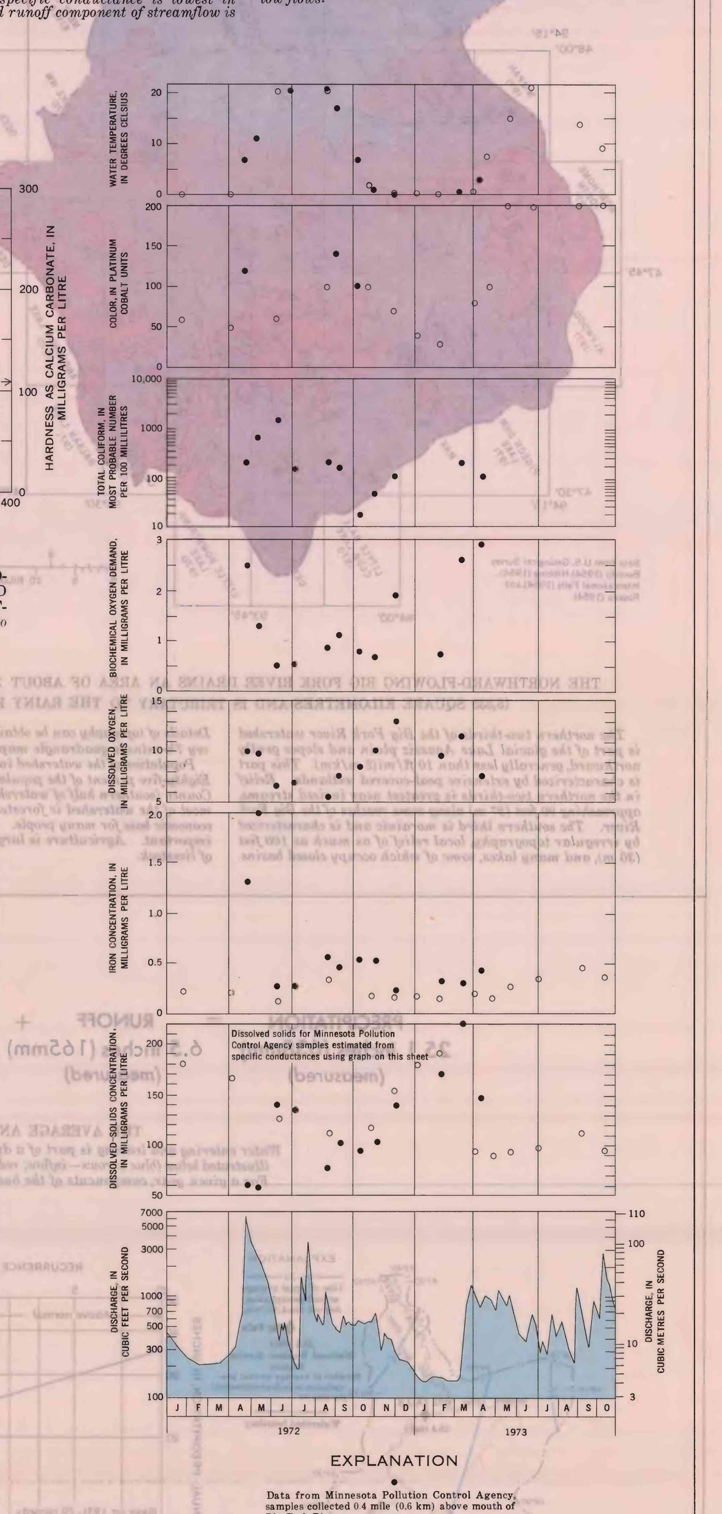
DISSOLVED-SOLIDS CONCENTRATION AND HARDNESS OF STREAM WATERS CAN BE ESTIMATED FROM MEASUREMENTS OF SPECIFIC CONDUCTANCE.

