DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MICHIGAN GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-353 (SHEET 1 OF 2)

INTRODUCTION

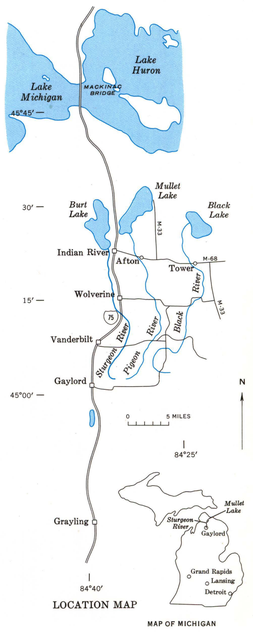
The cold-water streams of the northern states provide unique recreational values to the American people (wilderness or semi-wilderness atmosphere, fast-water canoeing, trout fishing), but the expanding recreational needs must be balanced against the growing demand of water for public and industrial supplies, for irrigation, and for the dilution of sewage and other wastes. In order to make intelligent decisions regarding use and management of the water resources for recreation and other demands, analysis of the hydrologic factors related to recreational values is essential.

The Sturgeon River north of Gaylord, one of the best brown trout streams in Michigan, is located in the north-central part of the southern peninsula of Michigan with headwaters just north of Gaylord. The Sturgeon flows northward, generally paralleling Interstate Highway 75. The West Branch of the Sturgeon, which joins the main stem at Wolverine, was not included in this study. Exits from Interstate 75 at Gaylord, Vanderbilt, Wolverine, and Indian River provide easy access to the Sturgeon.

The recreational value of a river depends on the hydrologic characteristics of the river—the streamflow, water quality, and character of bed and banks. The purpose of this atlas is to describe these characteristics and to show how they relate to recreational uses.

Much of the information presented here was derived from basic records of the U.S. Geological Survey's Water Resources Division. Additional information was obtained in a reconnaissance survey in May and June, 1966. The area of field study is limited to the channel, bed, and banks of the main stem from source to mouth. The study was made in cooperation with the Michigan Geological Survey, Gerald E. Eddy, Chief. Advice and assistance were also obtained from other sections of the Michigan Conservation Department.

Sheet 1 of this atlas presents information on streamflow characteristics and water quality. Sheet 2 describes the physical characteristics of the stream channel and bed and banks, and shows how these physical characteristics relate to streamflow, water quality, and recreational use.



LOCATION MAP

MAP OF MICHIGAN

GEOLOGIC SETTING

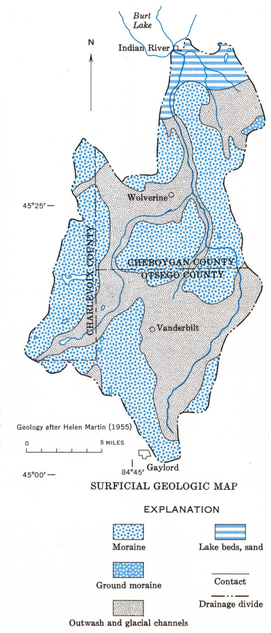
Driving northward from Gaylord, the traveller begins a descent that drops from an altitude of about 1370 feet to an altitude of about 1100 feet before he gets to Vanderbilt. This is the inner slope of the Fort Huron moraine* which was deposited at the front of a lobe of glacial ice about 13,000 years ago. The Sturgeon rises along the inner margin of this moraine and flows northward on terraces of sand and gravel outwash between smaller morainal hills and ridges which mark temporary halts in the retreat of the ice front. About 6 miles north of Wolverine the Sturgeon crosses an area of sandy lake beds that were laid down in ponded water from the melting ice.

The headwaters of the Sturgeon receive a large contribution of surface runoff from the steep morainal slopes during periods of heavy rains and melting snow. The headwaters also receive a large amount of ground water, part of which probably is derived from the broad area of outwash southwest of the Sturgeon watershed. Downstream, the morainal areas contribute a moderate amount of surface runoff, but relatively little ground-water discharge, while the sand and gravel outwash areas contribute a moderate amount of ground-water discharge but relatively little surface runoff.

Ground-water discharge is important to the recreational values of the river, because ground water is the principal source of water in the stream during rainless periods. Ground water is also a major control of water temperatures. Segments of the river where ground-water discharge is great generally are cooler in summer and warmer in winter than segments where ground-water discharge is small.

