INTRODUCTION

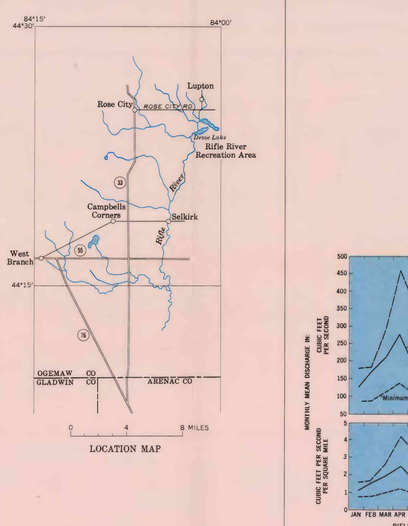
The cold-water streams of the northern states provide unique recreational values to the American people (wilderness or semi-wilderness atmosphere, fact-water canoeing, trout fishing). But expanding recreational needs must be balanced against the growing demand of water for public and industrial supplies,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

The Rifle River in Ogemaw County is a first-class trout stream and a popular canoe trail. The Rifle River Recreation Area, located about 4 miles east of Rose City, includes two rustic and one modern campground. South of the Recreation Area and about 2 miles north of Selkirk is another campground with rustic accomodations on both sides of the river. The main branch of the Rifle River begins at the west end of Devoe Lake near Lupton, and the river flows generally southward into Arenac County, then turns east and southeast to discharge into Saginaw Bay. Because of the greater abundance of hydrologic data in the drainage basin above Selkirk, only that part of the basin above Selkirk is included in this report.

The upper reaches of the Rifle can be reached by driving east from Rose City on Rose City Road. The middle reaches of the river are about 8 miles east of West Branch near Michigan Highway 55.

The recreational value of the Rifle depends on its characteristics of streamflow, water quality, and bed and banks. The purpose of this atlas is to describe these characteristics and to show how they relate to recreational use.

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



LOCATION MAP

STREAMFLOW

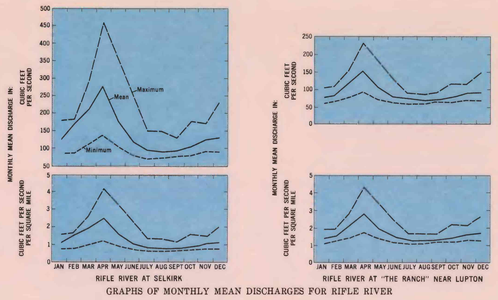
INTRODUCTION

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 discharge 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, usually, in high velocities. Velocity also varies in different reaches of the river, velocity generally being greater in reaches of steep fall than in the flatter reaches; and greater in shallow riffles than in deep pools.

DISCHARGE

Continuous records of discharge have been obtained since 1950 on the Rifle near Lupton and at Selkirk, and on two major tributaries, Houghton and Prior Creeks. Since 1951, records have been obtained on the South Branch Shepards Creek, a minor tributary south of Selkirk. Also, measurements have been made at 33 sites to determine differences in base flow in various segments of the Rifle and tributaries.

A graphic summary of streamflow at the five recording stations is shown below. The graphs show mean monthly discharge in cubic feet per second (cfs) and in cubic feet per second per square mile (cfsm). Discharges expressed in terms of cubic feet per second per square mile can be used to compare the flow of streams having different drainage areas, or to compare different segments of the same stream.