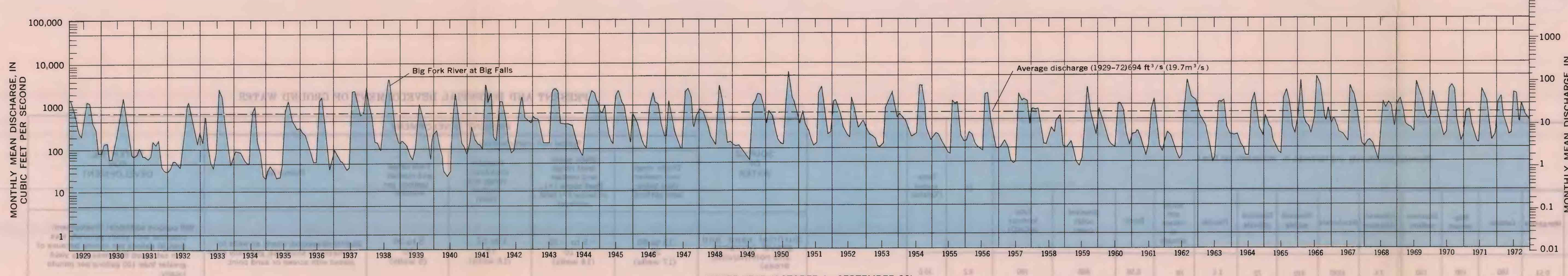
—*Both parameters show a linear relationship to conductance.*



SPECIFIC CONDUCTANCE OF WATER IN THE BIG FORK RIVER GENERALLY HAS AN INVERSE RELATIONSHIP TO DISCHARGE

Conductance is highest in winter, when discharge is lowest and consists almost entirely of ground water. In general, flows are highest and specific conductance is lowest in spring, when the overland runoff component of streamflow is greatest. Data for May 1973 clearly illustrate the relationship of conductance to discharge for several successive high and low flows.





STREAMFLOW IN THE WATERSHED IS GENERALLY GREATEST IN THE SPRING WHEN RUNOFF IS PRIMARILY FROM SNOWMELT AND SPRING RAINS

The annual maximum discharge at station 05132000, Big Fork River at Big Falls, occurred in April or May in 36 of the 44 years of record. The maximum recorded discharge was 14,800 ft³/s (419 m³/s) on May 8 and 9, 1950. The minimum discharge recorded was 7 ft³/s (0.198 m³/s) on August 7, 1939, resulting from regulation of a power plant a quarter of a mile upstream from the gaging station. The power plant, which caused some diurnal fluctuations at low flows, was dismantled in 1970.

Streamflow in the Big Fork River recedes during winter, when base-flow conditions prevail, and is usually at a minimum in February. The annual minimum monthly flow was in the winter 34 times during the 44 years of record. There is considerable variation in extremes of annual runoff for the Big Fork River at Big Falls. The minimum annual runoff was 0.86 inch (2.18 cm) in the 1931 water year. The second lowest was 1.95 inches (4.95 cm) in 1934. At the other extreme, the maximum annual runoff was 12.66 inches (32.2 cm) in 1950. Other years when runoff exceeded 10 inches (25.4 cm) were: 1966—12.14 inches (30.8 cm), 1969—11.28 inches (28.7 cm), and 1970—11.47 inches (29.1 cm).

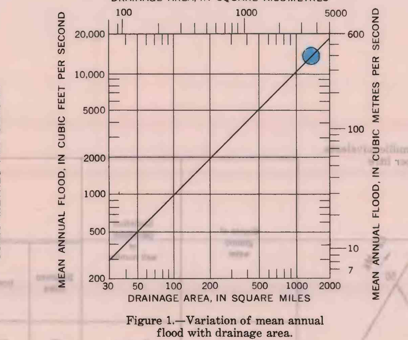


Figure 1.—Variation of mean annual flood with drainage area.

