LAKE HURON BASIN

CASS RIVER - MICHIGAN

WATER QUALITY DATA
1965 SURVEY

Clean Water Series DPO-14-C

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region

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JULY 1968

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Detroit Program Office
U.S. Naval Air Station
Grosse Ile, Michigan
48138

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INTRODUCTION

The water quality data contained in this report are the results of field investigations and other studies conducted in 1965 and 1966 to provide information for a water pollution control plan for the Lake Huron Basin. The Lake Huron Basin Study is a part of the Great Lakes-Illinois River Basins Project, directed by the Great Lakes Region, Federal Water Pollution Control Administration (FWPCA) and under authority of Public Law 84-660 (33 U.S.C. 466 et seq.).

> Sec. 3. (a) The Secretary shall, after careful investigation, and in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved, prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. For the purpose of this section, the Secretary is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial wastes, or substance which may adversely affect such waters.

Total water quality planning begins in the headwaters of the individual river basins and continues downstream through the major tributaries to and including the Great Lakes. The extent and complexity of the Great Lakes and tributaries are shown on Figures 1, 2, and 3.

Water quality standards for interstate waters (Lake Huron) have been adopted by the State of Michigan and approved by the Secretary

of the Interior. Intrastate standards for Michigan are being implemented by the Michigan Water Resources Commission. These standards will form a basis for long-range plan for controlling pollution and maintaining water quality for Lake Huron and its tributaries.

ACKNOWLEDGMENTS

The principal agencies taking an active part in providing assistance in the preparation of the report are as follows:

State Agencies - Michigan Water Resources Commission
Michigan Department of Public Health

Federal Agencies - U.S. Department of Commerce
Weather Bureau
Office of Business Economics
Bureau of Census

U.S. Department of the Interior
Bureau of Commercial Fisheries
Bureau of Sport Fisheries and Wildlife
Bureau of Outdoor Recreation
Geological Survey

For further information, contact the following:

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Michigan Water Resources Commission
Reniger Building
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3500 N. Logan
Lansing, Michigan 48914

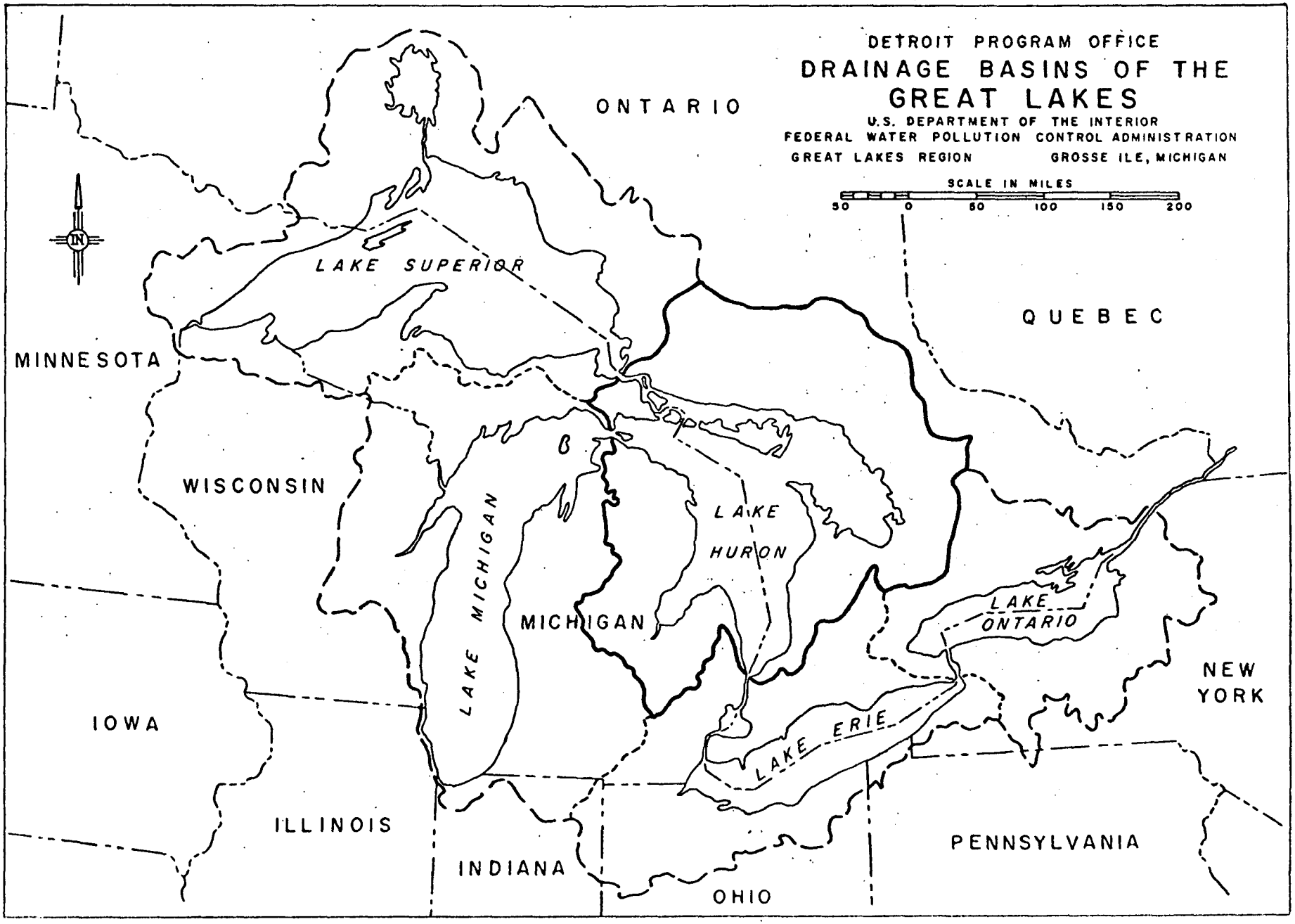
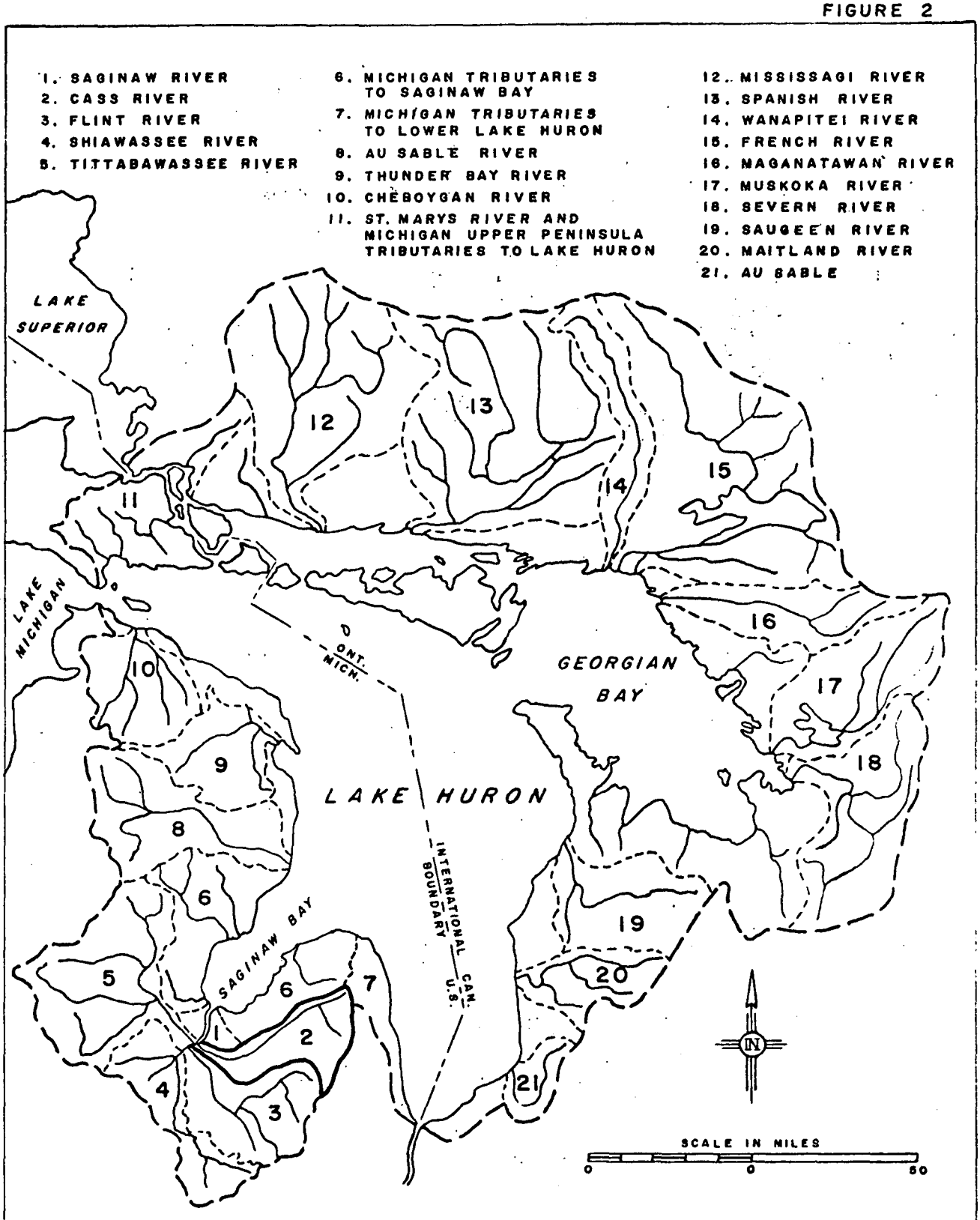

