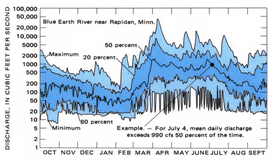
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

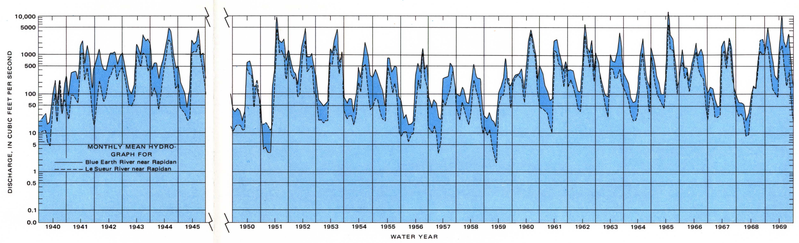
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-525 (SHEET 3 OF 3)

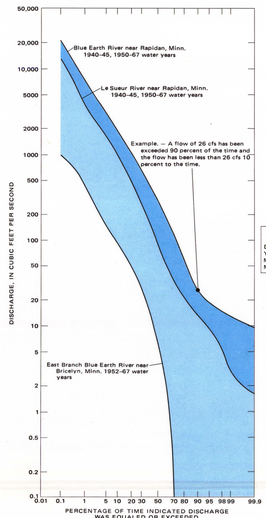
SURFACE WATER



THE VARIATION OF DAILY MEAN DISCHARGE FOR EACH DAY AND THE SEASONAL VARIATION OF DAILY MEAN DISCHARGE FOR A 19-YEAR PERIOD IS SHOWN BY THE DAILY DURATION HYDROGRAPH.—*The smallest range and the most uniform daily mean discharge occurs at the end of January and the beginning of February. Flows were lowest during October and highest during April.*

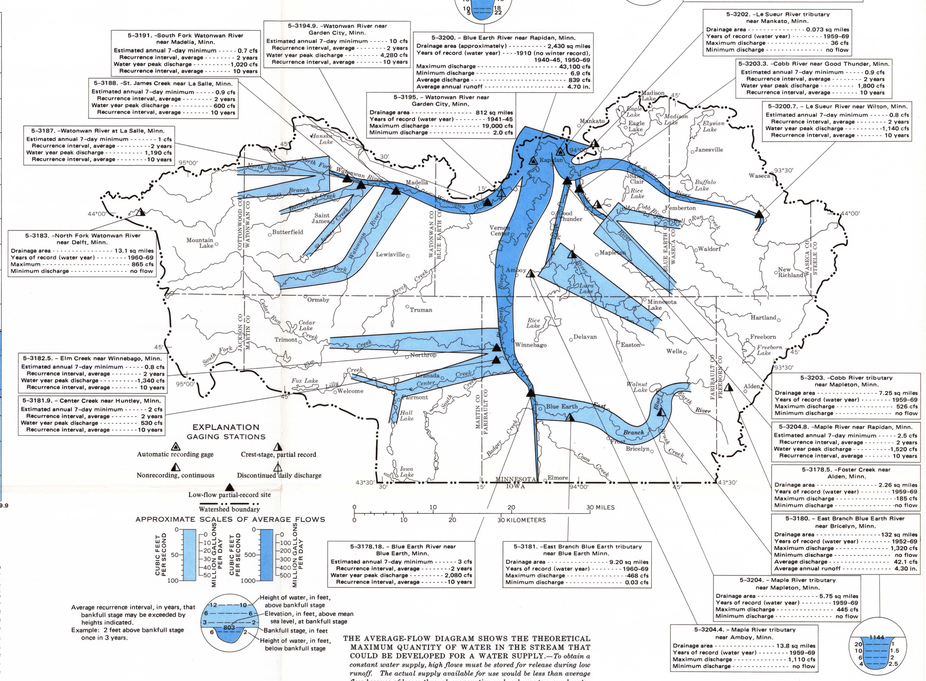


FLUCTUATIONS IN STREAMFLOW ARE CAUSED BY VARIATIONS IN PRECIPITATION AND TEMPERATURE.—*Generally, streamflow is highest in the spring and recedes through the late summer, fall, and winter. The highest monthly mean discharge recorded was in the 1965 water year, for both the Blue Earth and Le Sueur Rivers. Monthly mean discharge of the Blue Earth River was lowest during the 1951 water year, whereas that of the Le Sueur River was lowest during the 1959 water year.*



