SURFACE WATER

5-510 RABBIT RIVER AT CAMPBELL, MINN.	
Drainage area	266 sq. mi.
Years of record (water year)	1942-52
Maximum discharge	1,940 cfs
Minimum discharge	no flow
Average discharge	36.0 cfs
Average annual runoff	1.84 in.

5-505 BOIS DE SIOUX RIVER NEAR FAIRMONT, N. DAK.	
Drainage area (approximate)	1,540 sq. mi.
Years of record (water year)	1919-44
Maximum discharge	1,430 cfs
Minimum discharge	no flow
Average discharge	26.8 cfs
Average annual runoff	0.23 in.

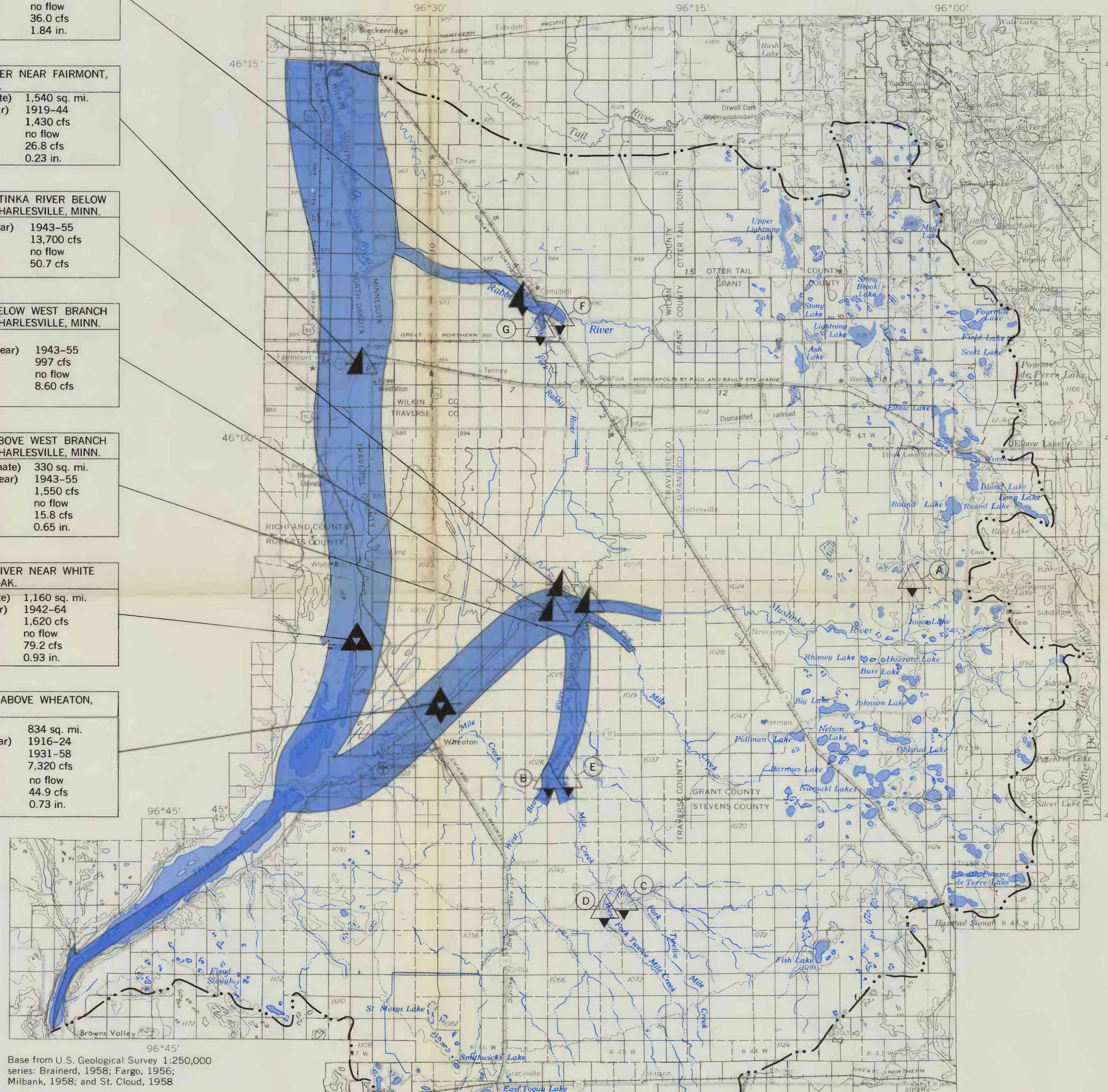
5-485 WEST BRANCH MUSTINKA RIVER BELOW MUSTINKA DITCH, NEAR CHARLESVILLE, MINN.	
Years of record (water year)	1943-55
Maximum discharge	13,700 cfs
Minimum discharge	no flow
Average discharge	50.7 cfs

