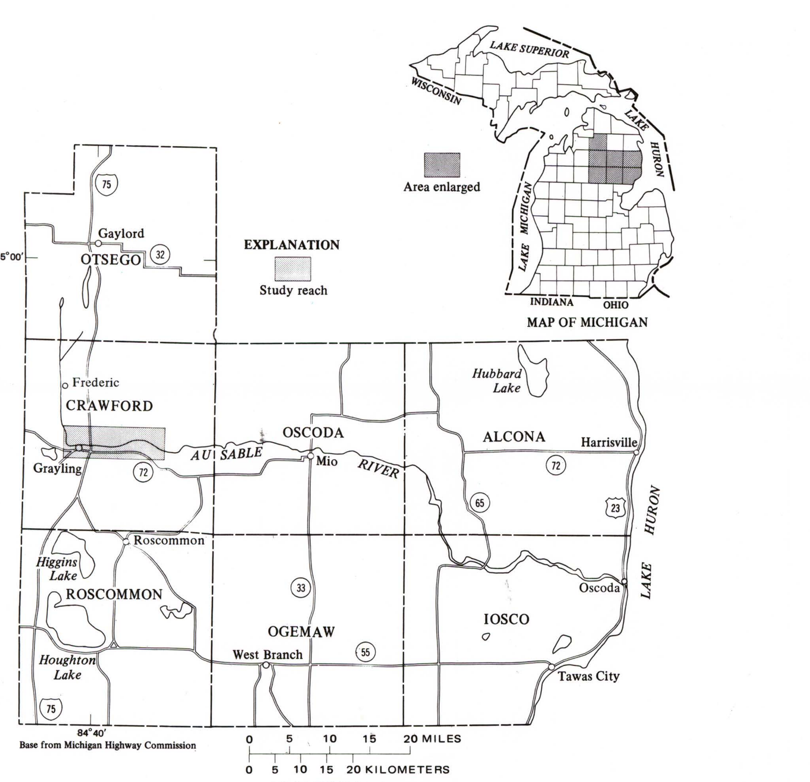
Prepared in cooperation with the
MICHIGAN GEOLOGICAL SURVEY

INTRODUCTION

The Au Sable River is one of Michigan's most popular trout streams and canoe trails. Its riverside campgrounds are enjoyed by thousands of campers each year, and many cabins and homes have been built on its banks. At present, interests of the different recreationists—fishermen, canoers, campers, and riverside property owners—conflict. The conflict results from the fact that the recreational potential is limited by the hydrologic characteristics of the river—its streamflow, quality of water, and character of stream channel, bed, and banks.

The purpose of this report is to describe these characteristics and to show how they relate to the recreational potential of the stream.

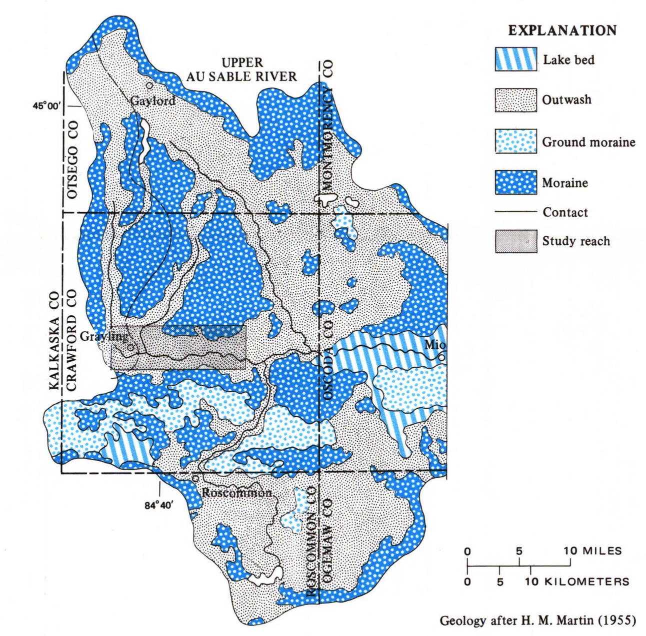
From its headwaters near Frederic the Au Sable flows southward to Grayling, then generally eastward to Lake Huron at Oscoda. Recreational use of the river is concentrated in the segment starting at Grayling and extending downstream to Wakeley Bridge, about 15 river miles. This report is concerned mainly with this part of the river.



LOCATION MAP

GEOLOGIC SETTING

The watershed of the upper Au Sable is underlain chiefly by glacial moraine and outwash deposits. The outwash deposits are composed mainly of sand and gravel, and the soils overlying them are composed for the most part of sand. The moraines also are generally sandy, but contain some silt and clay, and the overlying soils also contain some silt and clay in places. Rain and melting snow rapidly infiltrate the sandy outwash plains and slowly percolate to the river as ground-water runoff. Infiltration is somewhat slower on the hilly moraines, and a larger part of the water moves over the land as surface runoff. Ground-water runoff is important to recreational values of the Au Sable because it maintains the flow of the river during rainless periods.



