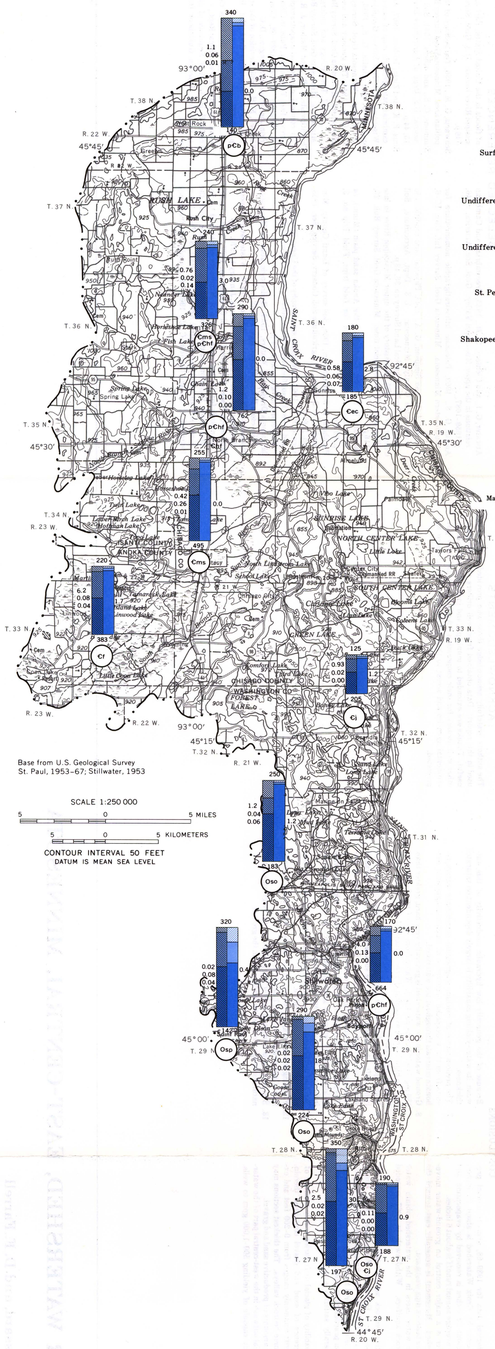
WATER QUALITY



EXPLANATION

SOURCE OF WATER

Qsw Surficial outwash
Qg Undifferentiated gray drift
Qr Undifferentiated red drift
Ossp St. Peter Sandstone
Osc Shakopee and Oneota Formations
pCb Basalt
Cj Jordan Sandstone
Cf Franconia Sandstone
Cec Eau Claire Sandstone
Cms Mt. Simon Sandstone
pChf Hinckley and Fond du Lac Formations of Winchell (1886 and 18 9)

Dissolved solids, in milligrams per liter

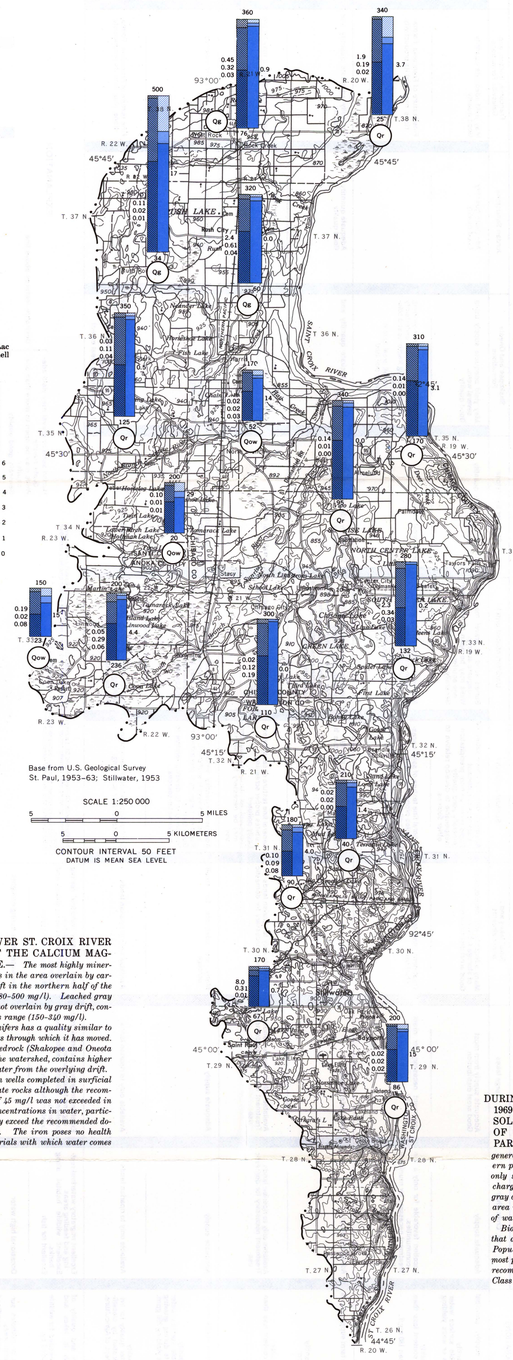
Na+K; Cl+NO_3; Mg; SO_4; Iron (mg/l)—0.02; Manganese (mg/l)—0.08; Orthophosphate (mg/l)—0.04; 0.4—Nitrate (mg/l); Ca; HCO_3