5-480 MUSTINKA DITCH BELOW WEST BRANCH MUSTINKA RIVER NEAR CHARLESVILLE, MINN.	
Years of record (water year)	1943-55
Maximum discharge	997 cfs
Minimum discharge	no flow
Average discharge	8.60 cfs

5-475 MUSTINKA DITCH ABOVE WEST BRANCH MUSTINKA RIVER NEAR CHARLESVILLE, MINN.	
Drainage area (approximate)	330 sq. mi.
Years of record (water year)	1943-55
Maximum discharge	1,550 cfs
Minimum discharge	no flow
Average discharge	15.8 cfs
Average annual runoff	0.65 in.

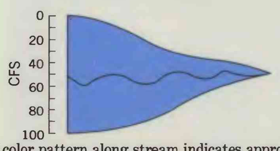
5-500 BOIS DE SIOUX RIVER NEAR WHITE ROCK, S. DAK.	
Drainage area (approximate)	1,160 sq. mi.
Years of record (water year)	1942-64
Maximum discharge	1,620 cfs
Minimum discharge	no flow
Average discharge	79.2 cfs
Average annual runoff	0.93 in.

5-490 MUSTINKA RIVER ABOVE WHEATON, MINN.	
Drainage area	834 sq. mi.
Years of record (water year)	1916-24 1931-58
Maximum discharge	7,320 cfs
Minimum discharge	no flow
Average discharge	44.9 cfs
Average annual runoff	0.73 in.



Base from U.S. Geological Survey 1:250,000 series: Brainerd, 1958; Fargo, 1956; Milbank, 1958; and St. Cloud, 1958

EXPLANATION



Width of color pattern along stream indicates approximate average flow in cubic feet per second (cfs)

GAGING STATION

Automatic recording gage

Non-recording continuous gage

Miscellaneous measurement site

CHARACTERISTICS OF GAGE

Base flow measurements

Discontinued gage

Identification of miscellaneous measurement site

Watershed boundary

LETTER KEY	MISCELLANEOUS DISCHARGE MEASUREMENT SITE	DRAINAGE AREA (SQUARE MILES)
A	Mustinka River near Elbow Lake	120
B	West Branch Mustinka River near Wheaton	200
C	Twelvemile Creek near Dumont	115
D	West Fork Twelvemile Creek near Dumont	25
E	Twelvemile Creek near Wheaton	175
F	Drainage ditch ¼ mile above Rabbit River near Campbell	100
G	South Fork Rabbit River near Campbell	60

SCALE 1:250 000

5 0 5 10 MILES

5 0 5 10 KILOMETERS

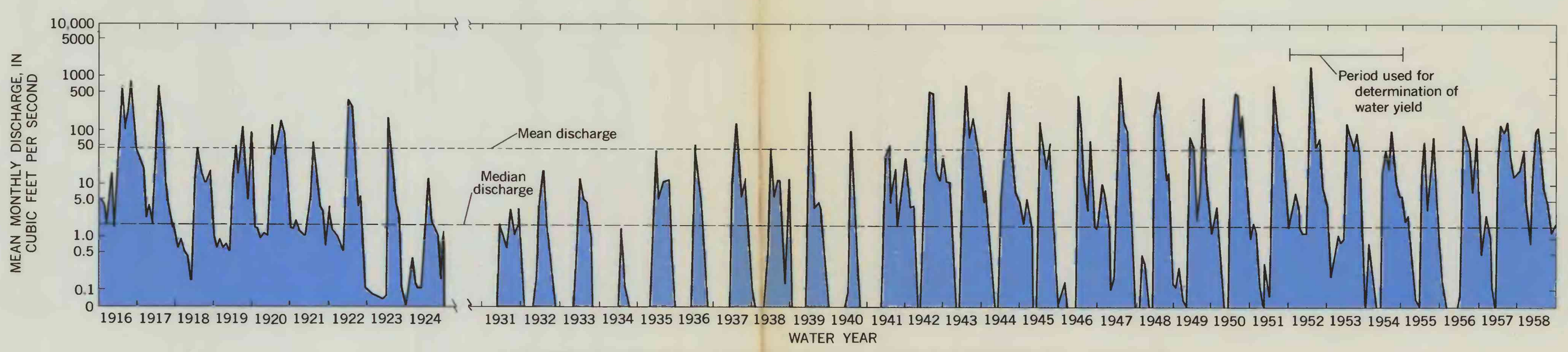
CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1968