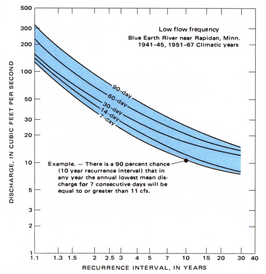
FLOW DURATION CURVES IN THE BLUE EARTH WATERSHED CAN BE USED TO DETERMINE STREAMFLOW AND BASIN CHARACTERISTICS.—*A curve with a steep slope throughout denotes a highly variable stream whose flow is largely from direct runoff, whereas a curve with a flat slope reveals the presence of either surface-water or ground-water storage, which tends to equalize the flow. The distribution of low flows is controlled chiefly by the geology. Thus, the lower end of the flow-duration curve is a valuable means for studying the effect of geology on ground-water runoff to a stream. East Branch Blue Earth River near Brice lyn includes little or no natural storage. Blue Earth River near Rapidan and Le Sueur River near Rapidan are both similar in characteristics throughout their range except the extreme low end, where the operation of Rapidan Reservoir gives the curve for Blue Earth River a slightly flatter slope.*

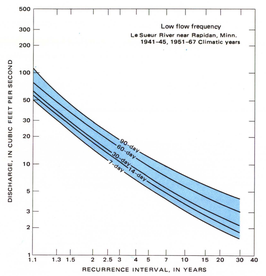
Duration curves may be used to estimate the percentage of time specified discharge will be equaled or exceeded in the future. By subtraction, the percentage of time that flow may be equal to or less than a specified amount may also be estimated. However, the curve does not show how frequently or the number of consecutive days during that period of time discharges of a lesser magnitude will occur.



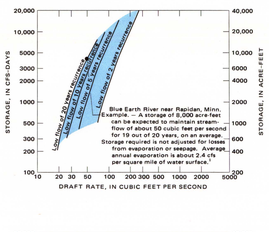
THE AVERAGE-FLOW DIAGRAM SHOWS THE THEORETICAL MAXIMUM QUANTITY OF WATER IN THE STREAM THAT COULD BE DEVELOPED FOR A WATER SUPPLY.—*To obtain a constant water supply, high flows must be stored for release during low runoff. The actual supply available for use would be less than average flow because of losses through evaporation and recharge to ground-water bodies. High flows usually occur in the spring, as a result of snowmelt and high rainfall. The watershed has a well-integrated drainage system and deeply incised stream valleys, which tend to cause high flows of short duration. The stage-frequency diagrams show the height and frequency of flooding and may be used in conjunction with a topographic map to determine areas of flood inundation above the gaging stations.*

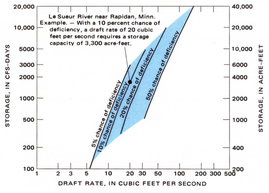
LOW FLOW





LOW FLOWS ARE LARGELY DISCHARGE FROM THE GROUND-WATER SYSTEM.—*Low-flow-frequency curves show the average interval at which a specific discharge may be expected to recur as the lowest discharge in the climatic year (April 1 to March 31) and the maximum number of consecutive days during which the flow would be equal to or less than a specified discharge. They represent the potential capability of a stream, and they can be used to predict the probabilities of low stream flows, assuming no change in 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 miscellaneous-discharge-measurement sites on the average flow map.*





THE APPROXIMATE STORAGE REQUIRED TO MAINTAIN SPECIFIED STREAMFLOW FOR LOW FLOWS OR VARIOUS RECURRENCE INTERVALS IS SHOWN BY THE CURVES.—*Low streamflow can be increased by release of water stored during periods of high flow. The curves were computed from streamflow records of the Blue Earth and Le Sueur Rivers near Rapidan. These curves are not applicable to a drought as severe as that of the 1930's.*

[1]Evaporation computed from data published in Technical Paper No. 37, Evaporation Maps for United States, National Oceanic Atmospheric Administration.