MILLIEQUIVALENTS PER LITER

Depth of well (feet)

Major constituents on bars are expressed as milliequivalents per liter (reacting values). Relative percentages of these may be observed visually from bars. Total of Ca + Mg is indicative of carbonate hardness.

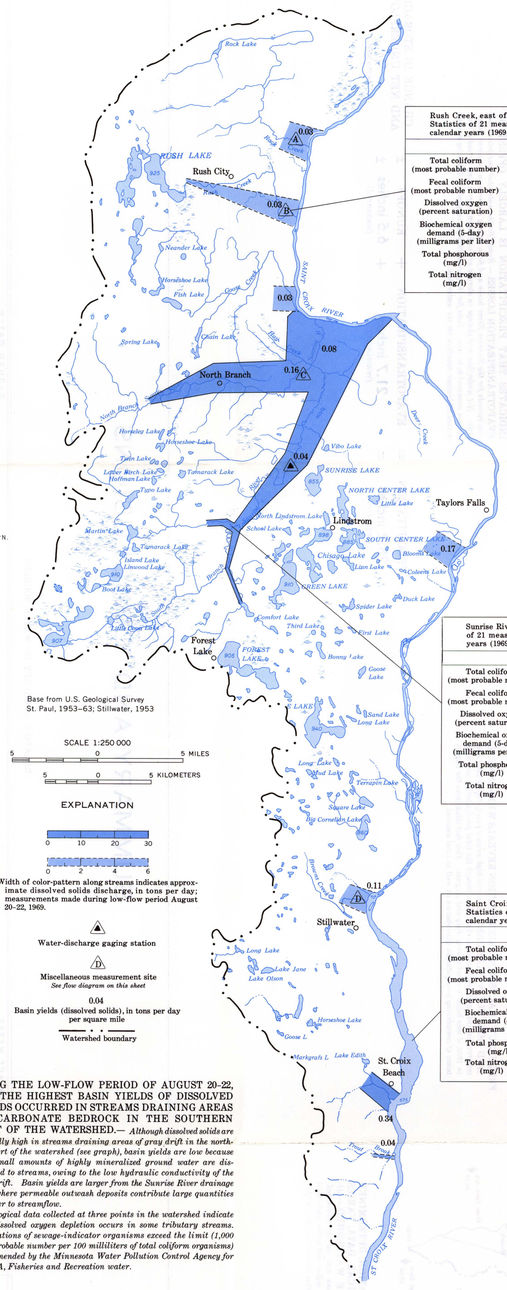
Watershed boundary



GROUND WATER IN THE LOWER ST. CROIX RIVER WATERSHED IS CHIEFLY OF THE CALCIUM MAGNESIUM BICARBONATE TYPE.— *The most highly mineralized water in the glacial drift occurs in the area overlain by carbonate-rich undifferentiated gray drift in the northern half of the watershed (dissolved-solids range of 280–500 mg/l). Leached gray outwash and carbonate-poor red drift, not overlain by gray drift, contain water with a lower dissolved-solids range (150–310 mg/l).*

Water from Cambrian sandstone aquifers has a quality similar to water from the overlying glacial deposits through which it has moved. Water from highly soluble carbonate bedrock (Shakopee and Oneota Formations), in the southern part of the watershed, contains higher dissolved solids (250–350 mg/l) than water from the overlying drift.