DETROIT PROGRAM OFFICE
DRAINAGE BASINS OF THE GREAT LAKES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
GROSSE ILE, MICHIGAN
SCALE IN MILES
50 0 50 100 150 200
IN
ONTARIO
LAKE SUPERIOR
QUEBEC
MINNESOTA
WISCONSIN
LAKE MICHIGAN
LAKE HURON
MICHIGAN
LAKE ONTARIO
NEW YORK
IOWA
LAKE ERIE
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA

FIGURE I

FIGURE 2



DETROIT PROGRAM OFFICE

LAKE HURON BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

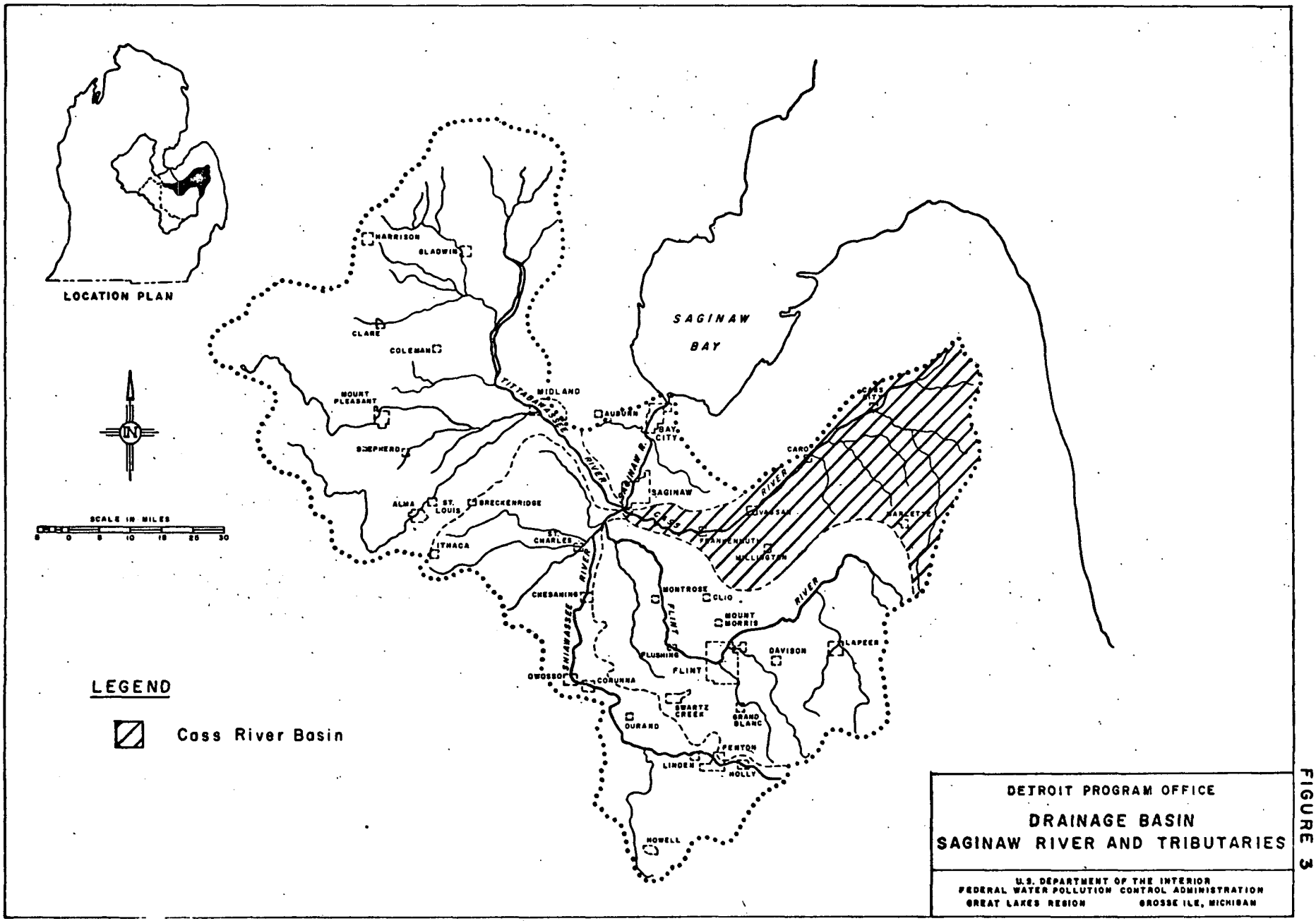

LOCATION PLAN
SCALE IN MILES
0 5 10 15 20 30
LEGEND
Coss River Basin
SAGINAW BAY
HARRISON
GLADWIN
CLARE
COLEMAN
MOUNT PLEASANT
SHEPHERD
MIDLAND
TITTABAWASSEE RIVER
AUBURN
BAY CITY
SAGINAW R.
SAGINAW
CARO
CASS CITY
CASS RIVER
VASSAR
BIRCH RUN
BAY CITY
FRANKENMUTH
MILLINGTON
BARLETTE
ALMA
ST. LOUIS
BRECKENRIDGE
ITHACA
ST. CHARLES
CHESANING
SHIAWASSEE RIVER
MONTROSE
CLIO
FLINT RIVER
MOUNT MORRIS
DAVISON
LAPEER
FLUSHING
FLINT
OWOSSO
CORUNNA
SWARTZ CREEK
GRAND BLANC
DURAND
FENTON
LINDEN
HOLLY
HOWELL
DETROIT PROGRAM OFFICE
DRAINAGE BASIN
SAGINAW RIVER AND TRIBUTARIES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
GROSSE ILE, MICHIGAN

FIGURE 3

GENERAL DESCRIPTION

Area Description

The Cass River Basin is located in the Thumb Area of Michigan's lower peninsula. The basin drains a total area of 948 square miles. The major portion of the basin lies in Tuscola and Sanilac Counties. The lower reach, from Frankenmuth to the mouth, lies in Saginaw County. Small portions of Huron, Lapeer, and Genesee Counties make up the remainder of the area drained by the Cass River.

The basin is irregularly shaped, varying in width from 15 to 35 miles, and measuring 55 miles at its longest point. The Cass River has three branches. The South Branch, originating in Lapeer and Sanilac Counties, flows in a northerly direction converging with the East Branch in the northwest section of Sanilac County. The East Branch joins the North Branch in Tuscola County to form the main stem. The Cass River flows southwesterly to Frankenmuth, then westerly to its mouth at the Saginaw River.

The Cass River Basin is bounded on the north by land adjacent to Lake Huron, on the east by the Black River Basin, on the south by the Flint River Basin, and on the west by the Saginaw and Flint River Basins.

There are no major population centers in the Cass River Basin. Caro, the largest community, had a population of 3,600 in 1960.

The Cass River Basin above Frankenmuth consists of moraine, sandy lake plains, outwash and till plain in equal portions. The till plain lies in the eastern headwaters region, and is flanked on the north and southwest by outwash-morainal sequences. The lake plain lies in the northern half of the Cass River Basin.

Climate

The climate of the Cass River Basin conforms to the general weather pattern that exists over the entire lower Great Lakes area. This climate is a result of the modifying influences of the large masses of water that nearly surround the region. These water masses tend to cool the air in the summer and warm it in the winter. The resulting climate can be described as one having many storms, wide seasonal temperature variation, and a constant yearly precipitation distribution. The precipitation in winter is usually in the form of snow. At Caro, the largest community in the Cass River Basin, average yearly temperature if 47°F, with average summer and winter temperatures of 69°F and 25°F, respectively. The average yearly precipitation at Caro is 28 inches. The growing season has a length of 145 days.

Hydrology

Location of U.S. Geological Survey Gages

There are four U.S. Geological Survey stream gaging stations in the Cass River Basin, three of which were utilized by the Federal Water Pollution Control Administration.

The first of these gaging stations is Cass River at Cass City, Michigan. It has a drainage area of approximately 370 square miles, and is located 500 feet downstream from the Cemetery Road bridge, one mile south of Cass City. It has been in operation from October 1947 to the present. Federal Water Pollution Control Administration sampling station X688 is located at the Cemetery Road bridge - mile point 59.2.

The second gaging station is Cass River at Vassar, Michigan. It is located on the downstream side of M-15 bridge in Vassar, has a drainage

area of approximately 700 square miles and has been in operation since October 1947. M-15 bridge, mile point 28.1, is the Federal Water Pollution Control Administration sampling station X650.

The third gaging station is Cass River at Frankenmuth, Michigan. It is located at mile point 17.0 on the right bank of the river, one-half mile downstream from Frankenmuth. The drainage area for this gage is 848 square miles and has been in operation continuously since June 1939, although discontinuous records exist for other time periods.

The ranges of observed discharges at these gaging stations are as follows:

Cass River at Cass City	Maximum -	8,460 cfs
	Average -	192 cfs
	Minimum -	0.5 cfs
Cass River at Vassar	Maximum -	11,400 cfs
	Average -	373 cfs
	Minimum -	11 cfs
Cass River at Frankenmuth	Maximum	17,700 cfs
	Average -	450 cfs
	Minimum -	1.5 cfs

Drought Flow

The one-day and seven-day low flows (once-in-ten years) have been calculated for the Cass River at two of the U.S. Geological Survey stations by use of Gumbel Extremal Probability Paper. Stations used were Cass River at Frankenmuth and Cass River at Vassar. The flow at the remaining points along the river was estimated by comparison of respective drainage areas with that of the U.S. Geological Survey stations (Table 1).