THE AVERAGE FLOW, WHICH IS THE THEORETICAL MAXIMUM QUANTITY OF WATER THAT COULD BE DEVELOPED FOR A WATER SUPPLY, IS RELATIVELY SMALL (AVERAGE FLOW SHOWN IS FOR THE PERIOD 1931-64)

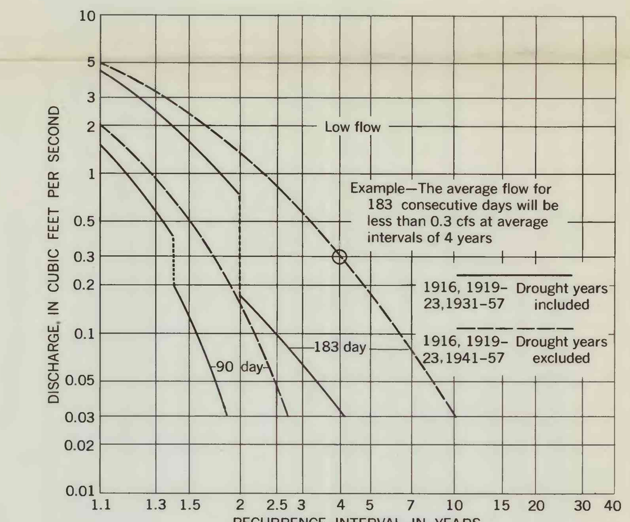
Natural streamflow is variable and provision for a constant supply requires storage of high flow. Average ground-water inflow in the valley of Traverse and Mud Lakes about equals the mean annual lake evaporation loss of 44 cfs during the 1931-64 period. This is 17 percent lower than that shown on the reservoir table because of less water surface area during the drought years and because the reservoir dams were not yet constructed. Evaporation losses in transmission below possible reservoir sites and lack of suitable reservoir sites prevent utilization of the average streamflow.

Flood peaks are reduced by natural storage in lakes and swamps located in the headwaters, by overbank storage on the lake plain due to flooding, and by storage in Traverse and Mud Lakes reservoirs



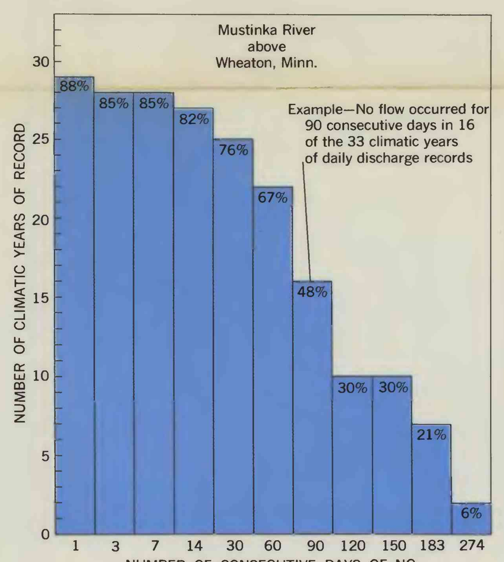
VARIATION IN MONTHLY MEAN DISCHARGE AND THE INTERMITTENT NATURE OF STREAMFLOW IN THE WATERSHED IS SHOWN BY THE HYDROGRAPH FOR THE MUSTINKA RIVER ABOVE WHEATON

Long periods of no flow occurred during the dry years of the 1930's though short periods occur most years. The lowest annual mean runoff recorded (0.19 cfs) was in the 1934 water year and the highest (177 cfs) was in the 1952 water year. The flood of April 1952 is the maximum during the period of record shown