Nitrate is present most commonly in wells completed in surficial outwash or shallow, fractured carbonate rocks although the recommended domestic consumption limit of 45 mg/l was not exceeded in any of the samples analyzed. Iron concentrations in water, particularly from bedrock aquifers, commonly exceed the recommended domestic consumption limit of 0.3 mg/l. The iron poses no health problem, but may cause stains on materials with which water comes in contact.



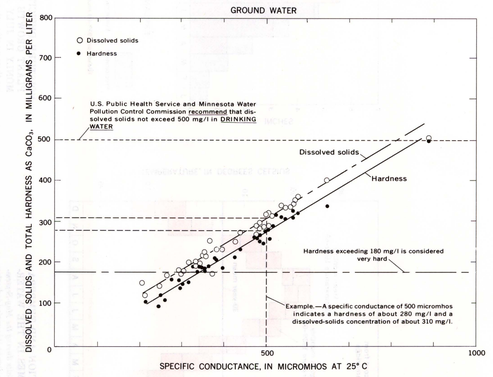
Rush Creek, east of Rush City at Site (B). Statistics of 21 measurements made during calendar years (1969–70).	Maximum	Minimum	Mean
Total coliform (most probable number)	130,000	140	8,800
Fecal coliform (most probable number)	1,300	20	410
Dissolved oxygen (percent saturation)	118	59	91
Biochemical oxygen demand (5-day) (milligrams per liter)	9.4	1.3	4.2
Total phosphorous (mg/l)	1.4	0.08	0.25
Total nitrogen (mg/l)	4.5	0.6	1.6

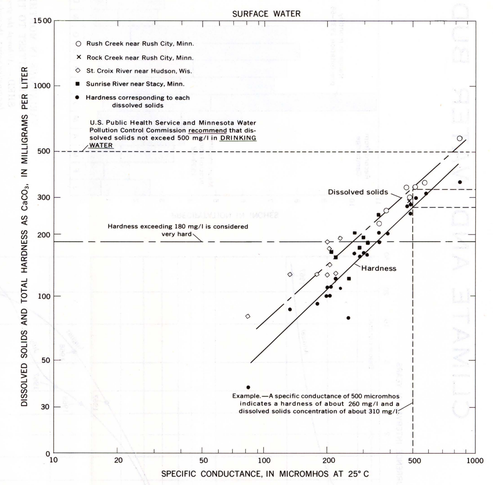
Sunrise River at Stacy, Minnesota. Statistics of 21 measurements made during calendar years (1969–70).	Maximum	Minimum	Mean
Total coliform (most probable number)	2,300	50	400
Fecal coliform (most probable number)	270	20	50
Dissolved oxygen (percent saturation)	93	3	57
Biochemical oxygen demand (5-day) (milligrams per liter)	6.8	2.0	3.6
Total phosphorous (mg/l)	0.34	0.05	0.15
Total nitrogen (mg/l)	3.9	0.7	1.9

Saint Croix River near Hudson, Wisconsin. Statistics of 21 measurements made during calendar years (1969–70).	Maximum	Minimum	Mean
Total coliform (most probable number)	5,400	20	750
Fecal coliform (most probable number)	490	20	130
Dissolved oxygen (percent saturation)	106	70	86
Biochemical oxygen demand (5-day) (milligrams per liter)	7.8	2.8	0.1
Total phosphorous (mg/l)	0.26	0.01	0.11
Total nitrogen (mg/l)	3.3	0.6	1.1

DURING THE LOW-FLOW PERIOD OF AUGUST 20–22, 1969, THE HIGHEST BASIN YIELDS OF DISSOLVED SOLIDS OCCURRED IN STREAMS DRAINING AREAS OF CARBONATE BEDROCK IN THE SOUTHERN PART OF THE WATERSHED.— *Although dissolved solids are generally high in streams draining areas of gray drift in the northern part of the watershed (see graph), basin yields are low because only small amounts of highly mineralized ground water are discharged to streams, owing to the low hydraulic conductivity of the gray drift. Basin yields are larger from the Sunrise River drainage area where permeable outwash deposits contribute large quantities of water to streamflow.*