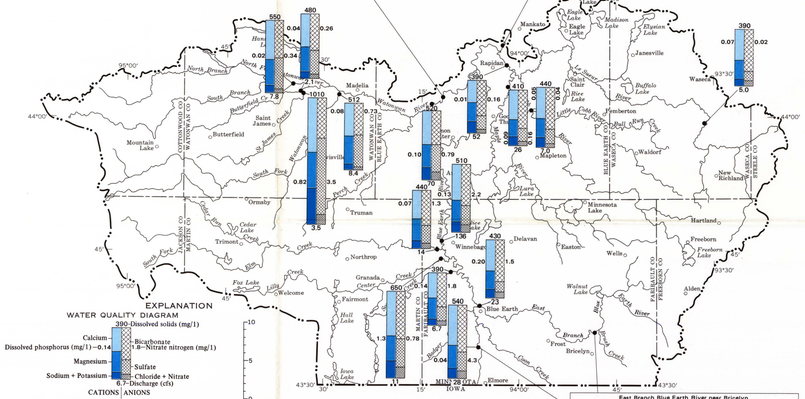
WATER QUALITY

Watonwan River, 1 mile west of Garden City
11 measurements made in 1969

	Maximum	Minimum	Median
Total Coliform (most probable number)	14,000	170	3,300
Fecal Coliform (most probable number)	7,900	20	490
Dissolved Oxygen (percent saturation)	130	43	87
Temperature (degrees Celsius)	27	0	9
Biochemical Oxygen Demand (milligrams per liter)	5.3	0.8	4
Total Phosphorus (milligrams per liter)	.4	0.16	.24
Total Nitrogen (milligrams per liter)	9.6	2	5.6

Blue Earth River at Sibley Park in Mankato
22 measurements made during calendar years 1969 and 1970

	Maximum	Minimum	Median
Total Coliform (most probable number)	490,000	1,400	16,000
Fecal Coliform (most probable number)	230,000	80	4,000
Dissolved Oxygen (percent saturation)	129	44	90
Temperature (degrees Celsius)	28	0	12
Biochemical Oxygen Demand (milligrams per liter)	23	2.5	7
Total Phosphorus (milligrams per liter)	.88	.18	.32
Total Nitrogen (milligrams per liter)	10.3	1.4	4



Blue Earth River, 4 miles south of Blue Earth
22 measurements made during calendar years 1969 and 1970

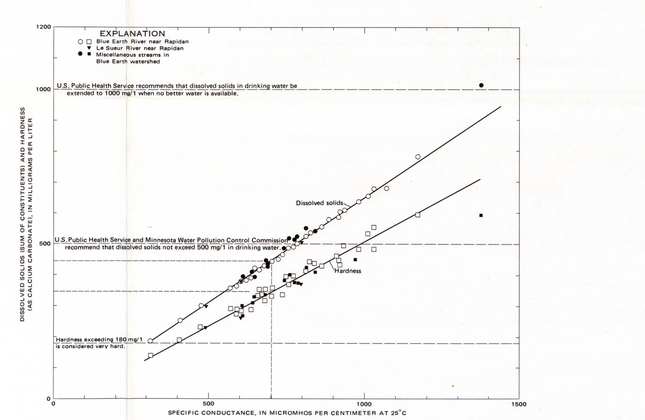
	Maximum	Minimum	Median
Total Coliform (most probable number)	240,000	790	5,000
Fecal Coliform (most probable number)	9,500	50	1,400
Dissolved Oxygen (percent saturation)	148	34	83
Temperature (degrees Celsius)	24	0	10
Biochemical Oxygen Demand (milligrams per liter)	5.9	1.5	3.5
Total Phosphorus (milligrams per liter)	.58	.09	.22
Total Nitrogen (milligrams per liter)	22	1.3	4.8

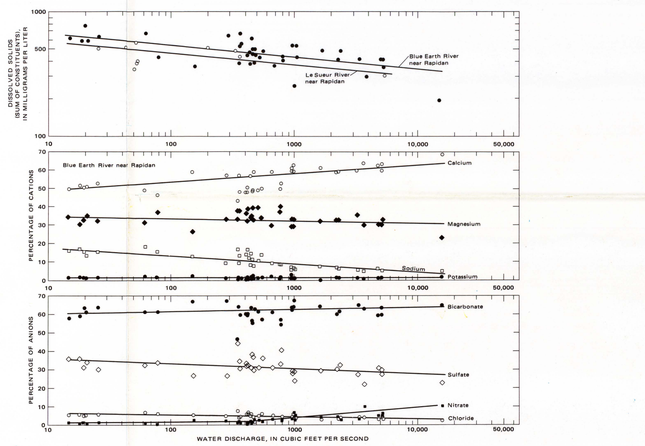
East Branch Blue Earth River near Brice lyn
21 measurements made during calendar years 1969 and 1970.