The areas of outwash along the river are also favorable for obtaining water supplies from wells. Drilled or driven wells in these areas should supply ample water for campgrounds and cabins.

*For definition of geologic terms, see "GLOSSARY," in lower-right corner of sheet.



SURFICIAL GEOLOGIC MAP

EXPLANATION

Moraine
Lake beds, sand
Ground moraine
Contact
Drainage divide
Outwash and glacial channels

STREAMFLOW

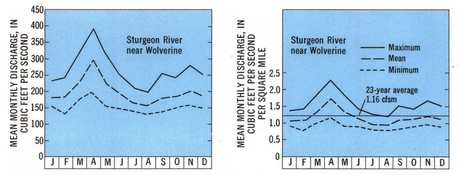
INTRODUCTION

The flow of any uncontrolled river 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 (speed of movement of water), and stage (elevation of water surface). These units are related—a high discharge results in high stages and, usually, in high velocities. Velocity also varies in different reaches of the river, the velocity being greater generally in reaches of steep fall than in the flatter reaches. The gradients of the reaches of the river are shown on the river profile (Sheet 2).

DISCHARGE

Daily discharge on the Sturgeon River is recorded at a station about two miles north of Wolverine. Records of mean monthly discharge for the period October, 1942 through September, 1966, are shown here. Discharge is shown in cubic feet per second (cfs) and cubic feet per second per square mile of drainage area (cfsm). The highest rates of discharge normally occur during the spring snowmelt season—usually in April. Discharge generally declines from April to August and then increases slightly as vegetation uses less water. Unusually intense rains may bring high discharge at any season.

Discharges expressed in terms of cubic feet per second per square mile are used to compare the flow of streams having different drainage areas, or to compare different sections of the same stream. The discharge on the Sturgeon averaged 1.16 cfsm during the 23 year period of record. This is substantially higher than most rivers in the Lower Peninsula. The high discharge per unit drainage area reflects a large contribution from ground water.

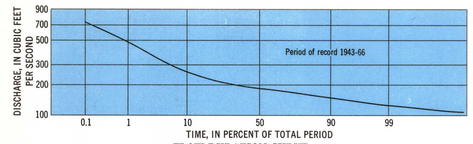


GRAPHS OF MEAN MONTHLY DISCHARGE

STREAMFLOW

FLOW-DURATION

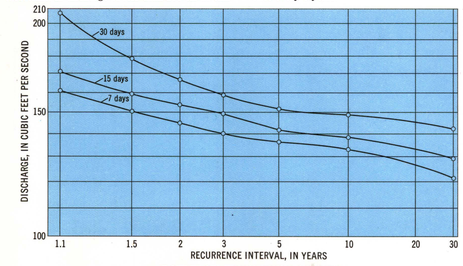
Discharge characteristics of streams can also be illustrated by flow-duration curves. These show the percentage of time that specified discharges are equaled or exceeded during the period of record. The flow-duration curve for the Sturgeon at the gaging station near Wolverine is shown below. The curve shows that discharge on the Sturgeon near Wolverine is equal to or greater than 150 cfs about 90 percent of the time, and 270 cfs 10 percent of the time. The curve is quite flat, which is typical of streams having a large component of ground-water flow. The relatively large ground-water flow keeps the Sturgeon River cooler than most Michigan streams during hot summer days.



FLOW-DURATION CURVE

FREQUENCY OF DEFICIENT FLOW

The frequency of deficient flow on the Sturgeon River is of interest to recreationists, because periods of extremely low flow generally are unfavorable for most recreational uses. The graph below shows frequency of deficient flows for periods of 7, 15 and 30 consecutive days, occurring during the 6 months May through October at the gaging station below Wolverine. A discharge of less than 150 cfs at this station usually is unfavorable for fishing in many parts of the river and for canoeing in the river above Wolverine. The graph shows that we may expect a mean daily discharge of no more than 150 cfs during these months for 7 consecutive days about twice every 3 years, for 15 consecutive days about once every 3 years, and for 30 consecutive days about once every 6 years.