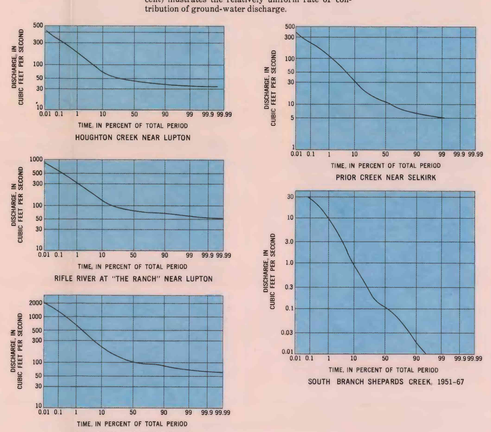
GRAPHS OF MONTHLY MEAN DISCHARGES FOR RIFLE RIVER

STREAMFLOW

FLOW DURATION CURVES

Discharge characteristics of streams can be illustrated graphically by flow-duration curves that show the percentage of time that specified discharge rates were equaled or exceeded. Flow-duration curves for 5 stations on the Rifle River and tributaries are shown below. These curves are based on discharge records for water years 1951 through 1967. In general the steeper the slope of the curve, the more variable the flow. The Rifle River and Houghton Creek near Lupton and Rifle River at Selkirk have relatively uniform flows; whereas Prior Creek near Selkirk and the South Branch Shepards Creek have relatively variable flows. The variability may be expressed as the ratio of the 90 percent to the 10 percent duration discharge. The ratios range from only 0.025 on South Branch Shepards Creek to 0.56 on Houghton Creek near Lupton.

The shape of the flow-duration curves for the Rifle River and Houghton Creek illustrates the rapid overland runoff and sustained base flow, as has been noted in the section on "Geologic Setting." The steeper part of the curve (durations less than about 20 percent) results from rapid overland runoff following periods of rainfall or snowmelt. The flatter part of the curve (durations greater than 20 percent) illustrates the relatively uniform rate of contribution of ground-water discharge.



GRAPHS SHOWING FLOW DURATION CURVES

STREAMFLOW

VELOCITY

Velocity of flow of the Rifle River and tributaries varies from place to place, obviously faster in the shallow riffles than in the deep pools. Velocity normally is faster near the surface in mid-channel than near the bed and banks of the stream. Velocity also varies with discharge at any given cross section. Normally an increase in discharge is accompanied by an increase in mean velocity.

Maximum and minimum velocities in cross-section at several sites on the Rifle and tributaries as measured on August 28 and 29, 1968, are listed below. These sites were selected for base-flow discharge measurements, and no attempt was made to measure the fastest reaches in the stream. However, it appears unlikely that velocities greater than 3 to 4 feet per second will be found in the area of study during normal summer flows.

Velocities on the Rifle River and tributaries, August 28, 29, 1968

Station No.	Stream and location	Velocity in cross section, in feet per second*	
		Maximum	Minimum**
1386.70	Rifle River below Devoe Lake	2.76	1.17
1387.10	Houghton Creek near Rose City	2.29	.21
1389.50	Houghton Creek near Rose City	1.65	.49
1395.20	Rifle River below "The Ranch"	1.63	.29
1396.00	Rifle River near Selkirk	2.08	.18
1396.50	Rifle River near Selkirk	2.47	.27
1398.00	Prior Creek at Morrison Road	1.17	.24
1402.50	Klacking Creek near Selkirk	.91	.11
1404.00	Klacking Creek near Selkirk	2.21	.28

* All velocity measurements at about mid-depth. Surface velocities generally are greater, bottom velocities are generally smaller.
** Zero velocities near banks at several sites not included.

QUALITY OF WATER

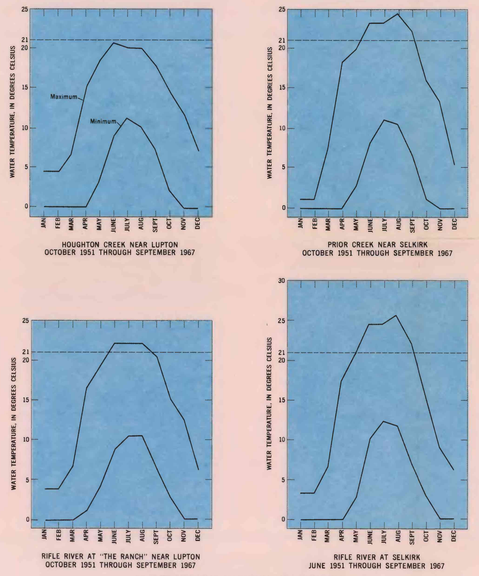
INTRODUCTION

The quality of water in a river is one of the essential factors in determining its recreational values. Quality of water is expressed in terms of dissolved and suspended substances and physical properties of the water. Dissolved substances are solids and gasses in the water; suspended materials include all undissolved materials, chiefly clay, silt, sand, and organic materials moved in the stream. Dissolved materials especially important to recreational values are dissolved oxygen, nutrients, and phosphates. Physical properties important to recreational values are temperature, pH, and specific conductance.