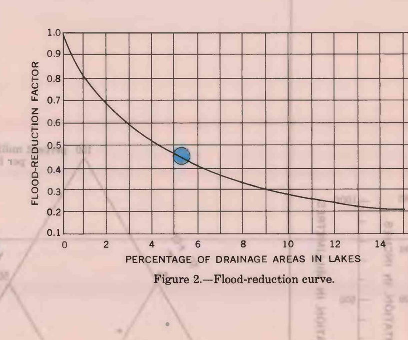


Figure 2.—Flood-reduction curve.

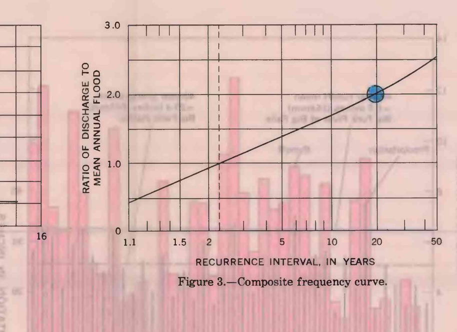


Figure 3.—Composite frequency curve.

THE MAGNITUDE AND FREQUENCY OF FLOODS IN THE BIG FORK RIVER WATERSHED CAN BE DETERMINED BY THE REGIONAL FLOOD-FREQUENCY METHOD GIVEN IN FIGURES 1-3

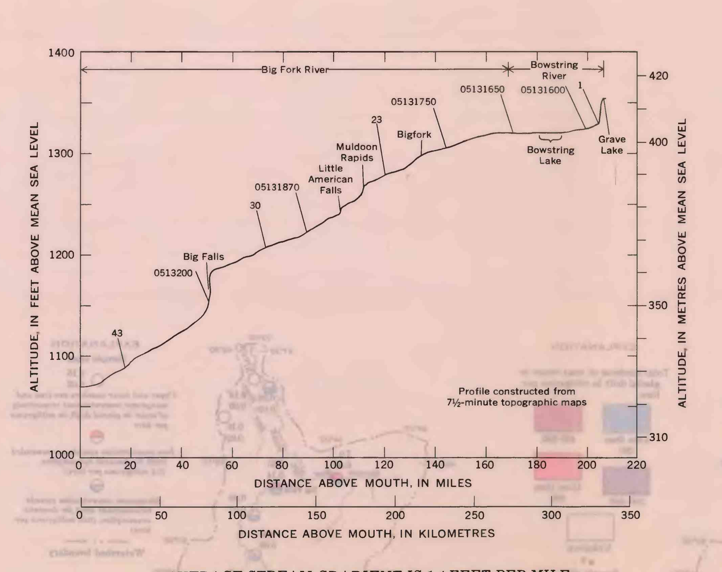
To compute the magnitude and frequency of floods for a site in the watershed, size of drainage basin and area of lakes in the basin must first be determined. Sizes of drainage areas for several sites are given in the table adjacent to the flow diagram. Percentage of lake area is computed by dividing the area of lakes by the total drainage area and multiply by 100. The flood-reduction factor in figure 2 is not used for sites that have lake areas of less than 0.2 percent of total drainage area.

Example.—Determine the magnitude of a flood having a 20-year recurrence for the Big Fork River at Big Falls, which has a drainage area of 1,460 mi² (3,780 km²) and a lake area of 77 mi² (199 km²).

1. *From the curve in figure 1, the mean annual flood for a drainage area of 1,460 mi² is 14,000 ft³/s.*
2. *The percentage of lake area in the basin is 77 mi²/1,460 mi² × 100 = 5.3 percent. From the curve in figure 2, when the percentage of lake area is 5.3, the flood reduction factor is 0.45.*
3. *Then, adjust mean annual flood-reduction factor determined in step 2. Adjusted mean annual flood = 14,000 ft³/s × 0.45 = 6,300 ft³/s.*
4. *The ratio of a flood of a given recurrence interval to the mean annual flood is obtained from the curve in figure 3. In this example, the ratio for a flood having a 20-year recurrence interval is 2.02.*
5. *The magnitude of a 20-year flood is the product of the adjusted mean annual flood determined in step 3 and the ratio obtained in step 4, or 6,300 ft³/s × 2.02 = 12,700 ft³/s (360 m³/s).*