LOW-FLOW FREQUENCY CURVES

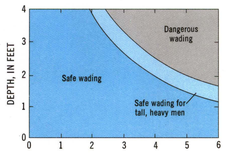
STREAMFLOW

VELOCITY

Velocity on the Sturgeon River varies in time and place. Increased discharge generally is accompanied by increased velocity. Velocity normally is faster near the surface at midstream than near the bottom and banks. Drowned logs, submergent vegetation, rocks, and other obstructions also cause local changes in velocity of the stream. The Sturgeon, like most streams in northern Michigan, flows alternately in shallow riffles or rapids, where velocity is fast, and deep pools, where velocity normally is slow. The midstream velocities in several riffles and pools on the Sturgeon on July 18, 1966, are listed below.

Location (see Maps, Sheet 2)	Midstream velocity in riffles, in feet per second	Midstream velocity in pools, in feet per second
Near Bridge on Poquette Road	3.0	0.2
Near Bridge on Whitmarsh Road (Doc Sehls Bridge)	1.0	.9
Near Bridge on Sturgeon Valley Road (Sturgeon Bridge)	1.5	.1
Near Bridge on Trowbridge Road	3.7	.1
Near Wolverine above mouth of West Branch	2.0	.5
Near Bridge on Rondo Road (Rondo Bridge)	4.5	.5
Near Bridge on White Road	4.1	3.0
Near Bridge on Old U.S. 27 South of Indian River	3.0	.5

The Sturgeon below Wolverine is too fast for safe wading in many places, especially at high stages. A rule of thumb for safe wading is that depth, in feet, multiplied by velocity, in feet per second, should not be greater than 10. Thus, when velocity is 4 feet per second, a fisherman should not wade into water more than 2.5 feet deep. This assumes a firm bottom. If bottom material is slippery clay, even 2 feet may be too deep.

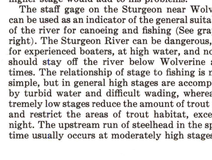


GRAPH SHOWING RELATION OF DEPTH AND VELOCITY TO WADING

STREAMFLOW

STAGE

The stage, or water level, of the Sturgeon fluctuates with discharge. This correlation is used at the gaging station near Wolverine to determine the discharge of the river between streamflow measurements. The correlation varies somewhat in different seasons of the year, owing to the influence of vegetation and icecover, but the graph below shows the approximate relationship during the warmer months, when the river is most used for recreation.



GRAPH OF DISCHARGE-STAGE RELATION

The record high stage was 4.48 feet, occurring on September 14, 1961, when exceptionally heavy rains caused unseasonably high discharge. Low stages of less than 2.0 feet occur a few days of most years. Fluctuation in stage most years is less than 2 feet. However, abrupt changes in stage of only ½ foot can cause problems for unwary anglers. For example, a fisherman who waded safely through a stretch of river on April 20, 1966, may find the water too deep on April 21 (See graph at right). Increased velocity that normally accompanies higher stage would add to his problems.

The staff gage on the Sturgeon near Wolverine can be used as an indicator of the general suitability of the river for canoeing and fishing (See graph at right). The Sturgeon River can be dangerous, even for experienced boaters, at high water, and novices should stay off the river below Wolverine at all times. The relationship of stage to fishing is not so simple, but in general high stages are accompanied by turbid water and difficult wading, whereas extremely low stages reduce the amount of trout cover and restrict the areas of trout habitat, except at night. The upstream run of steelhead in the spring-time usually occurs at moderately high stages.

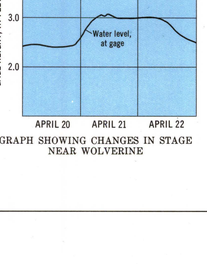
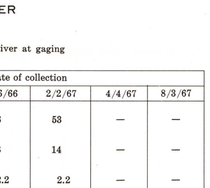


DIAGRAM SHOWING GAGE HEIGHT RELATED TO RECREATIONAL USE



GRAPH SHOWING CHANGES IN STAGE NEAR WOLVERINE

STREAMFLOW

SUMMARY

The following table summarizes the streamflow characteristics of the Sturgeon River and shows how these characteristics are related to recreational uses.