Because the dams on the Cass River at Frankenmuth and Caro had a pronounced effect on the one-day flow prior to 1946, only those flows in

the period 1948-1963 were used in this analysis. This results in a seven-day flow at Frankenmuth that is slightly higher than would have been expected had the entire period of record been used but also yields a one-day flow that is meaningful.

Figure 5 shows the mean daily flow at the U.S. Geological Survey gage at Frankenmuth for the period June through September 1965. Figures 6 through 8 are flow duration curves for the U.S. Geological Survey gages at Cass City, Vassar, and Frankenmuth. Figure 9 shows the river mile vs. drainage area relationship.

TABLE 1. DROUGHT FLOWS
CASS RIVER

Location	Drainage Area (sq. miles)	1-Day Flow (cfs)	7-Day Flow (cfs)
X650 USGS* gage at Vassar	700	16.0	19.0
Above Goodings Creek	703	16.1	19.1
Below Goodings Creek	760	17.4	20.7
Above Perry Creek	802	18.0	22.3
Below Perry Creek	840	18.7	23.7
Frankenmuth USGS* gage	848	19.0	24.0
X620	868	19.4	24.6
Above Dead Creek	872	19.5	24.7
Below Dead Creek	910	20.4	25.8
X615	918	20.6	26.0
X610	933	20.9	26.4
Mouth	948	21.2	26.8

* U.S. Geological Survey

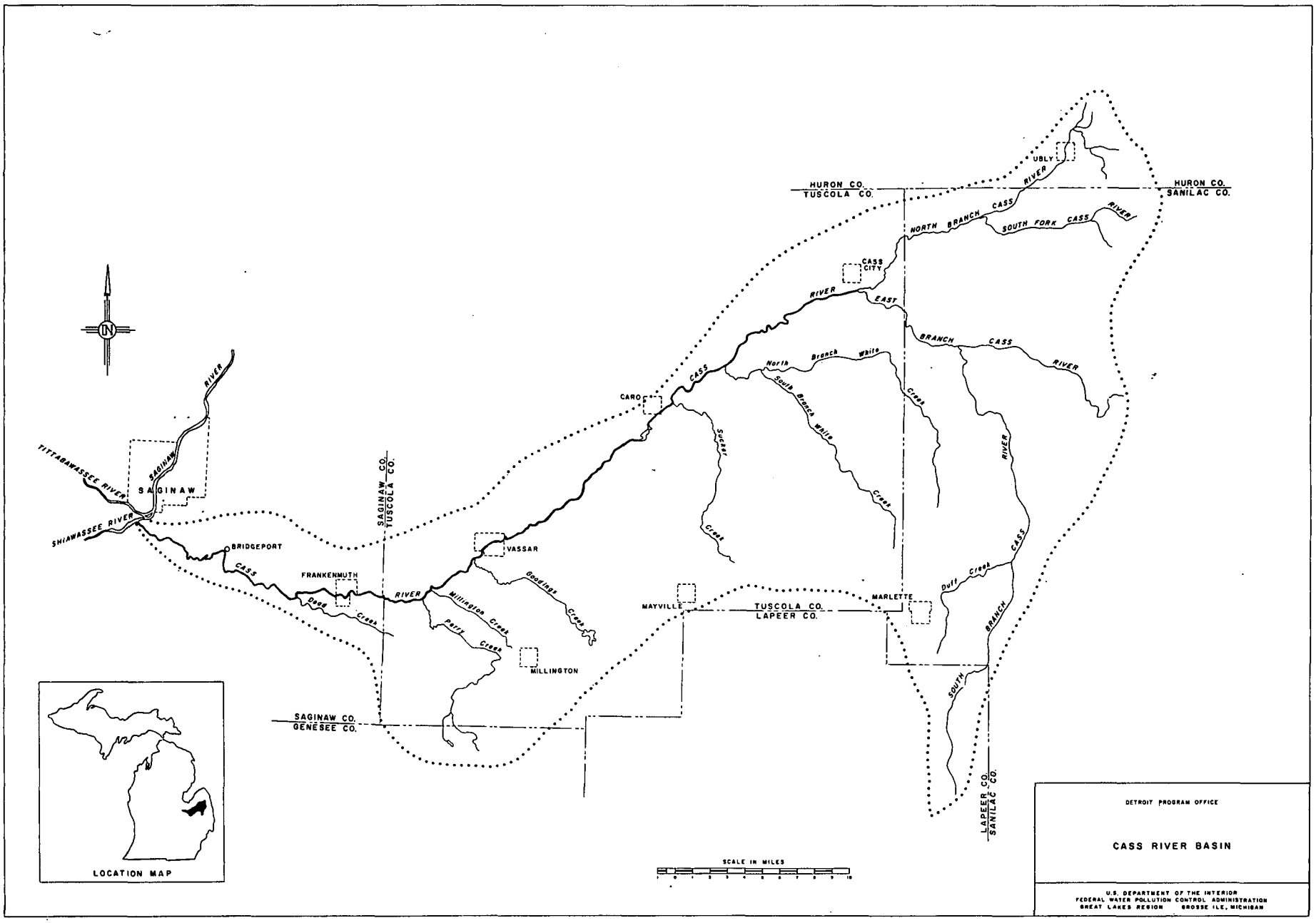

HURON CO.
TUSCOLA CO.
HURON CO.
SANILAC CO.
UBLY
CASS RIVER
NORTH BRANCH CASS RIVER
SOUTH FORK CASS RIVER
CASS CITY
EAST BRANCH CASS RIVER
CASS RIVER
CARO
North Branch White Creek
South Branch White Creek
Sugar Creek
CASS RIVER
SAGINAW
TITTABAWASSEE RIVER
SAGINAW RIVER
SHIAWASSEE RIVER
SAGINAW CO.
TUSCOLA CO.
BRIDGEPORT
VASSAR
FRANKENMUTH
CASS RIVER
Dogg Creek
Willington Creek
Patty Creek
Goodings Creek
MILLINGTON
MAYVILLE
TUSCOLA CO.
LAPEER CO.
MARLETTE
Duff Creek
CASS BRANCH
SOUTH
SAGINAW CO.
GENESEE CO.
LAPEER CO.
SANILAC CO.
LOCATION MAP
SCALE IN MILES
DETROIT PROGRAM OFFICE
CASS RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 4