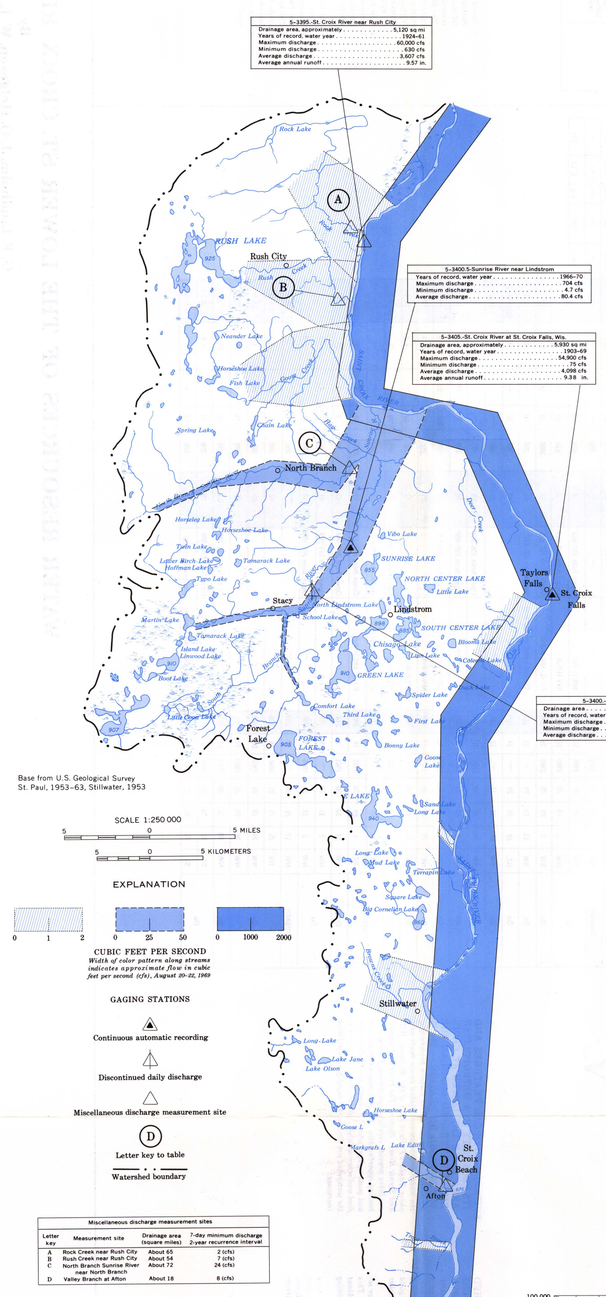
Biological data collected at three points in the watershed indicate that dissolved oxygen depletion occurs in some tributary streams. Populations of sewage-indicator organisms exceed the limit (1,000 most probable number per 100 milliliters of total coliform organisms) recommended by the Minnesota Water Pollution Control Agency for Class A, Fisheries and Recreation water.





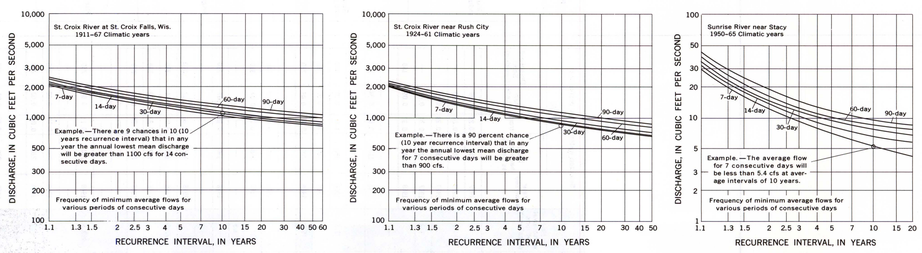
HARDNESS AND DISSOLVED SOLIDS, WHICH ARE IMPORTANT TO WATER USERS, CAN BE ESTIMATED FROM MEASUREMENTS OF ELECTRICAL CONDUCTIVITY OF THE WATER.—*The dominance of calcium magnesium carbonate minerals in the geologic environment is reflected by the commonly high hardness of ground and surface waters. Calcium plus magnesium comprises 60 to 99 percent of the cations, and bicarbonate comprises similar percentages of the anions in all samples. Carbonate hardness (temporary) is the major constituent of total hardness in the watershed. Varying concentrations (less than 150 mg/l of calcium carbonate) of noncarbonate hardness (permanent) are found in waters from gray drift.*