Recreational use	Characteristics related to use (Prepared by the Michigan Department of Conservation)	Characteristics of Sturgeon River
Trout fishing	High drought flow helps keep summer water temperatures low. Excessive flood flow removes cover and may cause erosion of banks.	Relatively high drought flow. Flood flows may cause some damage to river, bed and banks. River not subject to severe flooding.
	A variety of fast and slow stretches add interest for fishermen. Excessively high velocities make wading dangerous.	Velocity variable in different reaches. Too fast for safe wading in many reaches below Wolverine, especially at high water.
	Abrupt and large changes in stage are a hazard to wading fishermen.	Changes in stage generally moderate. Changes may be abrupt at snowmelt time.
Boating	Season of boating reduced by periods of flood and drought.	Flood season usually over before major vacation season. Late summer drought flows discourage boating in much of upper river.
	A variety of fast and slow reaches adds interest for boaters.	Velocity variable in different reaches.
	Low velocity makes upstream travel easier.	Velocities too fast for upstream travel in most of river.
Camping and cabin living	Streamflow characteristics favorable to fishing and boating also are generally favorable to camping and cabin living.	See descriptions above.

QUALITY OF WATER

INTRODUCTION

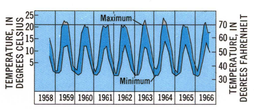
The quality of water in a river is expressed in terms of dissolved solids and gasses, suspended and floating materials, and physical properties of the water. Dissolved materials generally important to recreational uses are dissolved oxygen and nutrients —nitrates and phosphates. Other dissolved substances, such as toxic wastes, may affect the recreational quality of streams, but no wastes other than a minor amount of septic-tank effluent are discharged into the Sturgeon River. Suspended and floating materials include all undissolved materials, chiefly clay, silt, sand, and organic material moved in the stream. Physical properties important to recreation are temperature, pH, specific conductance, odor, and color.

TEMPERATURE

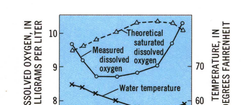
Usually the most critical requirement of a recreational river used primarily as a trout stream is water temperature. A continuous record of water temperature on the Sturgeon has been obtained at the gaging station near Wolverine since October 1958. Monthly high and low temperatures for the period October, 1958 through September, 1966, are shown at right. The maximum temperature recorded was 23.9°C (75°F), but most years the temperature does not get above 22.2°C (72°F). The recorded temperatures on the Sturgeon at Wolverine are cooler than those on most other rivers of Michigan. Temperatures vary in different reaches of the river depending chiefly on the amount of ground-water inflow and the surface area exposed to sunlight. Headwaters usually are cooler in summer than downstream segments. Records at the bridge on the Sturgeon east of Vanderbilt (on Sturgeon Valley Road) showed daily maximums about 2.8°C (5°F) cooler than those downstream at the gaging station at Wolverine (see graph at right). The daily range in temperature was also smaller at the upstream station. Summer temperatures in the lower reaches of the Sturgeon below Wolverine may be somewhat warmer than in the upstream stations, but in general the temperature of water in the Sturgeon is relatively favorable for trout at all times.

DISSOLVED OXYGEN

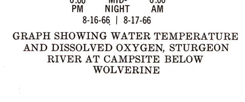
Dissolved oxygen is another critical requirement of recreational rivers. In a river free of significant contamination, such as the Sturgeon, dissolved oxygen is controlled chiefly by water temperature, and by plant photosynthesis and respiration. As water temperatures increase the capacity of the water to hold oxygen in solution decreases. The effect of temperature is masked in summer by the oxygen given off by plants during daylight hours and the small amount used up by plants at night. Thus, dissolved oxygen in the Sturgeon during summer days usually is at or slightly above saturation. At night the dissolved oxygen drops to 1 or 2 mg/l below saturation (see graph below). The relatively small diurnal fluctuation in dissolved oxygen in the Sturgeon reflects the sparse growth of water plants in the river. The high dissolved oxygen content of Sturgeon River water is favorable for trout. High dissolved oxygen also indicates that the Sturgeon is relatively free from contamination by organic wastes.



GRAPH SHOWING WATER TEMPERATURE STURGEON RIVER AT WOLVERINE



GRAPH SHOWING WATER TEMPERATURE STURGEON RIVER AT TWO STATIONS



GRAPH SHOWING WATER TEMPERATURE AND DISSOLVED OXYGEN, STURGEON RIVER AT CAMPSITE BELOW WOLVERINE

QUALITY OF WATER

HYDROGEN ION (pH)

The hydrogen ion concentration or pH is an indicator of the acidity or alkalinity of water. Waters with a pH of 7.0 are said to be neutral. A pH less than 7.0 indicates acid water; a pH more than 7.0 indicates alkaline water. The water of the Sturgeon is moderately alkaline, with pH values from 7.3 to 8.2 (see table of chemical analysis). This is a favorable range for trout habitat.