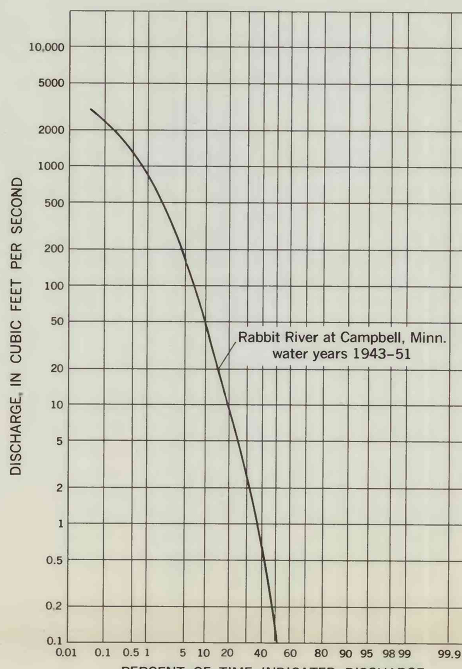
THE SEVERITY OF THE DROUGHT YEARS OF THE 1930'S IS SHOWN BY THE BREAK IN THE FREQUENCY CURVES OF THE AVERAGE LOW FLOWS FOR THE MUSTINKA RIVER ABOVE WHEATON

Frequency curves with the drought years excluded are shown for comparison.

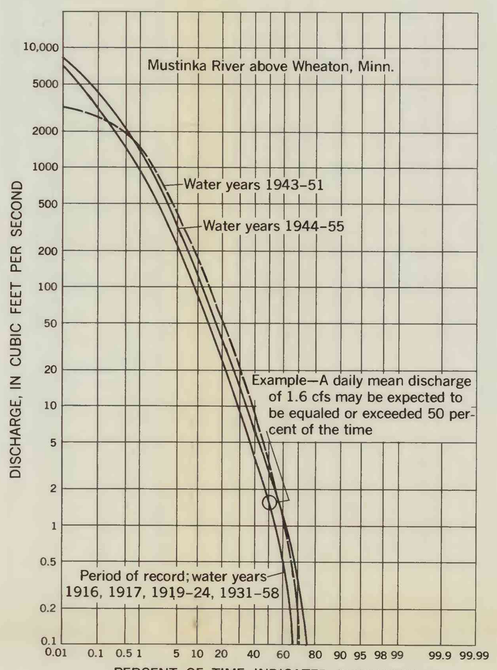


UNREGULATED STREAMS IN THE WATERSHED HAVE NO FLOW PERIODS FOR NEARLY EVERY YEAR OF RECORD

Most of the periods of 90 or more consecutive days of no flow within the period of record occurred during the drought years of the 1930's.

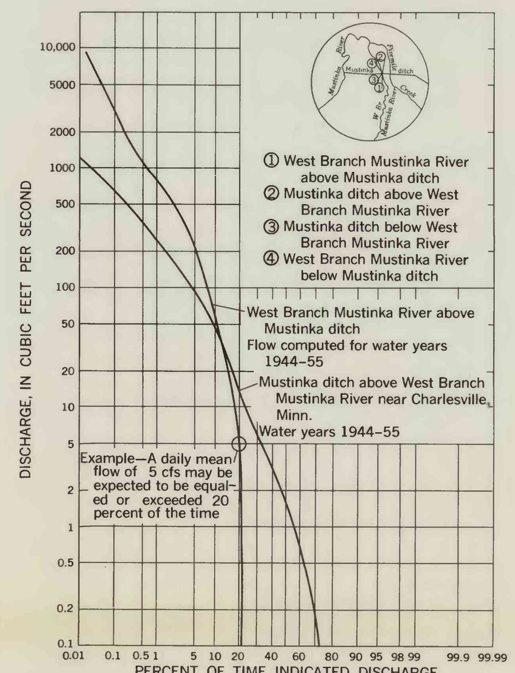


THE STEEP SLOPE OF THE DURATION CURVE FOR RABBIT RIVER AT CAMPBELL REFLECTS THE SMALL AMOUNT OF NATURAL STORAGE IN THE GLACIAL LAKE PLAIN AREA



NATURAL STORAGE IN THE MORAINAL AREA OF THE WATERSHED IS SHOWN BY THE MODERATE SLOPE OF THE DURATION CURVES FOR THE MUSTINKA RIVER ABOVE WHEATON AND CAN BE COMPARED TO THE RABBIT RIVER AT CAMPBELL FOR WATER YEARS 1943-51

In spite of the stabilizing effect of the moraine no flow occurs about 25 percent of the time.