SURFACE WATER



Miscellaneous discharge measurement sites			
Letter key	Measurement site	Drainage area (square miles)	7-day minimum discharge 2-year recurrence interval
A	Rock Creek near Rush City	About 65	2 (cfs)
B	Rush Creek near Rush City	About 54	7 (cfs)
C	North Branch Sunrise River near North Branch	About 72	24 (cfs)
D	Valley Branch at Afton	About 18	8 (cfs)

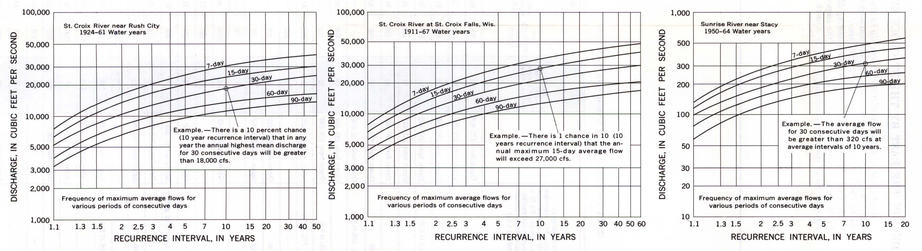
THE FLOW DIAGRAM SHOWS THE DISTRIBUTION OF STREAMFLOW IN THE WATERSHED DURING THE LOW-FLOW PERIOD AUGUST 20–22, 1969.— *Ground water and lake storage were the major sources of streamflow during a baseflow investigation August 20–22, 1969. A series of discharge measurements was made to determine the distribution of surface-water resources in the watershed within the given time interval. There was no measurable precipitation for 7 days prior to this period so the streamflow measured represents base-flow yields from the basin. Streamflow records indicated that the flow was at the 85 percent point on the daily duration curves and this will occur as the minimum 7-day flow at intervals averaging about 1.5 years.*



LOW FLOW IN THE WATERSHED IS SUSTAINED BY DISCHARGE FROM LAKES, SPRINGS, AND GLACIAL DEPOSITS OF SAND AND GRAVEL.

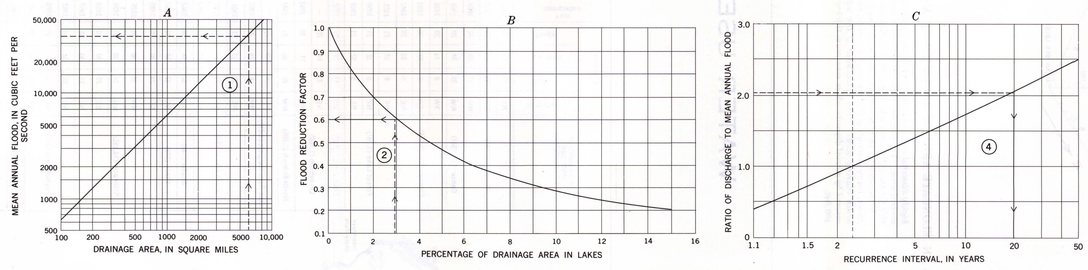
The duration and occurrence of low streamflow are considered in the design of a water supply, pollution abatement study, or a recreational development. Frequency curves for other sites would differ from those shown because of variations in surficial geology or basin characteristics.

The 7-day minimum discharges recurring every 2 years on the average for sites with small drainage areas can be compared by referring to the table listing miscellaneous discharge measurement sites.



HIGH FLOWS ARE LARGELY FROM SNOWMELT, AUGMENTED AT TIMES BY SPRING RAINS; HOWEVER, HIGH FLOWS OF SHORT DURATION MAY OCCUR AT ANY TIME AS A RESULT OF INTENSE STORMS.

High flows are not a serious problem on the St. Croix River due to the high valley banks. However, flooding does occur at communities on Lake St. Croix. The wide areal distribution of lakes in the basin helps to retard high flows on most of the tributaries.



FREQUENCY AND MAGNITUDE OF FLOODING IS RELATED TO DRAINAGE AREA AND PERCENTAGE OF BASIN IN LAKES.

Small drainage basins with little surface storage allow rapid runoff, resulting in relatively high peak flows of short duration. Larger basins with greater storage provided by lakes and swamps retard surface runoff, resulting in peak flows of lower magnitude and longer duration.