The following sections discuss each of these parameters of water quality. A summary table describes their relation to recreational use.

TEMPERATURE

Temperature of water is a critical requirement for trout habitat. Temperature records at four stations on the Rifle and tributaries are summarized graphically below.



GRAPHS SHOWING MAXIMUM AND MINIMUM MONTHLY WATER TEMPERATURES

QUALITY OF WATER

NUTRIENTS (NITRATES AND PHOSPHATES)

Nutrients, chiefly nitrates and phosphates, influence the amount and variety of plant and animal life in the stream. By stimulating growth of water plants nutrients also strongly influence the dissolved oxygen in the water. Nutrient values normally are low in summer because they are used up by submerged plants. Heavy spring rains, with resultant surface runoff, may wash in nutrients from fertilizers applied to agricultural lands.

A number of samples collected on the Rifle and tributaries in July, 1968 showed nitrates ranging from 0.5 to 1.0 mg/l (see table of analyses). These rather high values for this time of year possibly resulted from in-wash of agricultural fertilizers. Organic wastes from farms, homes, and campgrounds also may have contributed to the nitrate content.

pH

The pH of water is an indicator of its acidity or alkalinity. Waters with a pH of 7.0 are said to be neutral. A pH lower than 7.0 indicates acid water; a pH higher than 7.0 indicates alkaline water. The water in the Rifle River and tributaries is moderately alkaline, with pH values in the study area ranging from about 8.1 to 8.5.

SPECIFIC CONDUCTANCE

The specific conductance of water is an indicator of the concentration of dissolved solids. It is useful in measuring gross differences in the dissolved load of a stream. Specific conductance of several samples in the study area ranged from about 370 to 415 micromhos.

SUSPENDED AND FLOATING SOLIDS

No measurements were made of suspended and floating solids in the Rifle and tributaries. No objectionable floating solids have been reported in the main stream of the Rifle, but floating solids from sewage wastes have been reported in Houghton Creek. Suspended sediments, as indicated by visual estimate of turbidity are generally low, except after heavy rains, when the water becomes cloudy.

OTHER DISSOLVED SOLIDS

The chemical analyses tabulated below are typical of relatively unpolluted streams of this area. The water is of the calcium-bicarbonate type, quite hard, with moderate amounts of sulfates and minor amounts of chlorides (see table below).

STREAMFLOW

ACKNOWLEDGMENTS

Much of the information presented here was obtained from basic records of the U.S. Geological Survey's Water Resources Division. Additional information was obtained in field reconnaissance surveys in the summer and fall of 1968. Mr. Robert Larson assisted the authors in mapping the physical character of the tributaries of the Rifle. The study was made in cooperation with the Michigan Geological Survey, Gerald E. Eddy, chief. Assistance was also obtained from other sections of the Michigan Department of Natural Resources.