HARDNESS

Hardness of water is expressed as the equivalent concentration of calcium carbonate. The water in the Sturgeon is moderately hard (see table). Moderately hard water (more than 120 mg/l)* may be desirable in that it reduces the toxicity of some substances in water (Tarzwell, 1957). However, there is no indication of toxic materials in the Sturgeon River.

SUSPENDED AND FLOATING SOLIDS

Suspended solids in the Sturgeon were not measured in this study. Turbidity as an index of suspended material apparently was low during most of the summer season of 1966, as the bottom was clearly visible at depths up to 3 feet. During the spring season of high runoff, and also during intense storms, turbidity is reported to increase substantially, perhaps becoming high enough to cause problems in relation to trout-rearing. Runoff from recently-excavated borrow pits may contribute to turbidity. As these borrow pits become stabilized with vegetation turbidity may decrease.

Floating solids and oil slicks do not appear to be a problem on the Sturgeon.

SPECIFIC CONDUCTANCE

Specific conductance is an indicator of concentration of dissolved solids. The chief value of specific conductance readings is that they provide a quick field indicator of major charges in the dissolved solids load of a stream. Thus, a large discharge of brines to the stream would show up as an increase in specific conductance above normal levels. During the period October, 1965 to February, 1968, specific conductance on the Sturgeon generally ranged between 265 and 373 micromhos. This is in the normal range for an unpolluted stream in this area.

NUTRIENTS-NITRATES AND PHOSPHATES

Nitrates and phosphates are important dissolved constituents in recreational waters because they strongly influence the growth of aquatic vegetation, including algae. A moderate amount of these nutrients is desirable to provide fish food. Too much can choke the stream with vegetation and deplete the supply of oxygen.

Nitrates and phosphates in the Sturgeon were low in the few samples analyzed for this study (see table). Nitrates ranged from 0.3 to 1.0 mg/l; phosphates from 0.03 to 0.10 mg/l. The sparse growth of water vegetation further suggests that the river is low in these nutrients. No slime growths were noted anywhere in the river.

OTHER DISSOLVED MATERIALS

Chemical analyses of water from the Sturgeon are listed in the table of Chemical Analysis. The water of the Sturgeon is of the calcium bicarbonate type with calcium and magnesium as the major cations and bicarbonate as the major anion. The chemical character of the water is normal for an unpolluted river in this area. Chlorides and sulfates were very low in all samples. No analyses were made for toxic metals, but there is no indication that toxic materials are discharged into the river.

ODOR AND COLOR

The Sturgeon appears to be free of noticeable color or odor from the headwaters to the mouth.

*At concentrations normally found in fresh water, dissolved materials expressed in units of milligrams per liter (mg/l) are equivalent to dissolved solids expressed in units of parts per million (ppm).

QUALITY OF WATER

Chemical analysis of Sturgeon River at gaging station near Wolverine, Michigan

Measured parameter	Date of collection					
	7/12/60	4/27/66	8/16/66	2/2/67	4/4/67	8/3/67
Calcium (Ca) mg/l	54	53	48	53	—	—
Magnesium (Mg) mg/l	15	13	18	14	—	—
Sodium (Na) mg/l	1.8	2.4	2.2	2.2	—	—
Potassium (K) mg/l	.4	.4	.5	.3	—	—
Bicarbonate (HCO_3) mg/l	231	206	228	211	176	168
Carbonate (CO_3) mg/l	0	0	0	0	—	—
Sulfate (SO_4) mg/l	10	13	14	17	17	10
Chloride (Cl) mg/l	3.0	3.0	1.0	2.5	3.0	4.0
Fluoride (F) mg/l	.2	.2	.2	.2	—	—
Nitrate (NO_3) mg/l	.9	.4	.3	1.0	—	—
Phosphorous (as PO_4) mg/l	—	.04	.10	.03	—	—
Dissolved solids* mg/l	213	203	204	204	—	—
Hardness (as $CaCO_3$) mg/l	196	186	194	190	152	144
Noncarbonate Hardness	6	14	7	16	8	6
Specific Conductance**	363	348	373	359	300	265
pH	7.9	7.6	7.5	7.3	8.2	7.9
Discharge at time of sampling (cfs)	167	262	174	220	422	205

*Calculated
**Micromhos per centimeter at 25°C

QUALITY OF WATER

SUMMARY

The following table summarizes the quality of water characteristics of the Sturgeon River and shows how these characteristics are related to recreational uses.