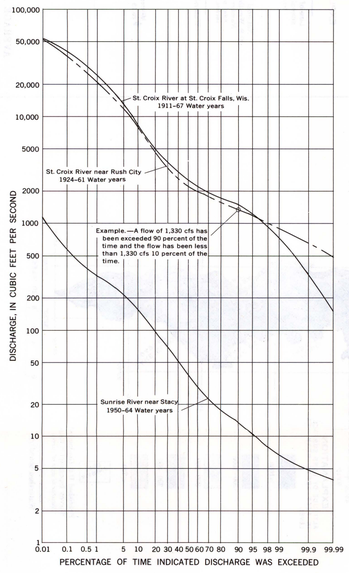
The magnitude and frequency of floods can be determined from the above relation curves (Patterson and Gamble, 1968). Curves A, B, and C apply only to streams within the watershed.

E X A M P L E

Find the recurrence interval of a flood of 43,000 cfs for the St. Croix River near St. Croix Falls, Wisconsin. The drainage area is 5,930 sq mi, and the area of lakes above the site is approximately 2.9 percent of the total drainage area.

1. *Relation curve "A" shows that for a drainage area of 5,930 sq mi, the discharge for the mean annual flood is 35,000 cfs.*
2. *Relation curve "B" shows that for a site whose drainage area is 2.9 percent lakes, the flood reduction factor is 0.60, and the discharge for the adjusted mean annual flood is 35,000 × 0.60, or 21,000 cfs.*
3. *The ratio of a flood of 43,000 cfs to the adjusted mean annual flood or 21,000 cfs is 43,000/21,000, or 2.05.*
4. *Entering the frequency curve "C" with the ratio of 2.05 shows that the flood with a discharge of 43,000 cfs will occur on an average once every 20 years.*

The magnitude of a flood at a specified recurrence interval at this same site can also be found by reversed procedure.



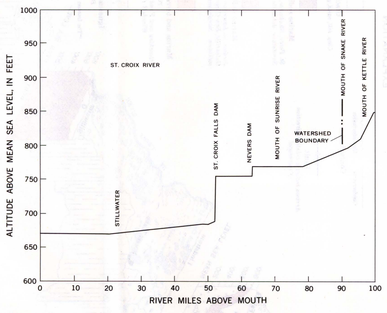
FLOW DURATION CURVES OF STREAMS IN THE LOWER ST. CROIX WATERSHED CAN BE USED TO DETERMINE STREAMFLOW AND BASIN CHARACTERISTICS.— *The upper end of the curve is indicative of high flows and shows the storage character of the basin; the flatter the slope, the greater the storage. The slope of the tail, or lower end, of the curve is the result of basin geology and storage; the flatter the slope, the greater the storage. High flows are closely related to drainage area and this can be seen in the ratio of 50 to 1, both in discharge and area, between the St. Croix River and the Sunrise River. The flat slopes of these curves also denote good natural storage in the lakes, swamps and ground-water reservoirs within the basin. The low end of the curve for St. Croix River Falls does not mean a decrease in natural storage when compared with the station at Rush City, but rather the effects of regulation from a power plant ½ of a mile upstream.*

[Data obtained from Minnesota Department of Natural Resources.]