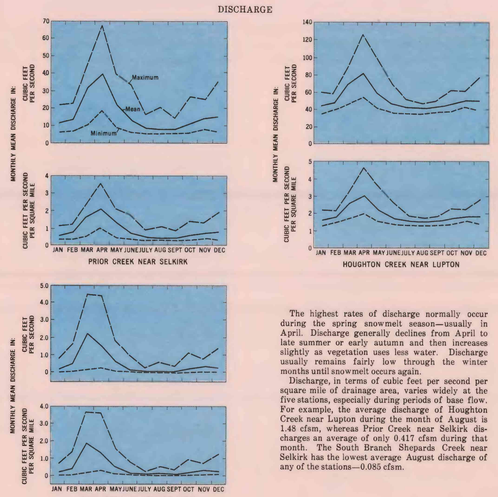
GEOLOGIC SETTING

The surface drainage area of the Rifle River above Selkirk includes 117 square miles, about three-fourths of which is underlain by moraine and ground moraine of relatively low permeability. The remaining one fourth is underlain by relatively permeable sand and gravel outwash. The dominant topographic feature of the basin is the massive West Branch Moraine which forms the highlands in the west and north parts of the basin. West and north of the West Branch Moraine are large areas of high-level outwash plains. To the east of the river is the relatively-low Gladwin Moraine. The central part of the basin, from Lupton to Selkirk, is an outwash plain of low relief. Tributaries from the west and north cut into the heavy clay till on the steep inner slope of the West Branch Moraine and flow across lower areas of rolling ground moraine and flat outwash plains to discharge into the Rifle River. The few small tributaries which enter from the east drain the heavy clay till of the Gladwin Moraine. The soils in the moraine and ground moraine areas are chiefly loam and sandy loam over clay subsoil; soils in the outwash areas are sand and peat over sand subsoil.

The predominance of moraine and ground moraine of low permeability in the upper Rifle basin results in large surface runoff following heavy rains and snowmelt. The base flow contributed by ground-water discharge in the Rifle and most tributaries from west and north also is large—larger than the glacial materials in the basin would be expected to contribute. A probable source contributing to this large base flow is the high-level outwash to the west and north of the topographic divide (basin boundary). It appears that the ground-water divide between the Rifle and adjacent streams extends further west and north than the topographic divide. As a result, the area contributing to base flow of the Rifle is substantially larger than the area contributing to surface runoff.

STREAMFLOW

DISCHARGE



GRAPHS OF MONTHLY MEAN DISCHARGES FOR TRIBUTARIES

The highest rates of discharge normally occur during the spring snowmelt season—usually in April. Discharge generally declines from April to late summer or early autumn and then increases slightly as vegetation uses less water. Discharge usually remains fairly low through the winter months until snowmelt occurs again.

Discharge, in terms of cubic feet per second per square mile of drainage area, varies widely at the five stations, especially during periods of base flow. For example, the average discharge of Houghton Creek near Lupton during the month of August is 1.48 cfsm, whereas Prior Creek near Selkirk discharges an average of only 0.417 cfsm during that month. The South Branch Shepards Creek near Selkirk has the lowest average August discharge of any of the stations—0.085 cfsm.

STREAMFLOW

FREQUENCY OF LOW FLOW

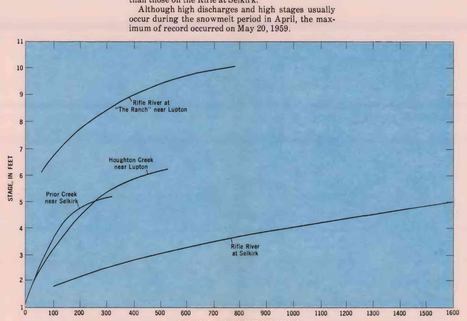
The frequency of low flow on the Rifle River and tributaries is of interest to recreationists, because periods of excessively low flow are generally unfavorable for most recreational uses. The curves below show frequency of low flow for periods of 1, 7, 15, and 30 days on the Rifle River at Selkirk, Houghton Creek near Lupton, and Prior Creek near Selkirk. The graph for the Rifle at Selkirk shows, for example, during the period May through October that we may expect a discharge no greater than 75 cfs for 7 consecutive days about once every 3 years. About once every 10 years we expect a discharge no greater than 70 cfs for 7 consecutive days. Discharge of less than 75 cfs on the Rifle at Selkirk is unfavorable for canoeing because canoes may scrape bottom in the shallow riffles. Many trout fishermen are less successful during periods of low flow than at other times, but others are not so affected. Any harmful effects that may be caused by sewage and other wastes which may enter the river are more pronounced during periods of low flows. For example the effects of discharge of raw sewage into Houghton Creek will be magnified when discharge of Houghton Creek near Lupton is less than 35 cfs. Such a discharge can be expected to last for 7 days about once over 4 years and for 15 days about once every 11 years.