SURFICIAL GEOLOGIC MAP

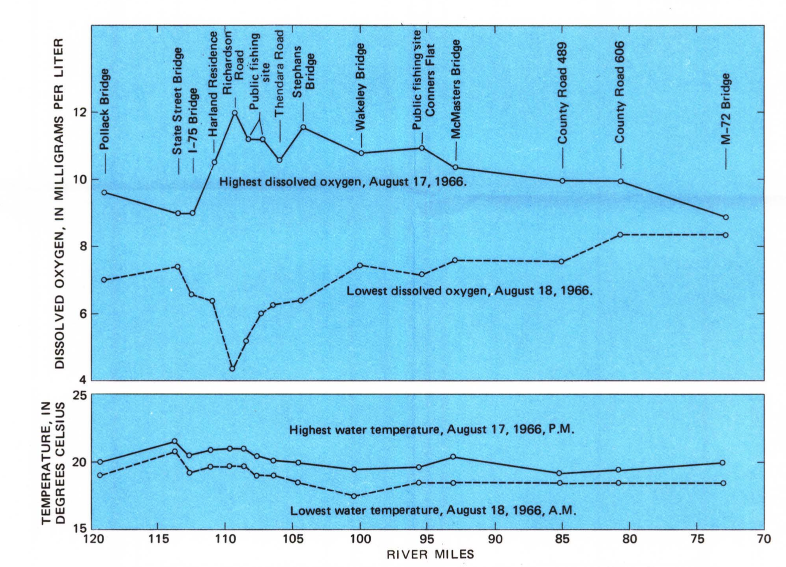
QUALITY OF WATER

INTRODUCTION

The quality of water of the Au Sable River varies in response to natural and man-made influences. Some water-quality parameters, such as temperature and dissolved oxygen, vary greatly with the season and with the time of day. Other parameters, such as specific conductance, vary somewhat with discharge. Dissolved substances that influence recreational values of the Au Sable include calcium, magnesium, nitrate, and phosphate. Important dissolved gases are oxygen and carbon dioxide. Other properties important to recreational values are temperature, pH, specific conductance, odor, and color. Suspended materials include all undissolved substances, chiefly clay, silt, sand, and organic material, carried by the stream.

TEMPERATURE

Continuous records of temperature of the Au Sable have been obtained at Grayling since March 1953. Temperatures at this station are generally higher in summer than at Stephans Bridge (Hendrickson, 1966). The recording station is situated in a pond just upstream from a fixed-crest dam at the M–72 bridge. Exposure to sunlight warms the water in this pond. Inflow of ground water downstream from the pond lowers summer water temperatures. The highest and lowest temperatures recorded during August 17 and 18, 1966, at several sites on the Au Sable, are shown on the graphs.



GRAPHS SHOWING WATER TEMPERATURE AND DISSOLVED-OXYGEN CONCENTRATIONS, AU SABLE RIVER, AUGUST 17, 18, 1966

QUALITY OF WATER

DISSOLVED OXYGEN

Dissolved oxygen usually is expressed in terms of milligrams per liter (mg/l). Dissolved oxygen in the Au Sable varies with temperature and, during the growing season, with plant photosynthesis and respiration. Solubility of oxygen in water decreases with rising temperature. Thus, other circumstances being equal, colder water contains more dissolved oxygen than warmer water. Ground water usually contains little or no dissolved oxygen, but, in summer, the cooling that results from ground-water discharge to surface-water bodies increases the amount of dissolved oxygen that surface-water bodies hold in solution.

During the growing season dissolved oxygen in streams is usually greater during daylight hours, when plant photosynthesis gives off oxygen, than during the night, when plant respiration uses up oxygen. The diurnal variation in dissolved oxygen is, therefore, generally great where aquatic vegetation is dense and is relatively small where vegetation is sparse. The highest and lowest dissolved-oxygen content recorded at several sites on the Au Sable on August 17 and 18, 1966, are shown on the graphs. The great difference (7.6 mg/l) between maximum and minimum concentrations of dissolved oxygen at the Richardson road site is attributed to dense aquatic vegetation above this site. The site is downstream from the Grayling sewage-disposal plant. Oxidation of organic wastes from the plant may also have contributed to the low night-time levels of dissolved oxygen. The range between maximum and minimum dissolved oxygen at Wakeley Bridge was much smaller—only 3.3 mg/l. The smaller range at Wakeley Bridge, as compared with that at Richardson Road, is attributed to sparser vegetation above the site. Also, organic wastes discharged at Grayling were probably completely oxidized before they reached Wakeley Bridge.