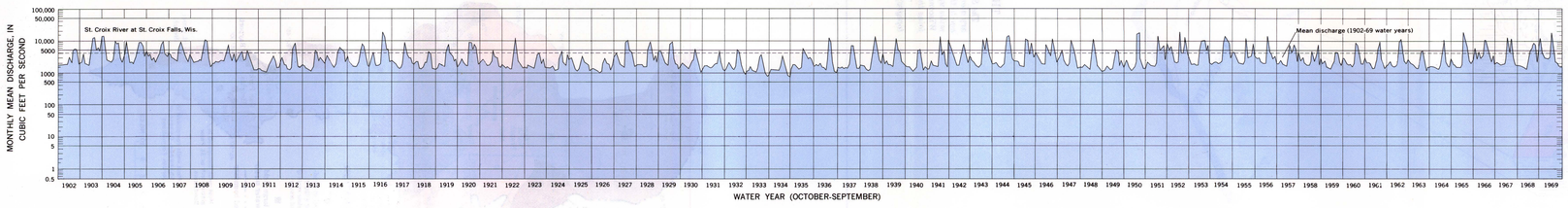
Name (County)	Surface area (acres)	Depth (feet) Maximum	Depth (feet) Median or average	Outlet control	Fish and game classification	Remarks
Coon (Anoka)	1,507	25	5	Dam	Bass, panfish, walleye, northern pike	Has public access Occasional winterkill Stocked recently with walleye fingerlings and northern pike fry
Linwood (Anoka)	567	45	11	Dam	Largemouth bass, panfish	Has public access Shoreline soils are 90 percent firm sand Stocked recently with walleye and northern pike fry
Rice (Anoka)	633	8	3	Dam	Waterfowl, bullhead	Has public access Periodic winterkill Shoreline soils are 85 percent firm sand
Chisago (Chisago)	930	27	7	—	Bass, panfish, northern pike	Has public access Stocked recently with northern pike yearlings and walleye fry
Green (Chisago)	1,830	29	9	—	Walleye, largemouth bass, panfish, northern pike	Stocked recently with walleye fingerlings and northern pike and bass adults
Goose (Chisago) Upper Lower	710	9 55	6 15	Natural	Bass, panfish, northern pike	Winterkill in upper portion Occasional removal of rough fish Stocked recently with sunfish
North Center (Chisago)	760	44	7	—	Bass, panfish, northern pike	Has winterkill Stocked recently with walleye fry
Rush (Chisago) East West	3,170	22 40	8 15	Natural	Walleye, bass, sunfish	Has public access Occasional removal of rough fish Stocked recently with muskellunge fingerlings
South Center (Chisago)	913	110	8	—	Walleye, bass, panfish, northern pike	Has public access Stocked recently with walleye and northern pike fingerlings
South Lindstrom (Chisago)	664	27	12	—	Bass, panfish, northern pike	Has public access Stocked recently with walleye fingerlings
Sunrise (Chisago)	810	21	4	—	Waterfowl, muskrat	Periodic winterkill Rough fish removed recently
Sunrise Pools (Chisago)	2,354	10	5	Dam	Waterfowl, muskrat	Periodic winterkill Rough fish abundant
Big Marine (Washington)	1,577	56	—	—	Northern pike, bass, walleye, panfish	Has public access Stocked recently with walleye fry and fingerlings
Forest (Washington)	2,206	40	10	Dam	Bass, panfish, northern pike	Has public access Stocked recently with walleye fingerlings and northern pike yearlings
St. Croix (Washington)	*3,990	78	—	—	—	Has public access Interstate waters and control

* Only that part in Minnesota, 4,180 acres in Wisconsin.

LAKES AND STREAMS IN THE WATERSHED ARE AN IMPORTANT ALL-SEASON RECREATIONAL RESOURCE.— *Lake levels are relatively stable, being maintained by ground-water contribution. Opportunities exist for hunting, fishing, water sports, and general vacation uses. Ice fishing is a major winter sport and extends the recreational use of lakes to the winter months. Although little consumptive use is made of surface water, it is potentially a valuable source for water supply.*



THE PROFILE OF THE LOWER ST. CROIX RIVER SHOWS A DROP OF 180 FEET.— *Over 60 feet of this drop is utilized by a hydroelectric plant at St. Croix Falls. The river is navigable from its mouth to St. Croix Falls, a distance of 52 river miles. A 9-foot channel is maintained to Stillwater. From Stillwater upstream to St. Croix Falls a 3-foot channel is maintained.*



FLUCTUATIONS IN STREAMFLOW ARE CAUSED BY VARIATIONS IN PRECIPITATION AND TEMPERATURE.— *Generally, the highest stream flow is in the spring followed by a recession through the late summer, fall, and winter months. Even though the flow of the St. Croix River at St. Croix Falls is regulated by a power plant, the monthly flows are only slightly affected. The highest monthly mean discharge was in April 1952. The lowest monthly mean discharge was in August 1934. The drought of the 1930's caused the longest extended period of low streamflow.*

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1974

WATER RESOURCES OF THE LOWER ST. CROIX RIVER WATERSHED, EAST-CENTRAL MINNESOTA

By
G. F. Lindholm, J. O. Helgesen, W. L. Broussard, and D. F. Farrell

1974