Recreational use	Relation of Quality of Water to recreational use	Quality of Water in Sturgeon River
Trout fishing	Temperature Criteria for intrastate waters, as established January, 1968, by the Water Resources Commission, Michigan Department of Conservation (1968) specify 21.1°C (70°F) as the maximum limit for intolerant fish (cold-water species).	Maximum temperatures of the Sturgeon near Wolverine occasionally exceed 21.1°C (70°F) during summer months.
	Dissolved Oxygen The Water Resources Commission (1968) specifies a minimum of 6 mg/l. At water temperatures above 20°C (68°F), Tarzwell (1957) indicated full air saturation is required for the full range of activity for brook trout.	Dissolved oxygen in the Sturgeon probably does not drop below 7mg/l at any time. At night it may drop 1 to 2 mg/l below saturation.
	Hydrogen Ion Concentration (pH) Water Resources Commission (1968) specifies limits of 6.5 and 8.8.	pH of Sturgeon River generally ranges from 7.3 to 8.2.
	Nutrients (chiefly nitrates and phosphates) Water Resources Commission (1968) requires nutrients to be limited to the extent necessary to prevent stimulation of growths of algae, weeds, and slime, which are or may become injurious to the designated use. Because these nutrients are rather quickly taken up by plants, exact limits of desirable concentrations are difficult to determine.	Sturgeon River is generally free of undesirable weeds, algae, and slime.
Trout fishing, boating, camping, and cabin-living	Floating, Settleable, and Suspended Solids Water Resources Commission (1968) specifies that there should be no objectionable unnatural turbidity, color, or deposits sufficient to interfere with designated use; no floating solids, or evidence of residues of unnatural origin.	Sturgeon River generally appears to be free of floating solids and residues of unnatural origin. Turbidity and color generally are low, except during high flows.

OUTLOOK FOR THE FUTURE

Although the Sturgeon is one of the most accessible trout streams in Michigan, paralleling the heavily-traveled I-75 between Gaylord and Indian River, it is not very heavily used by either fishermen or boaters, except during the spring Steelhead runs. Most of the river below Wolverine is too fast and narrow for easy wading, and public access is limited by private holdings in the upper reaches. The high velocity and narrow channel below Wolverine and numerous portages in the upper reaches discourage most inexperienced canoeists.

The river should continue to provide recreational opportunities to the public for many years. However, the very small amount of public frontage on the river leaves most of the river banks susceptible to overdevelopment. Overdevelopment could cause an increase in suspended sediment, water temperature, and pollutants with a corresponding decrease in dissolved oxygen, thereby reducing the recreational value of the river.

GLOSSARY

Discharge	Rate of flow in volume per unit of time.
Ground moraine	Gently rolling hills underlain by till. Usually lack the ridgelike character of moraines.
Ground water	Water in earth materials in the zone of saturation—below the water table.
Lake beds (glacial)	The bottom surface of abandoned lakes that were formed by glacial meltwaters. Usually underlain by layered deposits of sand, silt, and clay.
Moraine	Hills or ridges composed of glacial till.
Outwash	Sorted and bedded glacial drift deposited by meltwater streams beyond active glacial ice.
Riffle	A shallow extending across the bed of a river; a small rapid.
Stage	Elevation of water surface above any chosen datum plane; water level; gage height.
Till	Mixture of clay, silt, sand, gravel, and stones deposited directly by glacial ice with little or no sorting by meltwaters.
Turbidity	Cloudiness of water.

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RECONNAISSANCE OF THE STURGEON RIVER, A COLD WATER RIVER IN THE NORTHCENTRAL PART OF MICHIGAN'S SOUTHERN PENINSULA

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

1971

For sale by U. S. Geological Survey, price $ 1.25 per set