MEAN DAILY FLOW
CASS RIVER AT FRANKENMUTH

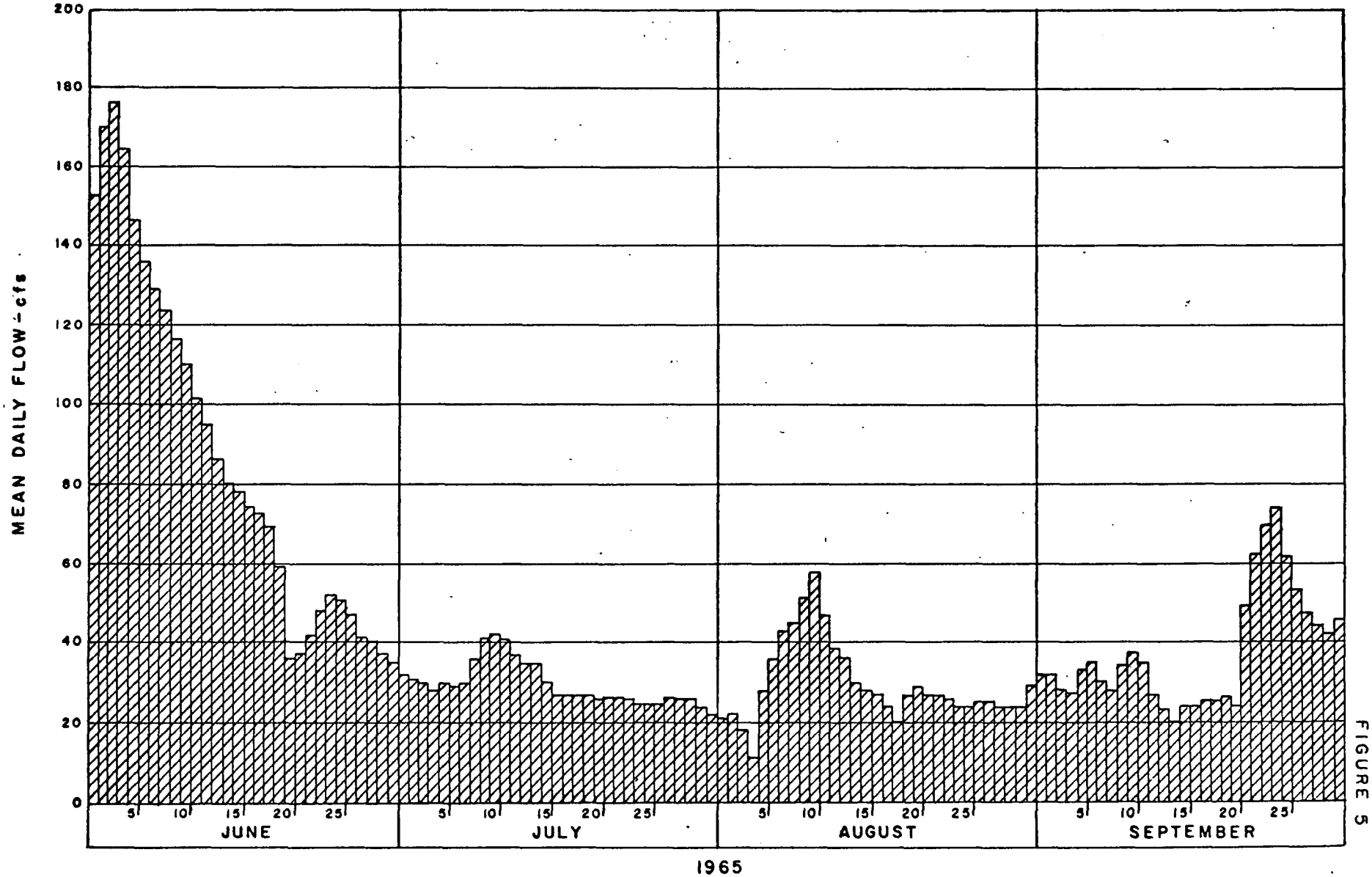


FIGURE 5

FIGURE 6

FLOW DURATION CURVE
CASS RIVER AT CASS CITY
1948–1964
370 Square Miles