STREAMFLOW

STAGE

The stage, or water level, of the Rifle and tributaries fluctuates with discharge. Stage-discharge relations at four gaging stations are shown graphically below. The relation of stage to discharge at any station varies somewhat because of ice effects and influence of vegetation. The range in stage on the Rifle River at Selkirk for the period of record, 1950-68, is about 5 feet. Most years the range is only 2 to 3 feet. Ranges in stage on the Rifle near Lupton, and at the stations on Prior and Houghton Creek are about the same or a little less than those on the Rifle at Selkirk.

Although high discharges and high stages usually occur during the snowmelt period in April, the maximum of record occurred on May 20, 1959.



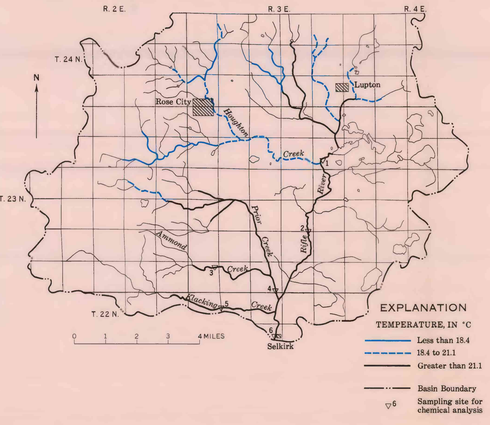
GRAPH SHOWING STAGE-DISCHARGE RELATIONS

QUALITY OF WATER

TEMPERATURE

The temperatures are controlled chiefly by climate and by the amount of ground-water inflow and the exposure of the water surface to sunlight. Houghton Creek near Lupton, which has the highest average August discharge per unit drainage area (1.48 cfsm), has the lowest maximum water temperature. Prior Creek, with the lowest average August discharge (0.417 cfsm), has the second highest maximum water temperature. The highest maximum water temperature is on the Rifle River at Selkirk, which has the second lowest average August discharge (0.839 cfsm). The high temperature here is attributed to the greater exposure of the water to sunlight because of the longer distance of travel, the broader reaches of stream, and the lakes that contribute to the flow

To supplement the temperature records obtained at the gaging stations, records of maximum and minimum temperatures were obtained at several sites on the Rifle River and tributaries during the summer of 1951. The maximum temperatures during the period July 23 through July 25 are marked on the map below. In general, water temperatures increase downstream as the area and time of exposure to the sun increase. Exceptions to this general rule are attributed to increased ground-water inflow or to additions from a cooler tributary. The influence of discharge from lakes and ponds is to increase the maximum water temperature.