CHANGES IN WATER QUALITY OF THE BIG FORK RIVER ARE RELATED TO DISCHARGE

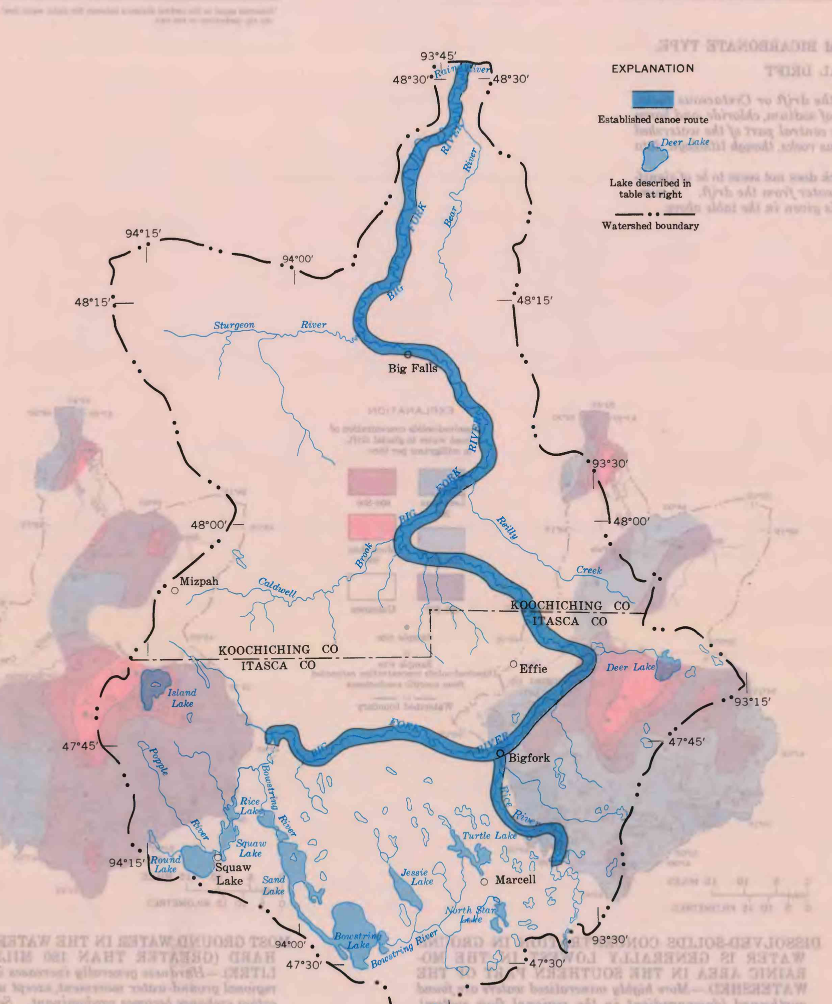
Although all samples analyzed are of the calcium bicarbonate type concentrations of dissolved solids and individual constituents vary considerably (table above and graph at right). Dissolved-solids concentration is generally lowest at high discharges, when the ratio of overland runoff to base flow is greatest. Color and iron concentrations are highest during high discharges, when runoff from peatlands constitutes a significant part of streamflow. Some of the increase in biochemical oxygen demand during high discharge can possibly be attributed to natural flushing of organic matter from peatlands. Total coliform varies substantially with time, whereas fecal coliform (not graphed) is consistently low, usually less than 20 colonies per 100 millilitres. Limits of iron and manganese concentrations in water for domestic consumption, as recommended by the Minnesota Water Pollution Control Commission (1967), are exceeded in some samples, and the limit for color is exceeded in all. Low concentrations of nitrite plus nitrate probably reflect the sparse population and related development in the watershed.