	Maximum	Minimum	Median
Total Coliform (most probable number)	950,000	790	5,400
Fecal Coliform (most probable number)	70,000	70	1,700
Dissolved Oxygen (percent saturation)	106	34	73
Temperature (degrees Celsius)	32	0	16
Biochemical Oxygen Demand (milligrams per liter)	10	1.8	4.4
Total Phosphorus (milligrams per liter)	.74	.12	.28
Total Nitrogen (milligrams per liter)	8.9	1.9	4

WATER-QUALITY MEASUREMENTS MADE AT LOW STREAMFLOW, SEPTEMBER 1969, SHOW EFFECTS OF LEACHING AND CONTRIBUTIONS OF GROUND WATER AND LAKE WATER.—*Streams draining the eastern part (Le Sueur River, its tributaries and East Branch Blue Earth Rivers)[1] the watershed contain water having a lower average dissolved solids (120 mg/l compared with 560 mg/l) and lower percentage of sulfate anions than streams draining the part west of the Blue Earth River. Water in streams receiving significant lake inflow, (Le Sueur River and Elm and South Creeks) contain a higher percentage of magnesium and lower dissolved solids than streams receiving significant ground-water inflow (St. James and Center Creeks). Most of the sodium in all streams is derived through base-exchange reactions in the glacial drift where sodium replaces other cations in the clay fraction of the drift.*

Agricultural and municipal pollution is indicated by coliform bacteria, nutrients, and biochemical oxygen demand at four sites shown on the map. Large amounts of nutrient in streams cause accelerated eutrophication and dissolved oxygen saturation during heavy rainfall periods in spring and summer. In contrast, organic loading of streams causes dissolved oxygen depletion under ice cover in winter and during low-flow conditions in spring and summer. Coliform bacteria in streams frequently exceed the maximum population allowed by the Minnesota Pollution Control Agency (1,000 most probable number per 100 ml) for water bodies used for recreation.





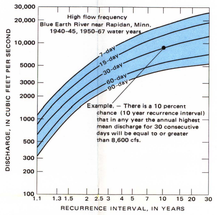
ESTIMATES OF DISSOLVED SOLIDS AND HARDNESS IN WATER FROM THE BLUE EARTH RIVER NEAR RAPIDAN CAN BE MADE BY MEASURING SPECIFIC CONDUCTANCE.—*A specific conductance of 700 micromhos is characteristic of water having a dissolved solids of 440 mg/l and a hardness of 340 mg/l. Even though surface water is of the calcium magnesium bicarbonate type, water entering streams from shallow ground water at low-flow conditions contains increased percentages of sodium and sulfate. Nitrate percentages are increased by overland runoff.*

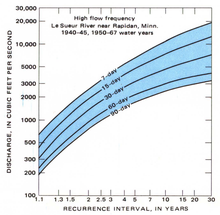
LAKES

NAME (County)	SURFACE AREA (acres)	DEPTH (feet) Maximum	DEPTH (feet) Median or average	OUTLET CONTROL	FISH AND GAME CLASSIFICATION	REMARKS
Eagle (Blue Earth)	1,183	13.5	4.5	Natural	Waterfowl and muskrat Rough fish Stocked with surplus bullheads and crappies	Hard sand bottom covered by ooze Has winterkill
Lura (Blue Earth)	1,263	7	5	No surface outlet	Semipermanent waterfowl Rough fish Stocked with crappies, sunfish, and bullheads	Has winterkill
Madison (Blue Earth)	1,345	59	15	Dam	Northern pike, bass, panfish, and rough fish	
Rice (Blue Earth)	508	3	1.5	Dam	Waterfowl and muskrat Rough fish	Duck food supply adequate Silt bottom Vegetation covers most of shoreline Has winterkill
Minnesota (Faribault)	1,915	4	2	Dam	Waterfowl and muskrat Rough fish Stocked with crappies and bullheads	Has winterkill
Rice (Faribault)	1,166	6	3.5	Dam	Waterfowl and muskrat Rough fish Stocked with bullheads	Has winterkill
Walnut (Faribault)	827	3	2	Dam	Wetlands, waterfowl, muskrat Stocked with bullheads	Silt bottom
Freeborn (Freeborn)	2,222	3	1.3	Dam	Waterfowl and muskrat Stocked with crappies	
Cedar (Martin)	732	6	-----	Dam	Marginal rough fish lake Not stocked	Has winterkill
Fox (Martin)	967	20	-----	Dam	Rough fish Stocked with northern pike, walleyes, crappies, and sunfish	
Hall (Martin)	552	10	6	Elevation controlled by Lake George	Rough fish and crappies Periodically stocked with pike, walleyes, bass, crappies, and sunfish	
Iowa (Martin)	732	9	-----	Dam	Rough fish Stocked with pike, walleyes, and crappies	210 acres in Iowa Has winterkill
Buffalo (Waseca)	895	5	1 to 3	Natural	Waterfowl and muskrat	
Elysian (Waseca)	2,462	13	7	Dam	Rough fish and bullhead Stocked with walleye and sunfish	Has winterkill
Wood (Watonwan)	1,844	4.3	2.8	Dam	Waterfowl and muskrat No fish stocked	Hard sand bottom covered by soft mud
Hanska (Brown)	1,844	7.5	4.5	Dam	Waterfowl Periodically stocked with pike, walleyes, and crappies. Rough fish removed periodically	

