SURFACE WATER

Streams and lakes in the Menominee–Oconto–Peshtigo River basin and the adjacent part of Lake Michigan (Green Bay) contain abundant water of generally good quality. However, man's use of this water has altered streamflow characteristics and water quality locally. About 1,400 billion gallons of streamflow leave the basin yearly. About 43 percent of this flow originates in Michigan.

Station No. 4-0610
Brule River near Florence
Drainage area: 389 square miles
Period of record: 1914-16, 1944-present[1]
Maximum instantaneous discharge: 4,700 cfs
Minimum instantaneous discharge: 118 cfs
Average discharge, 28 years: 349 cfs
Discharge exceeded 90 percent of the time: 200 cfs

Station No. 4-0630
Menominee River near Florence
Drainage area: 1,780 square miles
Period of record: 1914-present[1]
Maximum instantaneous discharge: 19,500 cfs
Minimum daily discharge: 154 cfs
Average discharge, 54 years: 1,777 cfs
Discharge exceeded 90 percent of the time: 820 cfs

Station No. 4-0637
Popple River near Fence
(Hydrologic benchmark station)
Drainage area: 131 square miles
Period of record: 1963-present[1]
Maximum instantaneous discharge: 1,100 cfs
Minimum instantaneous discharge: 15 cfs
Average discharge, 5 years: 127 cfs
Discharge exceeded 90 percent of the time: 40 cfs

Station No. 4-0645
Pine River at Pine River power plant, near Florence
Drainage area: 528 square miles
Period of record: 1923-present[1]
Maximum daily discharge: 4,380 cfs
Minimum instantaneous discharge: 0 cfs
Average discharge, 45 years: 423 cfs
Discharge exceeded 90 percent of the time: 140 cfs

Station No. 4-0660
Menominee River near Pembine
Drainage area: 3,240 square miles
Period of record: 1949-present[1]
Maximum instantaneous discharge: 26,900 cfs
Minimum instantaneous discharge: 708 cfs
Average discharge, 19 years: 2,947 cfs
Discharge exceeded 90 percent of the time: 1,500 cfs

Station No. 4-0665
Pike River at Amberg
Drainage area: 253 square miles
Period of record: 1914-present[1]
Maximum instantaneous discharge: 2,800 cfs
Minimum instantaneous discharge: 26 cfs
Average discharge, 54 years: 216 cfs
Discharge exceeded 90 percent of the time: 100 cfs

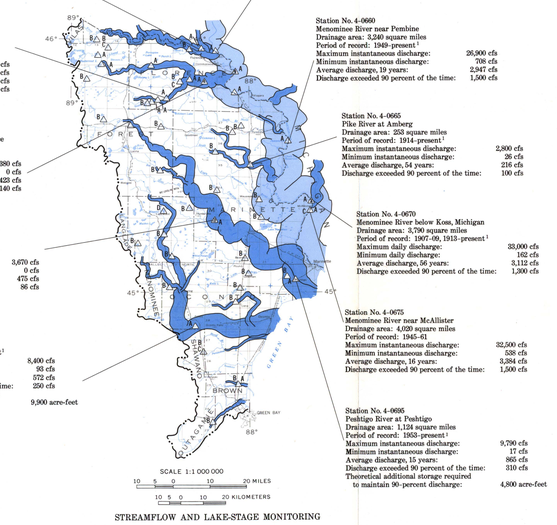
Station No. 4-0670
Menominee River below Koss, Michigan
Drainage area: 3,790 square miles
Period of record: 1907-09, 1913-present[1]
Maximum daily discharge: 33,000 cfs
Minimum daily discharge: 162 cfs
Average discharge, 56 years: 3,112 cfs
Discharge exceeded 90 percent of the time: 1,300 cfs

Station No. 4-0680
Peshtigo River at High Falls
Drainage area: 554 square miles
Period of record: 1912-57
Maximum daily discharge: 3,670 cfs
Minimum daily discharge: 0 cfs
Average discharge, 44 years: 475 cfs
Discharge exceeded 90 percent of the time: 86 cfs

Station No. 4-0675
Menominee River near McAllister
Drainage area: 4,020 square miles
Period of record: 1945-61
Maximum instantaneous discharge: 32,500 cfs
Minimum instantaneous discharge: 538 cfs
Average discharge, 16 years: 3,384 cfs
Discharge exceeded 90 percent of the time: 1,500 cfs