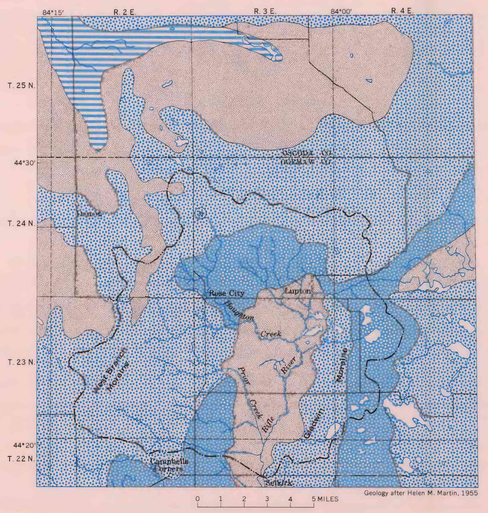
MAP SHOWING MAXIMUM WATER TEMPERATURES, JULY 25 THROUGH JULY 27, 1951

QUALITY OF WATER

CHEMICAL QUALITY OF WATER, RIFLE RIVER AND TRIBUTARIES, JULY 26, 1968

Site No.	Stream and location	Bicarbonate, mg/l	Sulfate, mg/l	Chloride, mg/l	Nitrate, mg/l	Dissolved solids, mg/l (calculated)	Hardness (as CaCO3), mg/l	Specific conductance (micromhos at 25°C)	pH
1	Rifle River at "The Ranch" near Lupton SE¼SW¼ sec. 11 T. 23 N., R. 3 E.	227	28	3.8	0.59	245	202	395	8.1
2	Rifle River at Sage Lake Road SE¼SE¼ sec. 22 T. 23 N., R. 3 E.	229	32	3.5	1.01	244	205	395	8.2
3	Ammond Creek at Morrison Road NE¼NE¼ sec. 31 T. 23 N., R. 3 E.	239	15	2.0	.63	229	190	370	8.2
4	Prior Creek near Selkirk SE¼SE¼ sec. 33 T. 23 N., R. 3 E.	239	15	4.0	.77	-	203	395	8.3
5	Klacking Creek at Morrison Road SE¼NE¼ sec. 4 T. 22 N., R. 3 E.	227	40	1.5	.48	257	222	415	8.4
6	Rifle River at Canoe Landing at Selkirk NE¼SE¼ sec. 9 T. 22 N., R. 3 E.	229	31	4.0	.73	242	205	390	8.4

GEOLOGIC SETTING



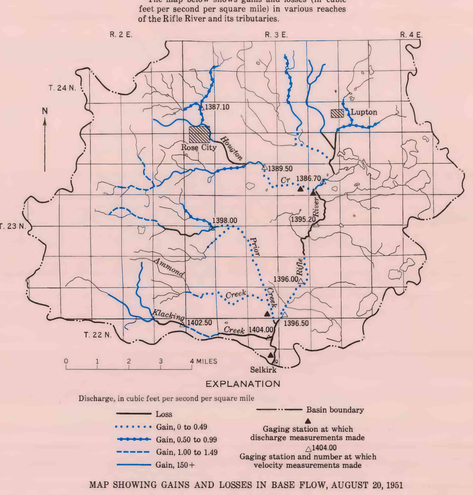
SURFICIAL GEOLOGIC MAP

STREAMFLOW

BASE FLOW

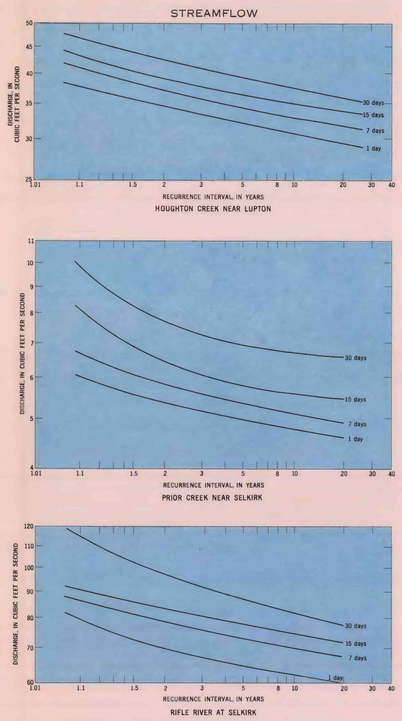
Miscellaneous base-flow measurements at other sites show even greater differences in discharge per unit area. As indicated above, the probable explanation for the very large base-flow discharge per unit drainage area at some sites is that the area contributing ground-water discharge is much larger than the area contributing surface runoff.

The map below shows gains and losses (in cubic feet per second per square mile) in various reaches of the Rifle River and its tributaries.



MAP SHOWING GAINS AND LOSSES IN BASE FLOW, AUGUST 20, 1951

STREAMFLOW



GRAPHS SHOWING FREQUENCY OF LOW FLOW (MAY-OCTOBER)