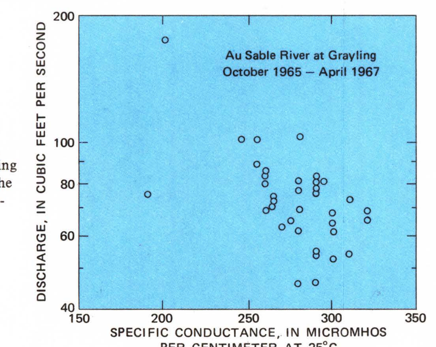
The dissolved oxygen content of the Au Sable River has probably changed since these records were obtained in 1966. In the fall of 1971 the Grayling disposal plant ceased discharge into the river. Sewage is now treated in a lagoon about a mile south of the river. The density of vegetation above the Richardson road site, thus, will probably diminish with time, and night-time levels of dissolved oxygen below Grayling should be higher in the future.

pH

The pH of water is an indicator of its acidity or alkalinity. Water with a pH of 7 is neither acid nor alkaline. A pH lower than 7 indicates acidity, and a pH higher than 7.0 indicates alkalinity. Water of the Au Sable is slightly alkaline; pH ranges from 7.2 to 8.1.

SPECIFIC CONDUCTANCE

The specific conductance of water is an indicator of dissolved-solids content. During October 1965 to April 1967, the specific conductance of water of the Au Sable at Grayling fluctuated between 190 and 325 micromhos as shown on the graph. Values of specific conductance were generally somewhat greater at low than at high flows.



GRAPH SHOWING INFLUENCE OF DISCHARGE ON SPECIFIC CONDUCTANCE, AU SABLE RIVER AT GRAYLING

QUALITY OF WATER

DISSOLVED SOLIDS

Chemical analyses of water from several sites on the Au Sable River are listed below. Dissolved solids generally range from about 150 to about 170 mg/l. The water is of a calcium magnesium bicarbonate type, moderately hard, and low in sulfate and chloride. Nitrate was slightly higher downstream from the Grayling disposal plant than at other sites. As wastes are no longer discharged into the river, nitrate concentrations have probably decreased at this site.

	Au Sable River at Grayling SE¼ sec.7 T.26N.,R.3W.	Au Sable River below Grayling disposal plant NW¼ sec.8 T.26N.,R.3W.	East Branch Au Sable River below fish hatchery NW¼ sec.8 T.26N.,R.3W.	Au Sable River above Stephans Bridge NW¼ sec.5 T.26N.,R.2W.
Calcium (Ca) (mg/l)	–	44	46	42
Magnesium (Mg) (mg/l)	–	8.7	9.2	7.6
Sodium (Na) (mg/l)	–	2.9	1.9	2.3
Potassium (K) (mg/l)	–	.8	.6	.6
Bicarbonate (HCO_3) (mg/l)	108	166	168	158
Carbonate (CO_3) (mg/l)	0	0	0	0
Sulfate (SO_4) (mg/l)	14	8.4	12	7.6
Chloride (Cl) (mg/l)	1.0	4.0	4.0	4.0
Fluoride (F) (mg/l)	–	.1	.1	.2
Nitrate (NO_3) (mg/l)	.4	1.5	.2	.2
Dissolved solids:				
Residue on evaporation at 180°C (mg/l)	136	168	169	150
Calculated (mg/l)	–	159	164	149
Hardness, as $CaCO_3$ (mg/l)	100	150	150	140
Noncarbonate (mg/l)	14	10	16	6
Specific conductance (micromhos at 25°C)	199	286	290	265
pH	8.1	7.2	7.3	7.4

SUSPENDED AND FLOATING SOLIDS

Suspended solids in the Au Sable were not measured in this study. Turbidity, an index of suspended materials, is apparently low during the summer, as the streambed is clearly visible at depths up to 3 feet. Even during the spring high-water season the Au Sable is only slightly cloudy.

At times, floating solids could be seen in the water below the Grayling disposal plant, but they were not seen by the authors during the summer of 1972, after cessation of plant operations. However, litter evidently discarded by visitors to the area, still could be seen from time to time.

STREAMFLOW

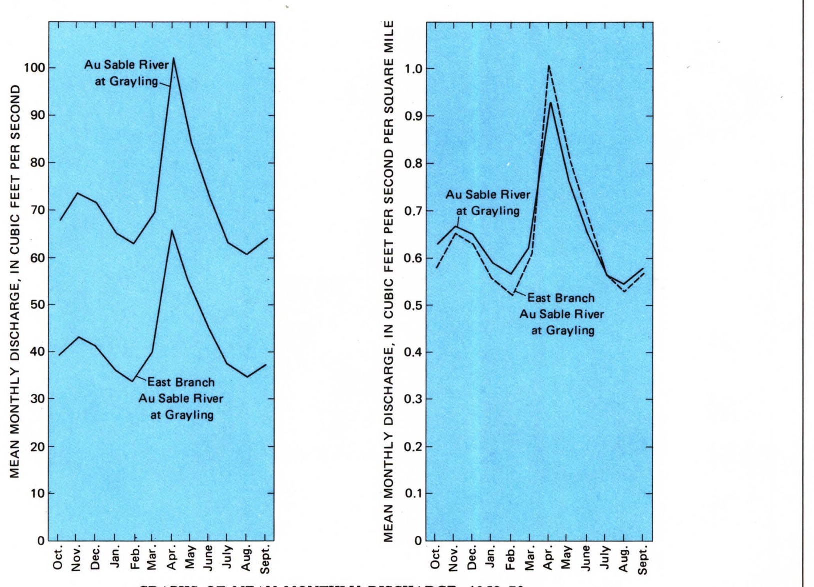
INTRODUCTION

The flow of the Au Sable River, like that of any other uncontrolled stream, varies from day to day and from year to year. This variation may be measured in units of discharge (volume of water discharged per unit of time), velocity (water speed), and stage (altitude of water surface). These units are related; a high rate of discharge results in high stage and usually in high velocity. Velocity also varies in different reaches of the river, generally being greater in steeper reaches than in flatter reaches, and greater in shallow riffles than in deep pools.