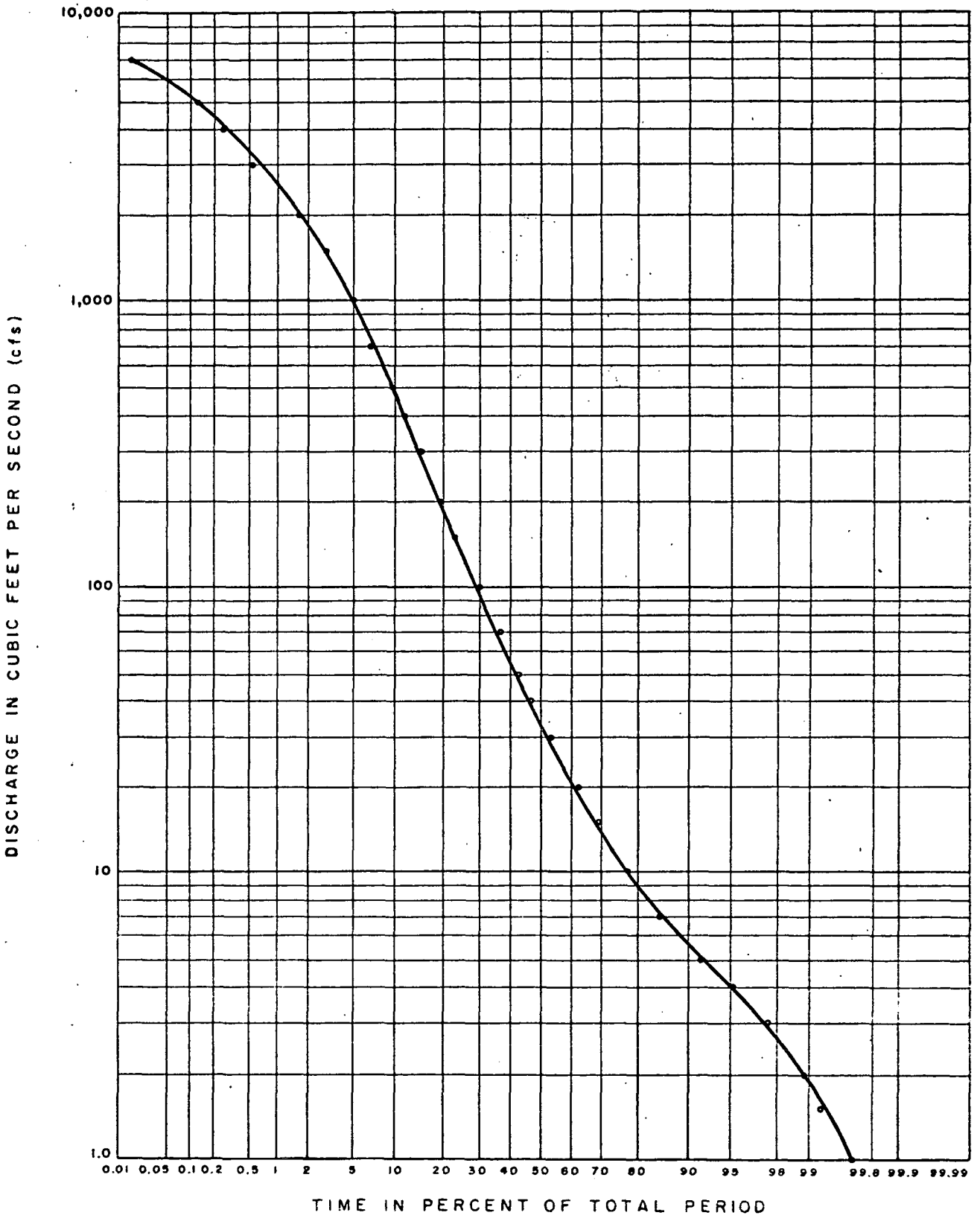


FIGURE 7

FLOW DURATION CURVE
CASS RIVER AT VASSAR
1949-1964
700 Square Miles

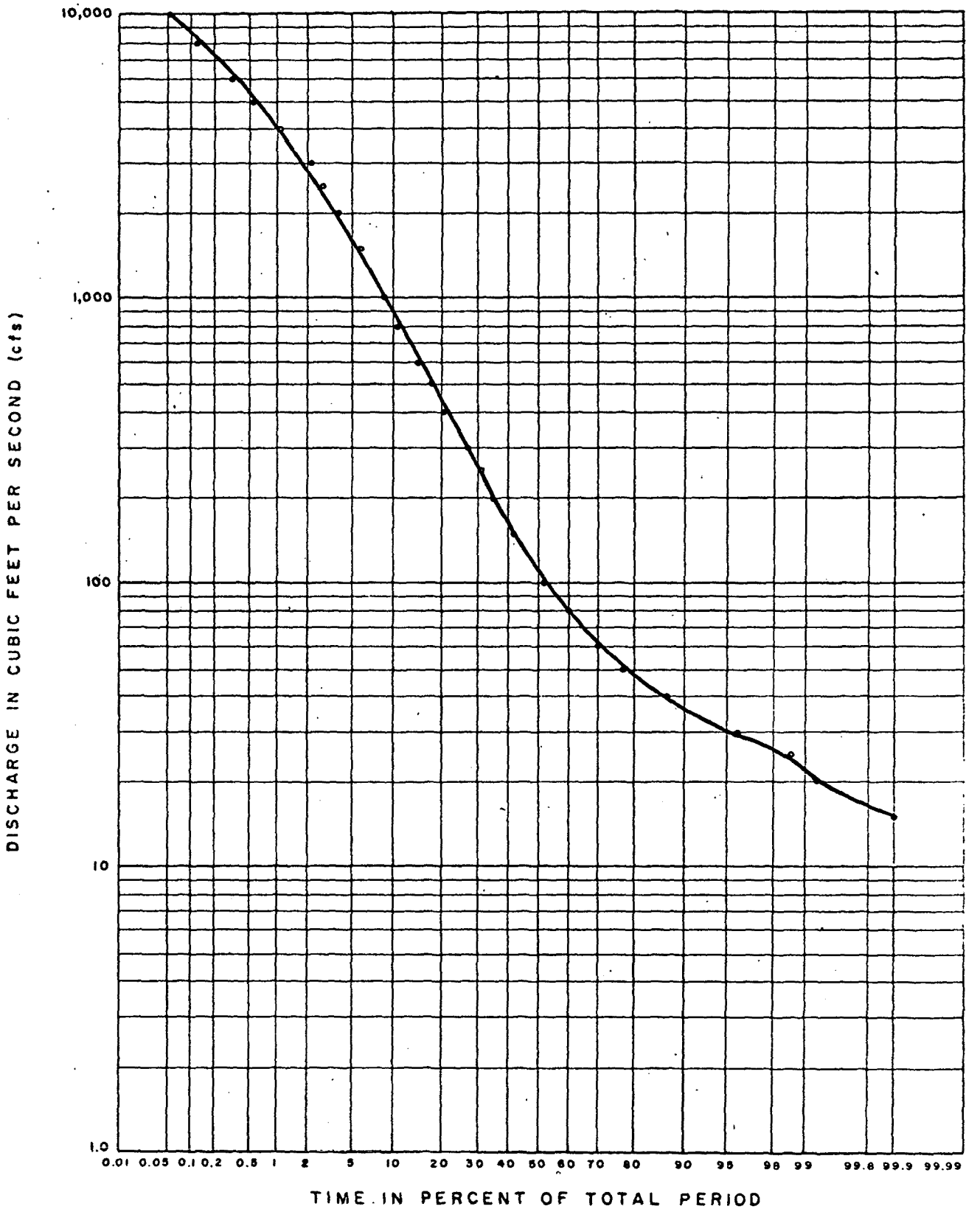
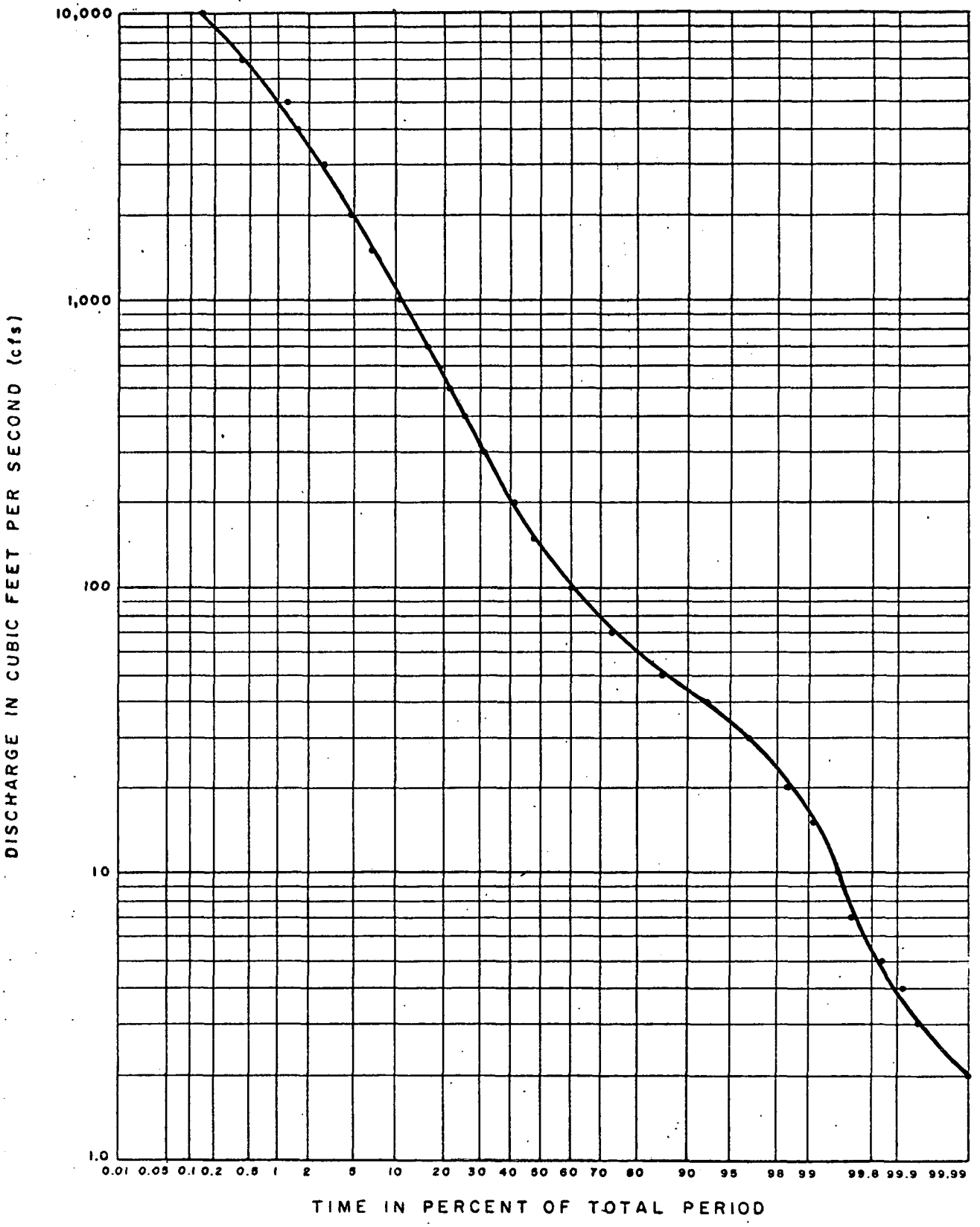