AVERAGE STREAM GRADIENT IS 1.4 FEET PER MILE (0.27 METRE PER KILOMETRE) BETWEEN THE HEADWATERS OF THE BOWSTRING RIVER AND THE MOUTH OF THE BIG FORK RIVER.

—*Gradient is lowest along most of the Bowstring River where it flows through a chain of lakes. Gradient of the Big Fork River is relatively low in its upper and lower reaches, but steepens in between, as indicated by rapids and falls. The profile of the upper third of the Big Fork River, where the river is incised into bedrock in several places, is slightly convex.*

Big Fork and Rice Rivers are established canoe routes (map). Several campgrounds and points of interest are located along each. Canoeing on the Big Fork River offers a variety of conditions—smooth reaches, rapids, and at least two portages (Little American Falls and Big Falls). Although a wilderness stream along much of its route, the Big Fork River has adequate access. Canoeing on the Rice River and other major tributaries is best at medium and high stages.



Lake name	Surface area (acres)	Depth (feet) Maximum	Depth (feet) Median or Mean	Outlet control	Ecological classification	Management classification	Public waters classification	Remarks
Bowstring	8,900	30	15	Natural	Hard-water walleye	Walleye	Recreational development	Public access. Shoreline soils 95 percent gravel and sand.
Deer	1,891	55	11	Dam	Hard-water walleye	Northern pike-walleye	Recreational development	Public access.
Island	2,920	30	19	Dam	—	Walleye	General development	Public access. Shoreline soils 76 percent sand.
Jessie	1,782	35	22	Natural	Hard-water walleye	Walleye	Recreational development	Public access. Shoreline soils 84 percent sand.
North Star	907	90	27	Natural	Centrarchid	Centrarchid-walleye	Recreational development	Public access. Recently stocked.
Rice	911	5	2	Natural	Rough fish-gamefish	Warm-water game fish	Natural environment	Public access.
Round	2,959	24	12	Natural	Hard-water walleye	Walleye-northern pike	Recreational development	Public access. Shoreline soils 100 percent sand.
Sand	3,785	70	17	Natural	Hard-water walleye	Walleye	Recreational development	Shoreline soils 70 percent sand.
Squaw	2,885	6	4	Natural	Waterfowl-wild rice	Game-muskrat	Natural environment	Public access. Yearly winterkill. Lake bottom 99 percent muck.
Turtle	2,066	150	34	Natural	—	Walleye	Recreational development	Public access.

(Data from Minnesota Department of Natural Resources)

LAKES, CONCENTRATED IN THE MORAINIC (SOUTHERN) PART OF THE WATERSHED, OFFER EXCELLENT RECREATION.

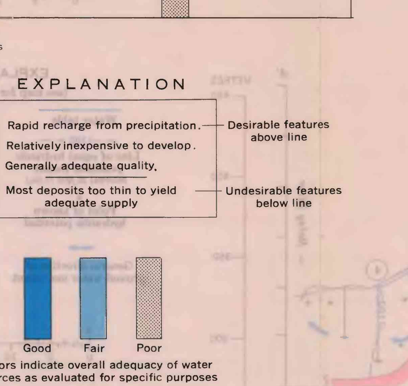
—*Resorts and campgrounds are numerous in the morainic area, and most lakes have public access. Data concerning the largest lakes (locations on map) are tabulated above. The public waters classification is based upon the suitability of the lake for future shoreland development. "Natural environment" is most restrictive and "general development" least restrictive with respect to development standards.*