THE SLOPES OF THE DURATION CURVES SHOW THE EFFECT ON DISCHARGE OF STORAGE IN LAKES, CHANNELS, AND GLACIAL DEPOSITS IN THE MORAINAL AREA (SITE 1) COMPARED WITH THE LACK OF STORAGE IN THE GLACIAL LAKE PLAIN (SITE 2)

Additional ditching and channel modification was completed in 1957 upstream from site 1. Thus the curve for the West Branch Mustinka River above Mustinka ditch is applicable only above County Ditch No. 42 (about 8 miles upstream) and the curve for the Mustinka ditch above West Branch Mustinka River is applicable only above Fivemile Creek.

NATURAL LAKES OCCUR IN THE MORAINAL AREA IN THE EASTERN AND SOUTHERN PARTS OF THE WATERSHED

Generally, the lakes are shallow and are excellent habitats for water-fowl, but few are suitable for fishing. Many of the lakes are subject to large changes in volume and may dry up during severe droughts. Data obtained from Minnesota Department of Conservation.

Name of Lake	Surface area (acres)	Length of shoreline (miles)	Depth (feet)		Outlet control	Composition of lake bottom	Fish and game classification	Access	Remarks
			Maximum	Median or average					
Stony Lake	164	1.7	4.0	3.6	Natural	Mostly silt	Waterfowl resting area and loafing sites good; no fish; leased by hunters	Three miles northwest of Wendall	Very hard water; dry in 1930's
Lightning Lake	519	5.1	10.5	7.0	Dam	1 foot of silt ooze over firm base	Waterfowl, furbearer lake; some winter kill of fish if heavy snow accumulates on ice	Near outlet; no designated access	Hard water; alkali lake; dry in 1930's
Worm Lake				Shallow		Old tree stumps in middle of lake (from 1930's)	No value for fish		Probably takes sewage from Elbow Lake; 4 lakes or ponds; dry in 1930's

TRAVERSE AND MUD LAKE RESERVOIRS ARE THE LARGEST AND MOST SIGNIFICANT LAKES IN THE WATERSHED

They are all-purpose reservoirs operated for flood control, water conservation, and fish and wildlife habitat. Evaporation, which averages 31 inches annually, generally exceeds inflow during the summer months.

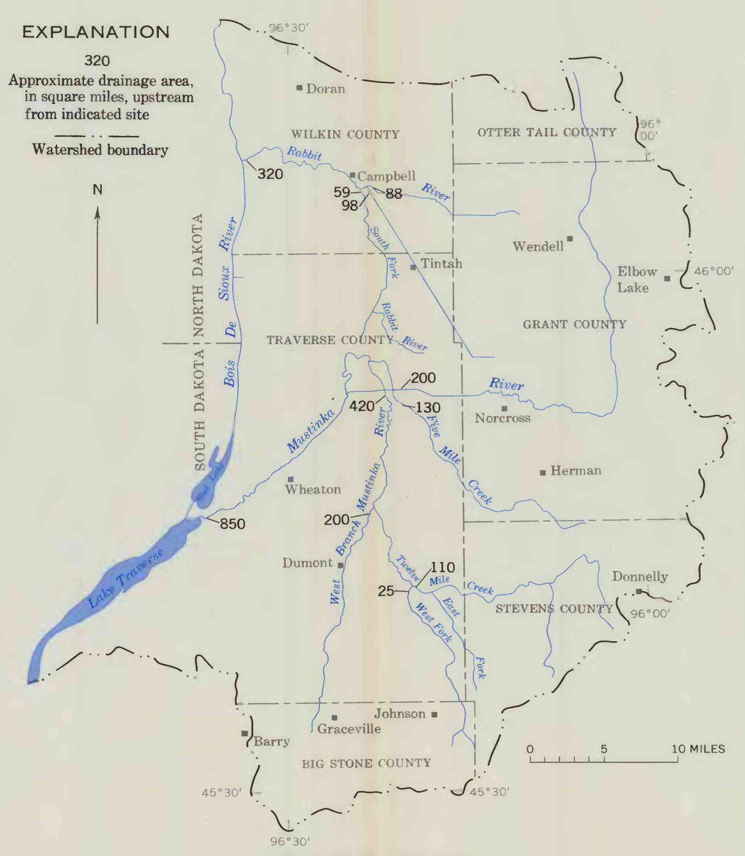
Reservoir	Year storage began[1] (calendar year)	Full pool storage capacity[1] (acre-feet)	Conservation pool[1]			Annual mean evaporation[2] (cfs)	Composition of lake bottom[3]	Type of shoreline[3]	Fish and game classifications[3]
			Storage capacity (acre-feet)	Surface area (acres)	Length (miles)				
Traverse Lake	1942	164,500	106,000	10,920	16.5	39	Silt, sand, gravel, and rubble	Mostly sand, gravel, and boulders, some muck	Migratory waterfowl resting area; rough fish predominate-some rough fish removed by State; some game fish and panfish
Mud Lake	1942	85,000	6500	3850	7.5	14	Mostly silt and root material		Migratory waterfowl resting area; marginal fish lake-winter freezeout