DISCHARGE

Continuous records of discharge have been obtained on the Au Sable at Grayling since 1942 and on the East Branch Au Sable at Grayling since 1958. In addition, occasional measurements of discharge have been made at Edgewater, near Stephans Bridge, and at several other sites. Mean monthly discharges at the two gaging stations, for 1958–70, are shown on the graphs. Discharge is shown in cubic feet per second (cfs) and cubic feet per second per square mile (cfsm). Discharge is usually highest during the snowmelt in early spring, usually in April, and usually declines during late spring and summer. Fall rains after killing frosts often increase discharge moderately, but the discharge decreases again in winter, when most precipitation is snow.

Discharges are expressed in cubic feet per second per square mile to compare the flow of streams having different drainage areas or to compare different segments of the same stream. Mean discharge on the Au Sable at Grayling is 0.67 cfsm; on the East Branch at Grayling the mean discharge is 0.65 cfsm. About 10 river miles downstream from Grayling, near Stephan's Bridge, the mean discharge of the Au Sable is 0.78 cfsm. The differences in discharge per unit drainage area are attributed chiefly to differences in the amount of ground-water discharge contributed to the streams. In general, the greater the proportion of discharge contributed by ground water, the greater the mean discharge per unit area.



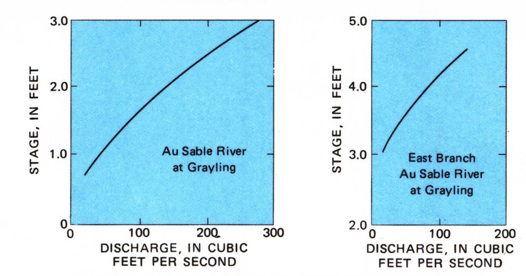
GRAPHS OF MEAN MONTHLY DISCHARGE, 1958–70

STREAMFLOW

STAGE

The stage of the Au Sable fluctuates with discharge. For a given change in discharge, fluctuations in stage are relatively large, where the channel is narrow and banks are high, and relatively small, where the channel is broad and banks are low. Channel width and bank heights are shown on the maps at right.

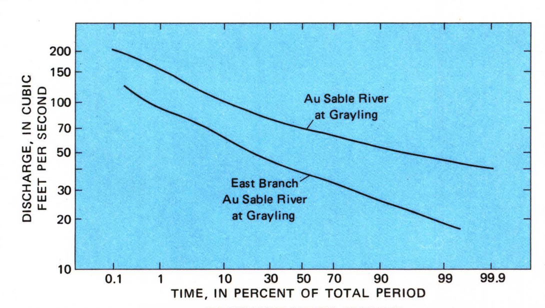
The relationships of stage to discharge on the Au Sable and East Branch at Grayling are shown on the graphs. Stage of the Au Sable at Grayling is 1.2 feet at a discharge of 50 cfs, and 2.1 feet at a discharge of 150 cfs. Stage of the East Branch is 3.2 at a discharge of 30 cfs, and 4.2 at a discharge 100 cfs. The zero datum of each gaging station is arbitrarily set at a convenient point below the lowest expected stage. Thus, it is the differences in various readings on the gage that are important, not the reading of itself. The average annual range in stage on the East Branch is 1.1 feet. These relatively low ranges in stage are typical of streams having relatively uniform discharge and a large component of ground-water discharge.



GRAPHS SHOWING STAGE-DISCHARGE RELATIONS

FLOW DURATION CURVES

Discharge characteristics of streams can be illustrated graphically by flow-duration curves. These curves show the percentage of time that specified discharges are equaled or exceeded during the period of record. For example, discharge of the Au Sable at Grayling is equal to or greater than 100 cfs 10 percent of the time; 90 percent of the time discharge is equal to or greater than 55 cfs. Discharge of the East Branch is equal to or greater than 60 cfs 10 percent of the time; 90 percent of the time discharge of the East Branch is equal to or greater than 25 cfs.



FLOW-DURATION CURVES

QUALITY OF WATER

SUMMARY

The following table summarizes the quality-of-water characteristics of the Au Sable River and shows how these characteristics are related to the recreational potential of the river.