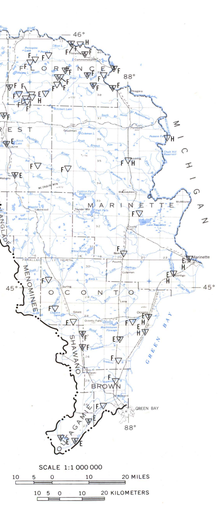
Station No. 4-0710
Oconto River near Gillett
Drainage area: 678 square miles
Period of record: 1906-09, 1913-present[1]
Maximum instantaneous discharge: 8,400 cfs
Minimum instantaneous discharge: 93 cfs
Average discharge, 57 years: 572 cfs
Discharge exceeded 90 percent of the time: 250 cfs
Theoretical additional storage required to maintain 90-percent discharge: 9,900 acre-feet

Station No. 4-0695
Peshtigo River at Peshtigo
Drainage area: 1,124 square miles
Period of record: 1913-present[1]
Maximum instantaneous discharge: 9,790 cfs
Minimum instantaneous discharge: 17 cfs
Average discharge, 15 years: 865 cfs
Discharge exceeded 90 percent of the time: 310 cfs
Theoretical additional storage required to maintain 90-percent discharge: 4,800 acre-feet

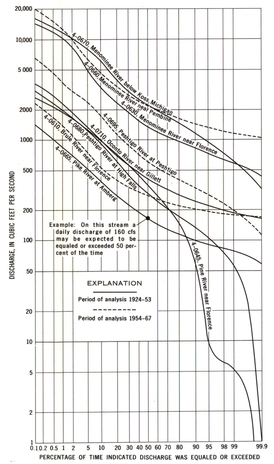


Based on data through 1968 water year

STREAMFLOW AND LAKE-STAGE MONITORING



STREAM AND LAKE WATER-QUALITY MONITORING



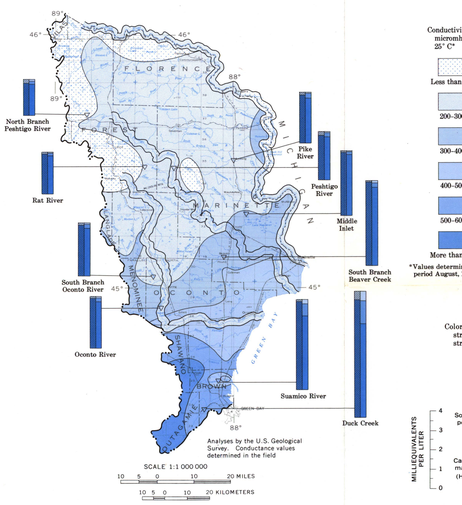
FLOW DURATION

Flow duration of a stream is affected by hydrogeologic conditions and regulation. Most streams in the basin have some regulation and have flow-duration curves of similar slope but differing magnitude commensurate with drainage area size. Examples of extreme regulation are shown by the curves for the Pine River near Florence and the Peshtigo River at High Falls, where dams temporarily caused streamflow to cease.

SURFACE-WATER QUALITY

Surface water in the basin is generally of good quality and is suitable for most purposes. Surface water is commonly very hard, >180 mg/l hardness as $CaCO_3$, but this does not restrict the use of water for recreation or most industries. The quality of water in Green Bay is similar to most surface water in the basin, although the water is harder and contains some pollution (Federal Water Pollution Control Administration, 1966, p. 6–1). Green Bay is used as the source of municipal water for the city of Marinette.

Pollution of surface water in the basin is not a severe problem, although the water quality of some reaches of streams has been degraded (Wisconsin Department of Natural Resources, written commun.,1969).



SURFACE-WATER QUALITY DURING LOW FLOW

Specific conductance of streamflow during the low-flow period (Aug. 12–14, 1969) ranged from 120 to 775 micromhos. The conductance of water at a point in a major stream is influenced by the sum of all quality effects upstream rather than conditions in small tributaries adjacent to that point.

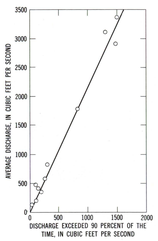
Specific conductance of water is related to total mineralization of the water (dissolved solids). In the basin conductance can be related to dissolved solids by the equation:

Dissolved solids = specific conductance × 0.67

This relationship is used in the diagram above to show approximate dissolved-solids concentrations.