[1] Data obtained from Corps of Engineers, U.S. Army
[2] Mean annual evaporation computed from data published in Technical Paper No. 37, Evaporation Maps for United States, U.S. Weather Bureau
[3] Data obtained from Minnesota Department of Conservation

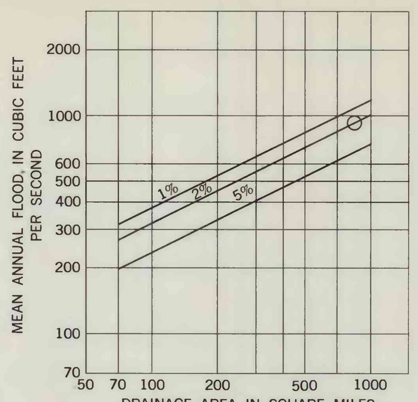
EXPLANATION

320
Approximate drainage area, in square miles, upstream from indicated site

Watershed boundary



A. DRAINAGE AREA MAP

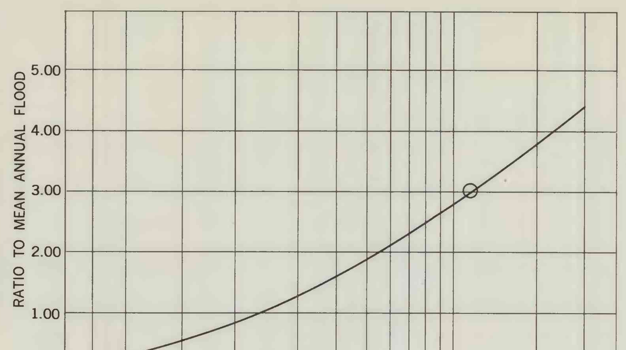


B. RELATION CURVES BETWEEN MEAN ANNUAL FLOOD, DRAINAGE AREA, AND PERCENTAGE OF LAKES

Example—Find the recurrence interval of a flood of 2,700 cfs at a site with a drainage area of 800 sq mi, of which 2% is lakes

1. The 2% curve in diagram (B) shows that for a drainage area of 800 sq mi the mean annual flood is 900 cfs
2. The ratio of the 2,700 cfs flood to the mean annual flood of 900 cfs is 2,700/900 or 3.0
3. Entering diagram (C) with a ratio of 3.0, the flood frequency curve shows that the 2,700 cfs flood will occur on an average about once every 12 years