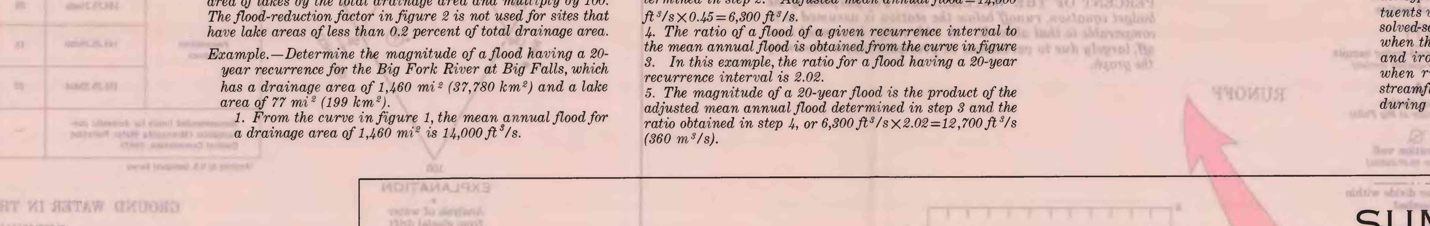
SUMMARY AND CONCLUSIONS

RELATIVE ADEQUACY OF WATER SOURCES

PURPOSE	CONSIDERATIONS	SURFACE WATER: Big Fork River	SURFACE WATER: Major tributaries	SURFACE WATER: Minor tributaries	SURFACE WATER: Lakes	GROUND WATER[1]: Surficial sand	GROUND WATER[1]: Undifferentiated drift	GROUND WATER[1]: Precambrian bedrock
Municipal or industrial supply	For a moderate supply, principal needs are: Quantity Minimum available surface water supply of 1 ft³/s (0.03 m³/s), or wells yielding 250 gal/min (15.8 l/s). Quality Dissolved-solids concentration less than 55 mg/l; hardness less than 180 mg/l.	Adequate flow. ——— Disinfection and clarification necessary for municipal use. Iron and manganese content may be high. Color removal may be necessary.	Additional storage possible. ——— Flow may be inadequate. Disinfection and clarification necessary for municipal use. Iron and manganese content may be high. Color removal may be necessary.	——— Flow generally inadequate. Disinfection and clarification necessary for municipal use. Iron and manganese content may be high. Color removal may be necessary.	Adequate supply from larger lakes. ——— Disinfection and clarification necessary for municipal use.	Rapid recharge from precipitation. Relatively inexpensive to develop. ——— Most deposits too thin to yield adequate supply. Easily polluted. Treatment for hardness, iron, and manganese may be necessary.	Buried sand or gravel may yield adequate supply. Wells may be open to more than one aquifer. ——— Aquifer extent may be small. Recharge may be slow. Commonly high dissolved-solids concentration. Treatment for hardness, iron, and manganese may be necessary.	——— Generally inadequate quantity. Treatment for hardness, iron, and manganese may be necessary.
Rural domestic or stock supply	For an adequate farm supply, needs are: Quantity Minimum of 5 gal/min (0.3 l/s). Quality Dissolved-solids concentration less than 1,000 mg/l.	Adequate flow. Suitable quality for stock. ——— Available only to riparian lands. Disinfection and clarification necessary for domestic use.	Generally adequate flow. Suitable quality for stock. ——— Available only to riparian lands. Disinfection and clarification necessary for domestic use.	Suitable quality for stock. ——— Available only to riparian lands. Flow may be inadequate. Disinfection and clarification necessary for domestic use.	Adequate supply. Suitable quality for stock. ——— Available only to riparian lands. Disinfection and clarification necessary for domestic use.	Commonly adequate quantity. Relatively inexpensive to develop. ——— Easily polluted. Treatment for hardness, iron, and manganese may be desirable for domestic use.	Generally adequate quantity. ——— Commonly high dissolved-solids concentration. Treatment for hardness, iron, and manganese may be desirable for domestic use.	Generally adequate quantity. ——— Quantity may be inadequate. Treatment for hardness, iron, and manganese may be desirable for domestic use.
Irrigation supply	For an average farm, needs are: Quantity Minimum available surface water supply of 1 ft³/s (0.03 m³/s) during growing season or wells yielding 250 gal/min (15.8 l/s). Quality Suitability of water quality for irrigation as indicated by classification of Wilcox (1955).	Adequate flow. Suitable quality. ——— Restricted to riparian lands.	Suitable quality. ——— Restricted to riparian lands. Flow may be inadequate.	Suitable quality. ——— Restricted to riparian lands.	Adequate supply from larger lakes. Suitable quality. ——— Restricted to riparian lands.	Rapid recharge from precipitation. Relatively inexpensive to develop. Generally adequate quality. ——— Most deposits too thin to yield adequate supply	Buried sand or gravel may yield adequate supply. Wells may be open to more than one aquifer. Generally adequate quality. ——— Aquifer extent may be small. Recharge may be slow.	Generally adequate quality. ——— Generally inadequate quantity.
Fish and wildlife habitat	Adequate depth and quality of water for fish in lakes and streams. Adequate cover needed for wildlife habitat as provided by: Wetlands—lakes or potholes surrounded by marsh areas. Streams—marsh and woodland along banks.	Adequate depth and flow. Suitable quality. Excellent wildlife habitat along banks and in adjacent wetlands. Good migratory waterfowl resting and feeding areas. ——— Occasional flooding.	Generally adequate depth and flow in lower reaches. Suitable quality. Excellent wildlife habitat along banks and in adjacent wetlands. ——— Occasional flooding.	Suitable quality. Excellent wildlife habitat along banks and in adjacent wetlands. ——— Intermittent flow in many.	Suitable quality. Excellent wildlife habitat along banks and in adjacent wetlands. Most lakes zoned to control shoreland development. ———			
Recreation	Adequate access to lakes and streams. Availability of areas suitable for hunting, fishing, and other sports. Available resorts, lake cottages, and campgrounds. Esthetic values and absence of pollution.	Excellent esthetic values. Public access at many sites. Suitable for fishing, hunting, and other sports. Established canoe route. ——— Occasional flooding.	Excellent esthetic values. Habitation sparse in northern part of watershed. Some canoeable at high stages. ——— Occasional flooding. Limited access to some streams.	Excellent esthetic values. Habitation sparse in northern part of watershed. ——— Limited access to many streams.	Excellent esthetic values. Public access at many sites. Excellent for most recreational uses. Most lakes zoned to control shoreland development. ———			