Recreational use	Relation of quality of water to recreational potential	Quality of water of upper Au Sable River
Trout fishing	Temperature: Criteria for intrastate waters (Michigan Water Resources Commission, 1968) specify 70°F (21.1°C) as the maximum limit for intolerant fish (cold-water species). Lethal temperature for brook trout is about 79°F (26°C) (McKee and Wolf, 1963, p.284).	Maximum temperatures of the Au Sable at Grayling exceed 75°F (24°C) during summer months. Maximum temperatures at Stephans Bridge generally exceed 70°F (21.1°C), but are less than 75°F.
	Dissolved oxygen: Michigan Water Resources Commission (1968) specifies a minimum of 6 mg/l. At water temperatures above 68°F (20°C) Tarzwell (1957) indicated full air saturation is required for the full range of activity of brook trout.	Dissolved oxygen in most of the river does not drop below 6 mg/l at any time. Before 1972, dissolved oxygen dropped below 5 mg/l at night in the segment below the Grayling sewage-disposal plant.
	Hydrogen ion concentration (pH) Michigan Water Resources Commission (1968) specifies lower and upper limits of 6.5 and 8.8, respectively.	pH of the Au Sable generally ranges from 7.2 to 8.1.
	Nutrients (chiefly nitrate and phosphate) Michigan Water Resources Commission (1968) requires nutrients to be limited to the extent necessary to prevent stimulation of growths of algae, weeds, and slime, which may impair water for its designated use. Because nutrients are rather quickly taken up by plants, exact limits of desirable concentrations are difficult to determine.	Nutrients in the Au Sable below the Grayling disposal plant probably decreased after 1971, when disposal-plant discharge into the river ceased. Changes in plant growth that might have resulted from the cessation, however, have not been observed by the authors.
Trout fishing, boating, camping, and cabin living.	Floating, settleable, and suspended solids Michigan Water Resources Commission (1968) specifies no objectionable unnatural turbidity, color, or deposits sufficient to interfere with designated use; no floating solids or evidence of residues of unnatural origin.	Floating discarded litter appears on the river during vacation season. Before 1972, some floating organic matter below disposal plant.

CHANNEL, BED, AND BANKS

The character of channel, bed, and banks of the Au Sable strongly influence the recreational potential of the river. The three maps on this sheet illustrate these physical features of the Au Sable River as determined by field reconnaissance in July 1969. During the reconnaissance the stage of the Au Sable at Grayling was about 1.5 feet. The depth of the stream and apparent height of banks vary with stage, but the stage of the Au Sable usually varies only a few tenths of a foot during the summer. The maps show width and depth of channel, bed and bank materials, height of banks, and character of bank vegetation. Each map is generalized, showing the predominant character of bed and banks. Small segments of unlike character are not shown. The character of channel, bed, and banks may change naturally with time or as a result of man's activities.

The character of channel, bed, and banks of the Au Sable and the effects on recreational potential are summarized below:

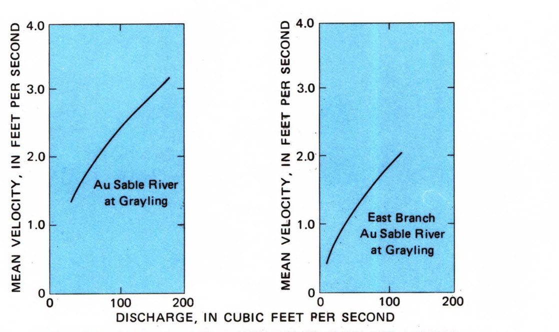
Recreational use	Relation of physical and hydrologic characteristics to recreational potential (prepared by Michigan Department of Natural Resources)	Characteristics of upper Au Sable River
Trout fishing	Broad open water makes fly casting easier, but tends to warm the water. Warm water can have adverse effects on trout propagation and population.	Broad and open enough for easy fly casting from Grayling to Wakeley Bridge. Broad, open pond at Grayling probably contributes to warming of water.
	Variability in depth, usually related to variability in velocity, affects wading. Predominantly shallow depth makes wading easier.	Easy wading in most of river. Too deep for wading in places where channel has been dredged and in a few of the deeper holes.
	Gravel beds provide spawning opportunity and produce fish food. Sand fills deeper holes, and buries escape cover, food organisms, and gravel beds.	Sand is predominant from 1 mile east of Grayling downstream to the Canoe Campground: gravel is predominant most of the river from Canoe Campground to Wakeley Bridge.
	Overhanging banks, logs, fallen trees, and boulders provide trout cover.	Drowned logs provide good cover in most of river.
	Streamside trees and shrubs shade water and keep water temperature low. This shade may reduce food production, and the plants may intercept part of ground-water discharge to stream.	Trees and brush line banks of most of river. Open areas are chiefly at riverside cabins and homes.
	Clay banks and bottoms produce turbidity, reducing photosynthesis and, hence, food production. Turbidity also interferes with sight feeding by trout. Sand, gravel, and muck banks more desirable in this respect.	Banks are mostly composed of muck and sand. High banks are generally composed of sand; low banks are muck. A few small patches of clay not shown on map.
	Banks that are devegetated by erosion, undercutting, cattle crossing, and boat landing traffic may be the source of undesirable quantities of sand, silt, and clay in streams.	Most banks unaffected. A few eroded areas near campgrounds and public-access sites.
	Variability in gradient is related to variability in velocity and affects wading.	Stream gradient varies, but velocity generally is slow enough for easy wading.
	Bottom vegetation adequate to contribute to food production is desirable, but excessive growth chokes stream and produces extreme daily fluctuations in dissolved oxygen and temperature.	Much bottom vegetation in places below Grayling disposal plant. Vegetation may decrease now that disposal is to sewage lagoon.
Boating	Boatability increases as width and depth increase. A wide channel allows boaters to stay clear of wading fishermen.	Au Sable is wide and deep enough for easy boating downstream from Grayling. Wide enough most places to allow boaters to pass wading fishermen with a minimum of disturbance.
	On smaller streams overhanging trees and log jams decrease boatability. Obstructions, shallows, boulders objected to by some canoeists, wecomed by others. If present in excessive amounts, may eliminate boating.	Obstructions on the Au Sable from Grayling downstream to Wakeley Bridge are chiefly logs and fallen trees that do not block the entire channel. No portages required. A few shoals may ground exceptionally heavily loaded canoes.
	A meandering stream is generally more attractive and interesting than a straight stream.	Meanders predominant from Grayling to Louis Cabin Landing. From Louis Landing downstream to Wakeley Bridge straight and crooked reaches alternate.
	Variety of streamside vegetation adds to interest.	Streamside vegetation mostly of the coniferous swamp type. Hardwood and coniferous upland types in places. Open grasslands limited chiefly to cultivated lawns.
	Alternating high and low banks add to interest.	Long reaches of low banks are intermittent with short segments of high banks.
	Undeveloped river banks add to enjoyment of most canoeists.	Cabins and homes line the banks of much of the Au Sable from Grayling to Wakeley Bridge. A few undeveloped reaches remain.
	Frequency and suitability of boat launching and take-out points, as determined by bank characteristics and vegetation, influence usability.	Low sandy banks and many public-access sites provide many easy launching and take-out points.
Camping and cabin living	Characteristics favorable to fishing and boating generally also desirable for camping and cabin living	See descriptions above.
	Moderately high sandy slopes provide good drainage and easy access to river.	Although low banks predominate, higher ground near river provides many well-drained camp and cabin sites with easy access to river.

STREAMFLOW

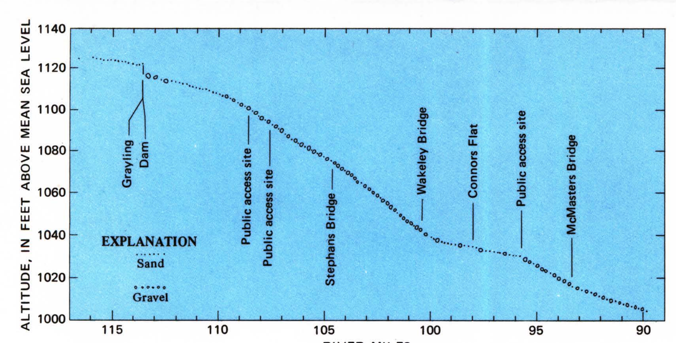
VELOCITY

In summer, the velocity of the upper Au Sable usually ranges from about 1 fps (foot per second), 0.68 mile per hour, to about 3 fps (2 miles per hour) in the faster riffles. Velocity also varies with discharge; generally higher discharges are associated with higher velocities as shown on the graphs.

The Au Sable falls slightly in the reach extending from about 1 mile east of Grayling downstream to the Canoe Camp, and its velocity is relatively slow. The gradient is much steeper in the reach between Stephans and Wakeley bridges, and the velocity is relatively fast. Predominantly sand beds are characteristic of the flatter reaches, and gravel beds are characteristic of the steeper reaches. See profile.



GRAPHS SHOWING VELOCITY-DISCHARGE RELATIONS



PROFILE SHOWING STREAM GRADIENT AND STREAMBED MATERIALS

STREAMFLOW

SUMMARY

The following table summarizes the streamflow characteristics of the Au Sable and shows how these characteristics are related to recreational potential.

Recreational use	Relation of streamflow to recreation potential (Prepared by the Michigan Department of Natural Resources)	Streamflow characteristics of upper Au Sable River
Trout fishing	High drought flow keeps summer water temperatures low. Excessive flood flow removes cover and may erode banks.	Relatively high drought flow per unit drainage area. No damaging floods on upper Au Sable.
	Variety of fast and slow reaches adds interest to fishermen. Excessively high velocities make wading dangerous.	Velocity variable in different reaches. Velocity not too fast for safe wading.
	Abrupt and large increases in stage are a hazard to wading fishermen.	No abrupt changes in stage on upper Au Sable. Downstream from Mio changes may be abrupt below power dams.
Boating	Boating season reduced by periods of flood and drought.	No floods on upper Au Sable. Drought flow generally enough to float loaded canoes.
	A variety of fast and slow reaches adds interest and challenge to boaters.	Velocity variable in different reaches, but not fast enough to challenge experienced canoers. Au Sable is especially suited for novice.
	Slow velocity makes upstream travel easier.	Upstream travel is possible for experienced canoeists, but many reaches are too fast for upstream travel by novices.
Camping and cabin living	Streamflow characteristics favorable to fishing and boating are generally favorable to camping and cabin living.	See descriptions above.
	High flood flows may damage boat docks, cabins, and camp facilities.	No floods on upper Au Sable.