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



C. FLOOD FREQUENCY CURVE FOR MUSTINKA–BOIS DE SIOUX WATERSHED

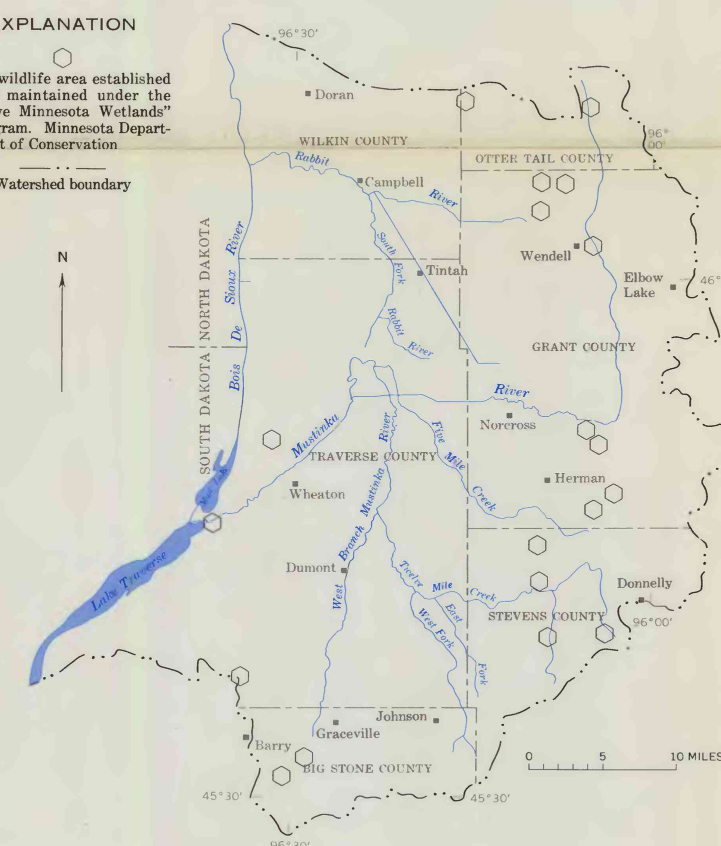
THE RECURRENCE INTERVAL OF A FLOOD OF SELECTED MAGNITUDE, OR THE MAGNITUDE OF A FLOOD AT A SPECIFIED RECURRENCE INTERVAL, CAN BE DETERMINED FROM THE DRAINAGE AREA MAP (A), RELATION CURVES (B), AND FLOOD FREQUENCY CURVE (C)

The relation curves are not applicable below Traverse and Mud Lake reservoirs because of storage of flood water. Frequency curve (C) from Prior and Hess (1961). Relation curves (B) modified for this report from same source. Most of the major floods on large drainage areas are from snowmelt and spring rains. Those on small drainage areas result from heavy local thunderstorm rainfall. Flat land surface and small capacity of natural stream channels results in channel overflow and flooding.

EXPLANATION

State wildlife area established and maintained under the "Save Minnesota Wetlands" program. Minnesota Department of Conservation.

Watershed boundary



WILDLIFE PROPAGATION AND PUBLIC HUNTING IN WETLAND AREAS ARE MAJOR USES OF SURFACE WATER IN THE WATERSHED

Nineteen State wetland wildlife management areas, shown on the map, are managed for maximum wildlife production and public hunting. The lakes and potholes in the wildlife area provide nesting, resting, and feeding areas for waterfowl, and surrounding drier marsh areas provide habitat for pheasants.

EXPLANATION

Channel modification

Reservoir dam

Browns Valley dike

Watershed boundary

THE RESERVOIRS AND CHANNEL MODIFICATION PROJECT OF THE U.S. ARMY CORPS OF ENGINEERS WAS PRIMARILY DESIGNED FOR FLOOD CONTROL

A secondary purpose of the modification is water conservation to augment low flow and preserve fish and wildlife. The reservoirs and channel modification of the Bois de Sioux River are designed to provide storage for floods of a 30-year frequency. Modification of the Mustinka River and its tributary channels is designed to provide capacity for floods of 10-year frequency. The reservoirs were completed in 1941 and storage began in 1942. Channel modifications were completed on the Bois de Sioux River in 1948 and on the Mustinka River in 1957. Information on reservoirs and channel modification was furnished by U.S. Army Corps of Engineers.

The Browns Valley dike prevents floodwaters in Lake Traverse from overflowing into the Little Minnesota River and Big Stone Lake.

Much of the lake plain is drained by ditches constructed by local interests.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1968—W67243

WATER RESOURCES OF THE MUSTINKA AND BOIS DE SIOUX RIVERS WATERSHED, WEST-CENTRAL MINNESOTA

By
R. W. Maclay, T. C. Winter, and L. E. Bidwell
1968