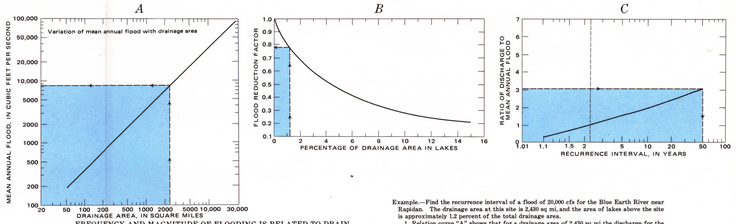
MAJOR LAKES IN THE WATERSHED ARE AN IMPORTANT RECREATIONAL ASSET AND MANY PROVIDE FISH AND WILDLIFE HABITATS.—*They are used principally for hunting, fishing, and water sports. Little use is made of the approximately 100 lakes in the area for water supply. Data shown on the table above were obtained from the Minnesota Department of Natural Resources.*

HIGH FLOW





HIGH FLOWS ARE LARGELY FROM SNOWMELT, AUGMENTED AT TIMES BY SPRING RAINS. HOWEVER, HIGH FLOWS OF SHORT DURATION MAY RESULT AT ANY TIME AS FROM INTENSE STORMS.—*High flows at the two gaging stations near Rapidan have similar frequency-duration relationships because climate and physiography of the Blue Earth watershed are uniform. Difference in drainage area for the two stations is the reason for the difference magnitudes of high flow. The curves are a necessary tool in the design of flood-control reservoirs.*

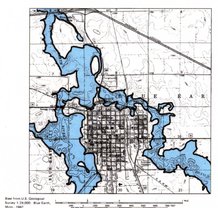


FREQUENCY AND MAGNITUDE OF FLOODING IS RELATED TO DRAINAGE AREA AND PERCENTAGE OF BASIN IN LAKES.—*Small drainage basins having little surface storage allow rapid runoff, resulting in relatively high peak flows of short duration. Larger basins having greater storage provided by lakes and swamps retard 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, 1965). Curves A, B, and C refer to streams within the watershed. These curves are not applicable to the main stem of the Minnesota River.*

Example.—Find the recurrence interval of a flood of 20,000 cfs for the Blue Earth River near Rapidan. The drainage area at this site is 2,430 sq mi, and the area of lakes above the site is approximately 1.2 percent of the total drainage area.

1. Relation curve "A" shows that for a drainage area of 2,430 sq mi the discharge for the mean annual flood is 9,400 cfs (cubic feet per second).
2. Relation curve "B" shows that for a site whose drainage area is 1.2 percent lakes the flood-reduction factor is 0.75, and the discharge for the adjusted mean annual flood is $9{,}400 \times 0.75$, or 6,550 cfs.
3. The ratio of a flood of 20,000 cfs to the adjusted mean annual flood of 6,550 cfs is $20{,}000/6{,}550$, or 3.06.
4. Entering the frequency curve "C" with the ratio of 3.06 shows that a flood with a discharge of 20,000 cfs will occur on an average once every 50 years.

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



FLOOD-PRONE AREAS AT THE CONFLUENCE OF THE EAST BRANCH BLUE EARTH AND BLUE EARTH RIVERS.—*The purpose of this flood-prone-area map is to portray to administrators, planners, and engineers concerned with future land development those areas that are occasionally flooded. No information on frequency, depth, duration, and other details of flooding is given or intended.*

Base from U.S. Geological Survey
1:250,000: Mason City and Fairmont 1954;
New Ulm and St. Paul 1953

WATER RESOURCES OF THE BLUE EARTH RIVER WATERSHED, SOUTH-CENTRAL MINNESOTA

By
H. W. Anderson, Jr., D. F. Farrell, and W. L. Broussard

1974

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