EXPLANATION

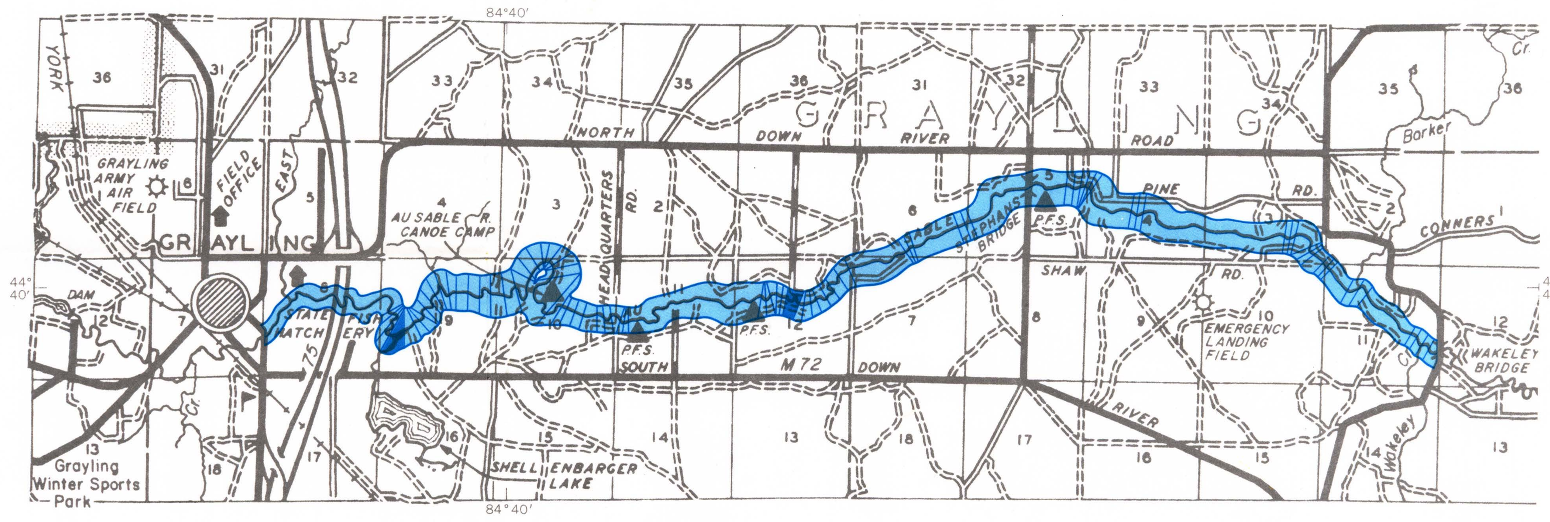
DISTANCE BETWEEN BLUE LINES INDICATES WIDTH OF RIVER ACCORDING TO FOLLOWING SCALE:

DEPTH OF RIVER IN FEET INDICATED BY SHADING

0 to 3

3 to 6

More than 6



MAP 1 – WIDTH AND DEPTH OF CHANNEL

EXPLANATION

BED MATERIAL

Sand

Sand and gravel

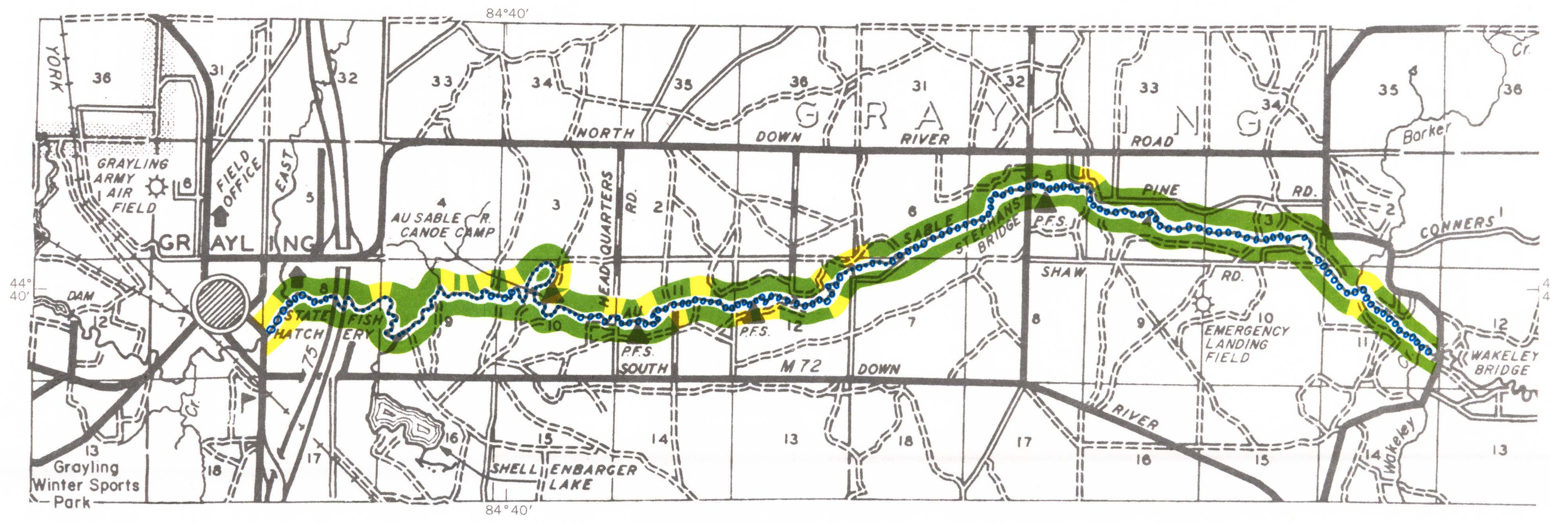
Gravel

Clay

BANK MATERIAL

Sand

Muck



MAP 2 – BED AND BANK MATERIALS

EXPLANATION

BANK HEIGHT, IN FEET

0 to 3

3 to 20

More than 20

BANK VEGETATION

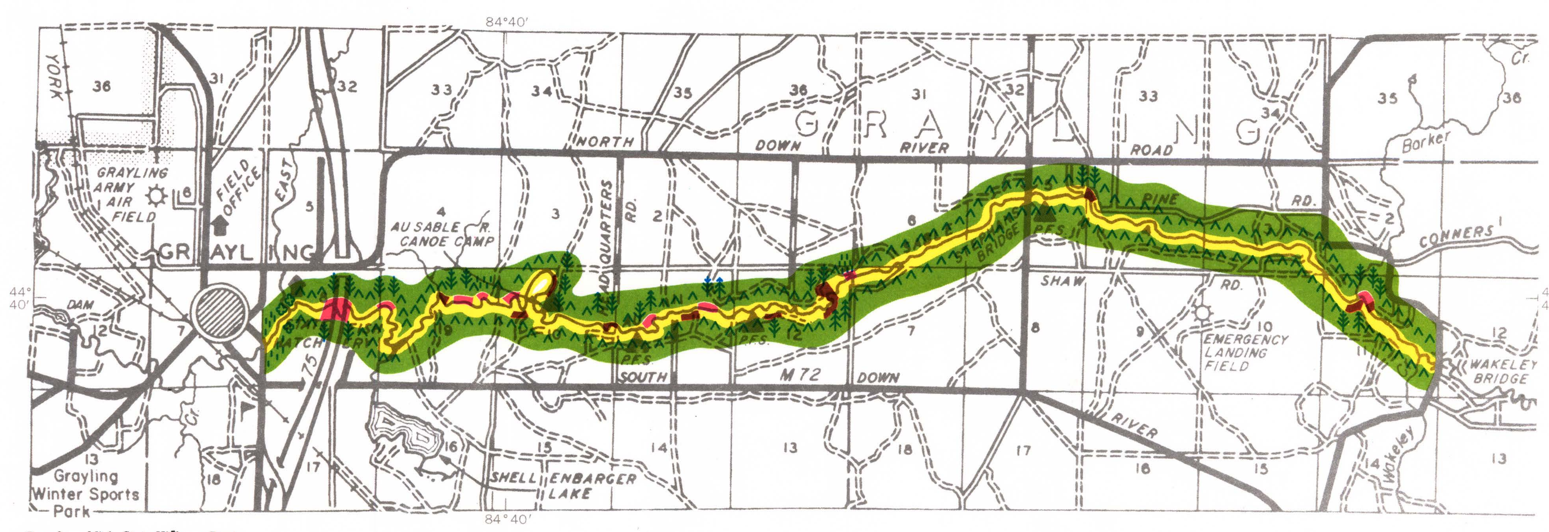
Open grass land

Hardwood swamp (elm, ash, basswood, aspen)

Coniferous swamp (spruce, balsam, cedar, pine)

Hardwood upland (oak, maple, aspen, birch, cherry)

Upland pine (may include some aspen)



MAP 3 – HEIGHT OF BANKS AND BANK VEGATATION

SCALE 1:62 500

1 ½ 0 1 2 3 4 MILES

1 .5 0 1 2 3 4 KILOMETERS

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INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1974

RECONNAISSANCE OF THE UPPER AU SABLE RIVER, A COLD-WATER RIVER IN THE NORTH-CENTRAL PART OF MICHIGAN'S SOUTHERN PENINSULA

By
G. E. Hendrickson and C. J. Doonan

1974

For sale by U. S. Geological Survey, Reston, Va. 22092, price $1.00