The chemical quality of streamflow sampled largely reflects groundwater quality, which varies with hydrogeology throughout the basin. The least mineralized streamflow occurred in the northwestern, northern, and central parts of the basin where ground water moves rapidly through highly permeable outwash and ice-contact deposits associated with end moraine, and where the low-flow yield per square mile is high. Streamflow is more mineralized in the southern and southeastern parts of the basin where ground water moves slowly through ground moraine and clayey lake deposits. Also, low flow in this area may contain water that has been in contact with dolomite bedrock.

The water during low flow, as shown above by bar graphs, is basically a calcium magnesium bicarbonate type. Sodium, sulfate, and chloride concentrations are relatively low. The high sulfate content of the water in Duck Creek may be due to the influence of mineralized dolomite in the Galena-Platteville unit (sheet 2).

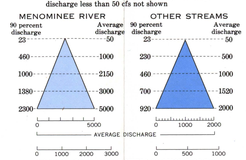


RELATION BETWEEN AVERAGE DISCHARGE AND 90 PERCENT DISCHARGE

Streamflow, including flood flow and low flow, and a lake-stage fluctuation are or have been monitored at 56 sites in the basin. Streamflow is continuously monitored at nine sites. Continuous records exist for 11 other sites where streamflow measurements have been discontinued. Intermittent measurements of low flow and periodic measurements of flood flow are measured at 29 and six sites, respectively. The stage of Wheeler Lake is measured periodically.

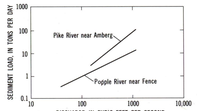
The average-discharge pattern represents amounts that would yield continuous, unvarying (and hypothetical) flow through the period of record. The 90-percent duration scale is included because it correlates well with average flow at gaging stations (see adjacent graph). The 90-percent scale is probably least accurate in the south (see low flow).

Additional sites for storage reservoirs provide an opportunity for increased regulation of streamflow if the need arises. Estimates of additional storage on the Peshtigo and Oconto Rivers required to maintain a 90-percent discharge are presented above for stations 4-0695 and 4-0710. These estimates are not adjusted for evaporation losses. An estimate was not made for the Menominee River because its flow is already highly regulated.



Measurement site symbol*	Parameter measured	Frequency of measurement
A △	Stream discharge	Continuous
B △	Low-flow stream discharge	Intermittent
C △	Flood-flow stream discharge	Periodic
D △	Lake stage	Periodic
E ▽	Chemical quality	Monthly
F ▽	Chemical quality	Intermittent
H ▽	Sediment	Intermittent

*Letter to left indicates present measurement; letter to right indicates discontinued measurement. Number in center indicates operating agency: 1, Wisconsin Department of Natural Resources; 2, U.S. Bureau of Commercial Fisheries; 3, Wisconsin Public Service Commission; 4, Wisconsin-Michigan Power Company; 5, Northeastern Wisconsin Regional Planning Commission. All others, U.S. Geological Survey.



STREAM SEDIMENT LOAD RELATED TO DISCHARGE

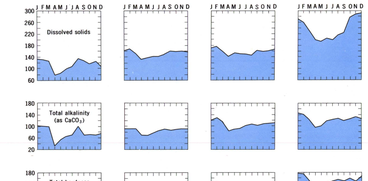
The capacity of a stream to carry sediment depends upon stream velocity and discharge, but the actual sediment load depends also upon the availability of sediment. The peak concentration of sediment usually occurs during storm runoff, shortly before the stream reaches peak discharge.

The graph above shows the suspended sediment load related to discharge, based on samples from two streams in the basin. The relationship is only approximate; for example, at a discharge of 100 cfs the Popple River near Fence has been measured carrying 0.28 ton per day at one time and 2.5 tons per day at another.

Streams in the basin have among the lowest sediment yields of any streams in the State. Hindall and Flint (1970) report that the Popple River near Fence and the Pike River near Amberg carry less than 10 tons of sediment per square mile of drainage area per year. These streams, in the northern part of the basin, are located in a forested region of end moraines and outwash where soils have high infiltration capacities. Farther south in the basin, in an agricultural area of ground moraine and glacial lake deposits, the sediment yields of streams are 20–40 tons per square mile per year (Hindall and Flint, 1970). This range still represents relatively low sediment yields.

Reservoirs may be a factor contributing to low sediment yields in major streams in the basin because they trap sediment.

Stream sediment is not a major problem in the basin, nor does it currently diminish the usefulness of stream water for fish and wildlife or industrial needs.