[1] Cretaceous bedrock is a poorly defined source of water in this watershed and is not evaluated





CONCLUSIONS

1. Water resources are not intensively developed anywhere in the Big Fork River watershed. Development is mostly in the southern half, for the northern half is largely peat-covered wetlands. About 221 million gal (.836 million m³) of water was withdrawn in 1970, almost entirely from ground-water sources.
2. Average annual precipitation in the watershed is 25.1 inches (638 mm), runoff 6.5 inches (165 mm), and evapotranspiration is 18.5 inches (470 mm) based on 1931-70 data.
3. North of a regional ground-water divide, all ground water is discharged within the watershed; south of the divide about 0.1 inch (3 mm) per year is discharged from the watershed as underflow.
4. Glacial drift ranges in thickness from 0 to about 250 feet (76 m). Well yields of several hundred gallons per minute may be obtained locally from drift. Many wells are completed between the altitudes of 1,260 and 1,320 feet (384 and 402 m) above mean sea level in the southern part of the watershed. Buried sand and gravel in the drift is the most favorable source for ground-water development. Surficial sand and gravel, generally having low saturated thickness, is a less reliable source of water.
5. Individual wells completed in fractured Precambrian bedrock are generally incapable of supporting water-supply needs larger than those required for domestic or stock use.
6. Most ground water is of the calcium or sodium bicarbonate type, depending primarily upon position in the regional flow system. Dissolved-solids concentration generally increases downgradient in the flow system, although hardness in places decreases because of cation exchange. Hardness, iron, and manganese concentrations in ground water are commonly troublesome.
7. The large amount of natural storage in lakes and wetlands has an attenuating effect on flow in the Big Fork River. Storm runoff stored in lakes and wetlands reduces flood peaks, whereas at other times, flows are sustained as water is released slowly from storage.
8. Annual maximum flows in the Big Fork River generally occur in April and May during the spring "breakup".
9. Annual minimum flows in the Big Fork River usually occur in February or early March. Minimum flows during the summer generally are in August when evapotranspiration losses are high.
10. Water in streams is of the calcium bicarbonate type. The amount of mineralization at a given time reflects surficial geology, being greatest in streams draining glacial lake deposits and least in streams draining peatlands. Water drained from peatlands is typically higher in color and iron and lower in pH than water from areas of mineral soil.
11. Specific conductance and, therefore, dissolved-solids concentration of the Big Fork River are inversely related to discharge. Dissolved-solids concentration is generally highest, and discharge lowest, in winter when ground water constitutes most of the flow. During high flows, mineralization is decreased by dilution.