STREAMFLOW

SUMMARY

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

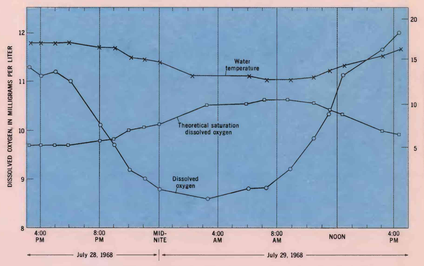
Recreational use	Relation of streamflow to recreational use (Prepared by the Michigan Department of Natural Resources)	Characteristics of Rifle River
Trout fishing	High drought flow helps keep summer water temperatures low. Excessive floodflow removes cover and may cause erosion of banks.	Drought flow in Rifle and most tributaries is high. Prior Creek and South Branch Shepards Creek have low drought flows. Flood flows cause some bank erosion where not protected by vegetation or rip-rap.
	A variety of fast and slow reaches adds interest to Fishermen. Excessively high velocities make wading dangerous.	Velocity varies in different reaches. Generally not too fast for safe wading in the study area except at high water stages.
	Abrupt and large increases in stage are a hazard to wading fishermen.	Increase in stage at flood times, such as on May 20, 1959, makes much of the main stem and tributaries unwadable. Increases in stage generally are not abrupt, but increases as great as 2 to 4 feet in 24 hours have been recorded on the Rifle at Selkirk.
Boating	Boating season reduced by periods of flood and drought.	Flood season usually over before vacation season, but occasional floods occur during late spring. Low late summer drought flows may discourage boating.
	A variety of fast and slow reaches adds interest to boaters.	Alternating riffles and pools make boating interesting for novice. No rapids above Selkirk to challenge the expert.
	Low velocity makes upstream travel easier.	Velocity too fast for easy upstream travel in riffles.
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

DISSOLVED OXYGEN

Dissolved oxygen is another critical requirement of the trout fishery, and is also a general indication of the concentration of organic wastes in the water. Water saturated with dissolved oxygen contains about 14 mg/l (milligrams per liter) at temperature just above freezing. As the water is warmed its capacity to hold dissolved oxygen decreases, and at a temperature of 21.1°C (70°F) the saturation capacity is only 9 mg/l. In summer, the effects of dissolved oxygen released by submerged plants may mask the effect of temperature.

Dissolved oxygen was measured periodically for 24 hours in July, 1968, at the campsite on the Rifle about 2 miles north of Selkirk. Dissolved oxygen was 1 to 2 mg/l greater than saturation during most of the daylight hours and dropped to 1 to 2 mg/l less than saturation at night. Measured dissolved oxygen ranged from 8.6 to 11.9 mg/l. This is a normal range for an unpolluted cold-water stream with a moderate density of bottom vegetation.



GRAPH SHOWING DISSOLVED OXYGEN AND WATER TEMPERATURE, RIFLE RIVER AT CAMPSITE IN SE¼ SECTION 27, T. 23 N., R. 3 E.

The Rifle River probably receives a very small amount of organic wastes except for that from Houghton Creek, which receives untreated sewage from Rose City. No records were obtained of dissolved oxygen in Houghton Creek, but it appears that any effects of the raw sewage on dissolved oxygen in Houghton Creek are minimal or absent by the time the water reaches the main stream of the Rifle.

QUALITY OF WATER

SUMMARY

The following table summarizes the quality of water characteristics of the Rifle 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 Rifle River
Trout fishing	**Temperature**	
	Criteria for intrastate waters, as established January, 1968, by the Water Resources Commission Michigan Department of Natural Resources (1968) specify 70°F (21.1°C) as the maximum limit for intolerant fish (cold-water species).	Maximum temperatures at most stations on the Rifle and tributaries occasionally exceed 70°F (21.1°C). Maximum temperatures on Prior Creek exceed 70°F (21.1°C) on many warm summer days each year.
	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 on the Rifle and tributaries probably does not fall below 6 mg/l at any time. At night may drop 2 mg/l below saturation.
	Hydrogen ion concentration (pH)	
	Water Resources Commission (1968) specifies limits of 6.5 and 8.8.	pH of the Rifle River and tributaries generally range from about 8.1 to 8.5.
	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.	Rifle River and tributaries are generally free from undesirable weeds, algae, and slime. Chemical analyses indicate relatively high nitrate content during season of spring runoff.
Trout fishing, boating, camping, and cabin-living	**Floating, settleable, and suspended solids**	
	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.	Rifle River and most tributaries appear to be free of floating solids and residues of unnatural origin. Houghton Creek occasionally shows evidence of floating solids from sewage wastes. Turbidity is moderately high during spring runoff and after heavy rains.

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INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972—W70473

RECONNAISSANCE OF THE RIFLE RIVER, A COLD-WATER RIVER IN THE NORTHEASTERN PART OF MICHIGAN'S SOUTHERN PENINSULA

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

1972

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