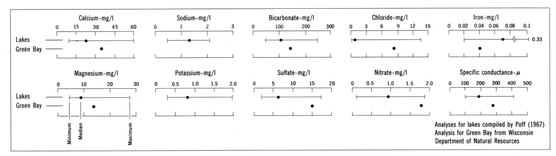


RELATIONSHIP OF SURFACE-WATER QUALITY TO DISCHARGE

The average chemical quality of stream water varies regionally and with discharge. Dissolved solids, total alkalinity, and total hardness vary directly with each other but generally inversely with flow. Natural chloride concentrations vary inversely with flow. Chloride concentrations in the Oconto River may be the result of municipal or industrial wastes. Natural biochemical oxygen demand (BOD) concentrations do not fluctuate appreciably annually; in streams receiving municipal or industrial wastes, BOD concentrations, which express an oxygen requirement, vary directly with certain waste concentrations. Natural dissolved oxygen varies inversely with water temperature. In streams receiving a relatively constant input of wastes, BOD concentrations vary directly with discharge.

Color in stream water is the result of decayed organic matter, mostly vegetable. The higher color concentrations in late spring and early summer may represent a washing of dead vegetation into the streams by rain.

Water quality of the Popple, Menominee, Peshtigo, and Oconto Rivers are compared and contrasted on these graphs. The Popple River is unaffected by man's activities or development. A hydrologic benchmark station has been established on this river, near Fence, so that the quality of all other streams in and out of the basin may be compared to the water quality at this site. Water quality of the Menominee River at Marinette and the Peshtigo River at Peshtigo compare very closely with the Popple River near Fence. The Menominee River receives some municipal and industrial wastes far upstream. However, the effect of these wastes is not indicated by the analyses at the downstream sampling site. The presence of municipal and industrial wastes in the Oconto River analyses is indicated by the relatively high dissolved solids (mineralization), chloride, and BOD concentrations, and by the relatively low dissolved oxygen concentration.

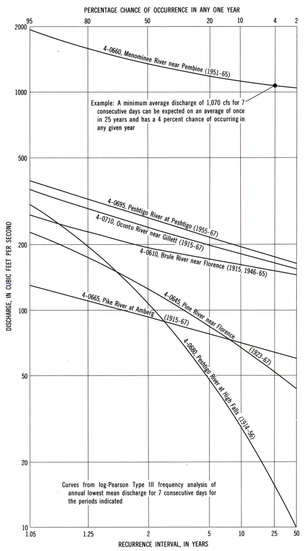


QUALITY OF LAKE WATER

This diagram shows the range of mineralization in lakes within the basin and in Green Bay. Water in lakes is less mineralized than water in the ground (sheet 2).

Some lakes show evidence of contamination. The maximum values for chloride and nitrate concentrations may indicate septic-tank effluent from lakeshore development. There are no lakes within the basin that receive inflow from streams transporting municipal or industrial wastes.

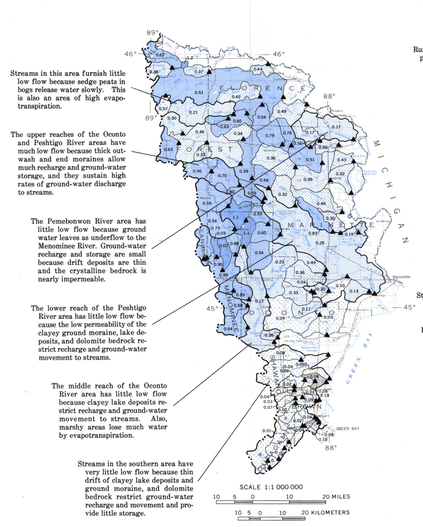
LOW FLOW



LOW-FLOW FREQUENCY

A knowledge of low flow of a stream is necessary to determine the adequacy of streamflow for minimum supply needs, to maintain reservoir storage, to estimate ground-water discharge, and to estimate a stream's capacity to dilute and transport waste.

Low flows represent the discharge of ground water or the gradual release of water from impoundments. As with the flow-duration curves, the curves for the Pine River near Florence and the Peshtigo River at High Falls indicate regulation during the period for which the curves were constructed, and they show extremely low discharges for long recurrence intervals. The remaining curves are nearly parallel and indicate similar streamflow characteristics. The arrangement of the curves from low to high on the graph is commensurate with the drainage area of a stream above the gaging site.