ACKNOWLEDGMENTS

The authors appreciate the cooperation of well drillers, well owners, and municipal officials, who provided much of the data used in this report. Thanks are given to the U.S. Soil Conservation Service, Minnesota Department of Natural Resources, and Minnesota Pollution Control Agency, for unpublished information used in this report.

SELECTED REFERENCES

Heinselman, H. L., 1963, Forest sites, bog processes, and peatland types in the glacial Lake Agassiz region, Minnesota: Ecol. Monogr., v. 33, no. 4, p. 327-374.
Minnesota Department of Public Health, 1971, State of Minnesota public water supply data: Minnesota Department of Public Health, Div. of Environmental Health, 170 p.
Minnesota Division of Parks and Recreation, 1968, Minnesota voyageur trails: Minnesota Div. Parks and Recreation, 48 p.
Minnesota Division of Waters, 1959, Hydrologic atlas of Minnesota: Minnesota Div. Waters, Bull. 10, 182 p.
Minnesota Pollution Control Agency, 1970, Wastewater disposal facilities inventory, State of Minnesota, January 1, 1970: Minnesota Pollution Control Agency, Div. of Water Quality, 45 p.
Minnesota Water Pollution Control Commission, 1967, Water quality standards for the interstate waters of Minnesota established by the Minnesota Water Pollution Control Commission in accordance with the Federal Water Pollution Control Act of June 1965: St. Paul, 174 p.
Patterson, J. L., and Gamble, C. R., 1968, Magnitude and frequency of floods in the United States, Part 5. Hudson Bay and upper Mississippi River basins: U.S. Geol. Survey Water-Supply Paper 1678, 546 p.
Sims, P. K., 1970, Geologic map of Minnesota: Minnesota Geol. Survey Misc. Map ser., Map M-14.
Souris-Red-Rainy River Basins Commission, 1971, Program formulation and alternatives: Prepared by the program formulation and alternatives work group, appendix N, first draft, 313 p.
Thiel, G. A., 1947, The geology and underground waters of northeastern Minnesota: Minnesota Geol. Survey Bull. 32, 247 p.
Thornthwaite, C. W., and Mather, J. R., 1957, Instructions and tables for computing potential evapotranspiration and the water balance: Drexel Inst. Technology Pubs. in Climatology, v. X, no. 3, 311 p.
U.S. Department of Commerce, Weather Bureau, 1931-70, Climatological data: Washington, D. C., U.S. Govt. Printing Office.
University of Minnesota, 1971, Minnesota soil atlas (Hibbing sheet): Minnesota Agricultural Experiment Station, Misc. Report 110.
Wilcox, L. V., 1955, Classification and use of irrigation waters: U.S. Dept. Agriculture Circ. 969, 19 p.

Interior—Geological Survey, Reston, Va.—1976—W75034

WATER RESOURCES OF THE BIG FORK RIVER WATERSHED, NORTH-CENTRAL MINNESOTA

By
G. F. Lindholm, J. O. Helgesen, and D. W. Ericson

1976