RUNOFF PATTERN DURING LOW FLOW AUGUST 12-14, 1969

Large differences in the amount of streamflow per unit area from subbasins occur during periods of low flow. The differences are the result of differences in geology, evapotranspiration, and drainage-system controls. Ninety-five discharge measurements were made during August 12–14, 1969, when streamflow was sustained by the slow release of water from storage (about 90 percent on the flow-duration curves). Streamflow is presented on the map above as runoff per square mile to aid in comparing contributions from individual subbasins. The runoff per square mile for a subbasin is an average for the area and does not typify every place within the subbasin.

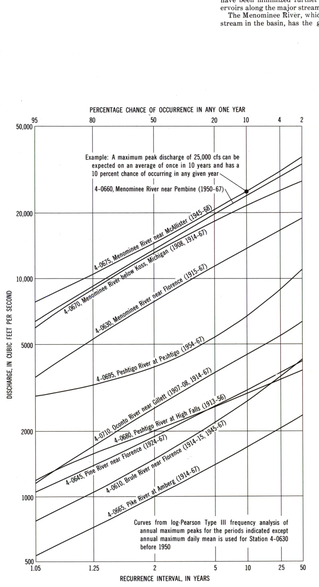
Runoff from subbasins ranged from -0.04 (a net loss) to 1.3 cfs per square mile. Median streamflow for the 95 subbasins during August 12–14, 1969, was 0.33 cfs per square mile.

FLOOD FLOW

The Menominee-Oconto-Peshtigo River basin is an area of low flood risk because of extensive vegetative cover, generally high soil infiltration rates, and little development of flood plains. Damages due to floods have been minimized further by an extensive series of dams and reservoirs along the major streams.

The Menominee River, which has the greatest average flow of any stream in the basin, has the greatest flood discharge. Stages above bank full on the Menominee River recur more frequently than on the other, smaller streams.

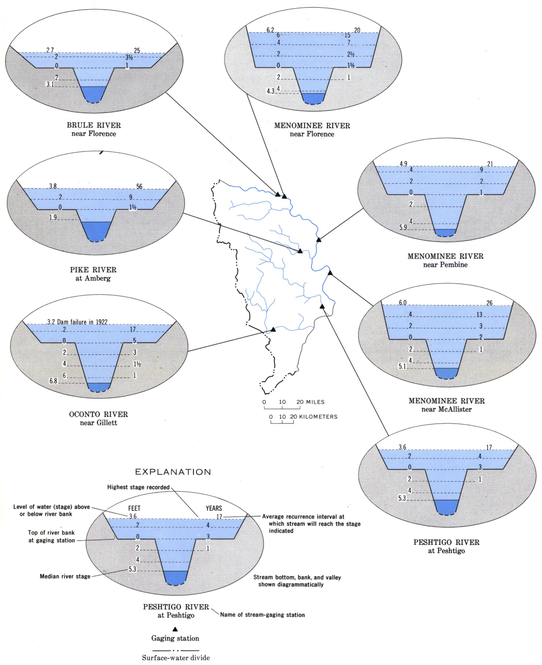
Because major floods have been infrequent in most parts of the basin, there may be a tendency for commercial and industrial expansion on the flood plains. Although most flood-plain areas in the basin are presently unoccupied, an increase in occupancy may result in increases in flood damage.



FLOOD-FLOW FREQUENCY

The magnitude of flood flows depends mainly upon the size of the drainage area. The largest area collects the most rainfall and has the most runoff. However, intensity and duration of rainfall, rate of snowmelt, and effects of frost in the ground may also influence the magnitude of flood flows. Curves on the graph above fall in descending order with decreasing drainage area size, with the exceptions of the Menominee River below Koss, Mich., and the Menominee River near Pembine. The transposition of these very similar curves is attributed to the dissimilar periods of record for these sites.

The similarity of the curves indicates a similarity of stream conditions in the basin. The relatively lower slopes of the curves for the Peshtigo River sites indicate proportionally greater temporary storage of flood waters by lakes and reservoirs.



FLOOD-STAGE FREQUENCY

Flood stage depends upon numerous control factors. Among these are channel width and depth; velocity of streamflow within the channel and on the flood plain; and channel controls such as bridges, dams, ice or debris jams, or natural constrictions. The diagrams shown above illustrate the frequency of high water stages at long-term stream-gaging stations. Because the controlling factors differ at each site, these diagrams can be used to estimate flood risks only in the immediate vicinity of the gages.

Base from U.S. Geological Survey
1:500 000, 1968

WATER RESOURCES OF WISCONSIN—MENOMINEE-OCONTO-PESHTIGO RIVER BASIN

By
E. L. Oakes and L. J. Hamilton

1973

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1974—W72056