FIGURE 8

FLOW DURATION CURVE
CASS RIVER AT FRANKENMUTH
1936, 1940-1964
848 Square Miles



DRAINAGE AREA VS. RIVER MILES
CASS RIVER

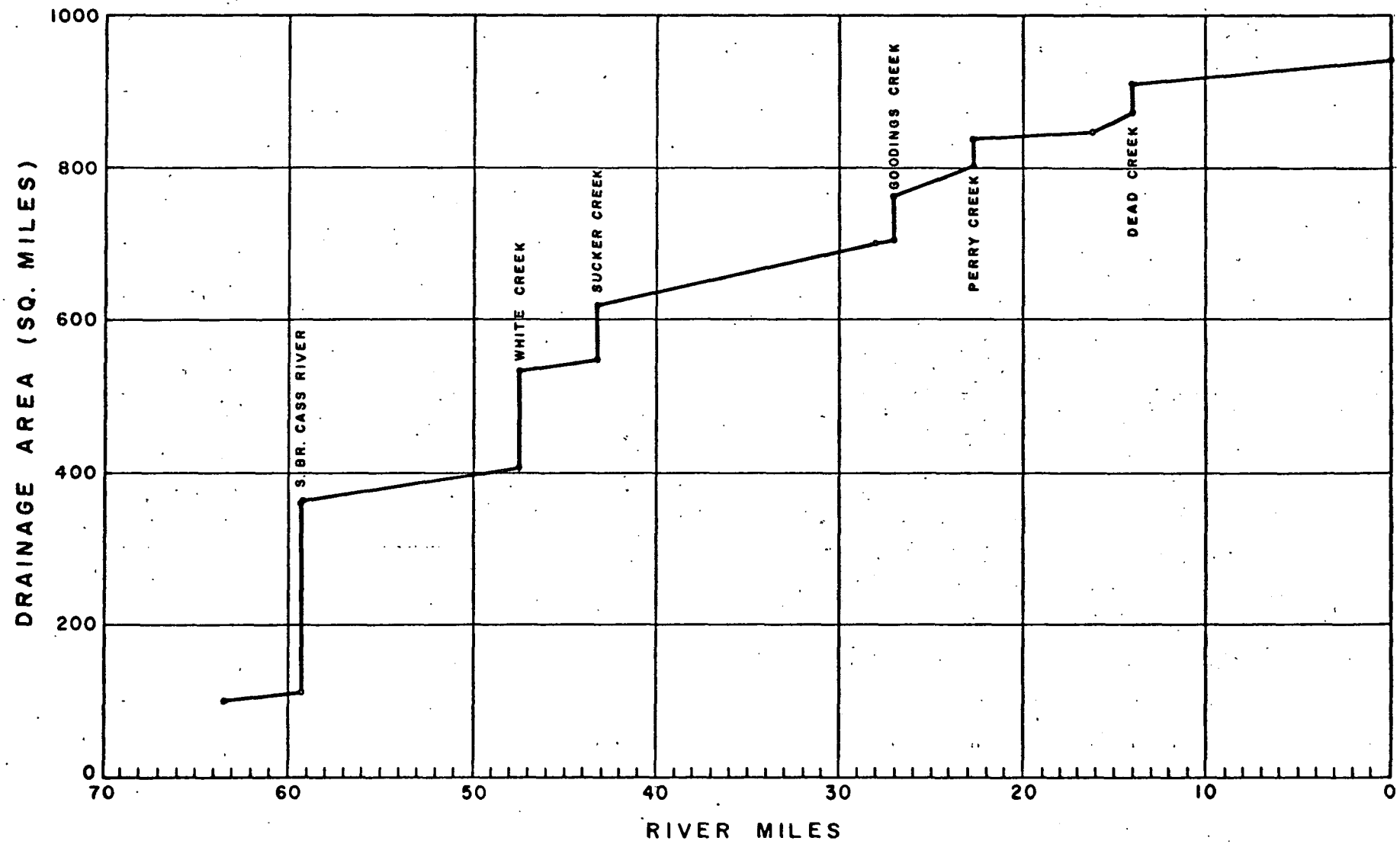


FIGURE 9

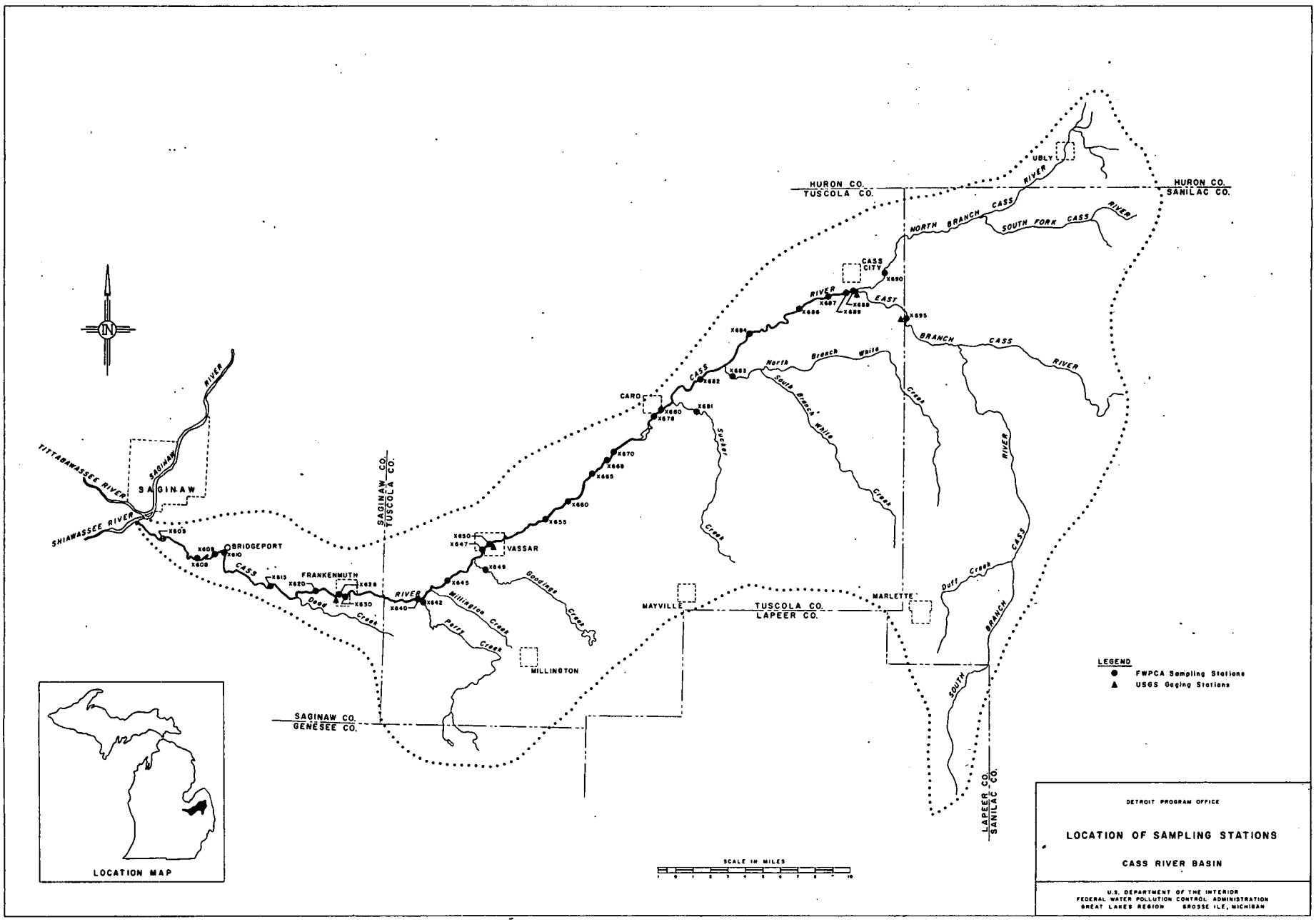

HURON CO.
TUSCOLA CO.
HURON CO.
SANILAC CO.
UBLY
CASS CITY
CARO
VASSAR
SAGINAW
BRIDGEPORT
FRANKENMUTH
MILLINGTON
MAYVILLE
MARLETTE
TUSCOLA CO.
LAPEER CO.
SAGINAW CO.
TUSCOLA CO.
SAGINAW CO.
GENESEE CO.
LAPEER CO.
SANILAC CO.
TITTABAWASSEE RIVER
SHIAWASSEE RIVER
SAGINAW RIVER
CASS RIVER
NORTH BRANCH CASS RIVER
SOUTH FORK CASS RIVER
EAST BRANCH CASS RIVER
North Branch White Creek
South Branch White Creek
Sucker Creek
Dead Creek
Willington Creek
Petit Creek
Goodings Creek
Duff Creek
SOUTH BRANCH
LOCATION MAP
LEGEND
FWPCA Sampling Stations
USGS Gaging Stations
SCALE IN MILES
DETROIT PROGRAM OFFICE
LOCATION OF SAMPLING STATIONS
CASS RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 10

TABLE 2. CASS RIVER SAMPLING STATIONS

Mainstream Stations

Station	Mile Point	Location
X605	2.3	Bridge on M-13 East Rd.
X609	5.0	Bridgeport sewage treatment plant
X610	7.8	Bridge on Fayette St. in Bridgeport
X615	11.7	Bridge on Dixie Highway
X620	15.2	Bridge on S. Beyer St.
X628	17.0	Frankenmuth sewage treatment plant (USGS gage #4-1515)
X630	17.2	Bridge on S. Main St. in Frankenmuth
X640	22.4	Bridge on Bray St. in Tuscola
X647	27.8	Vassar sewage treatment plant
X650	28.1	Bridge M-15 in Vassar (USGS gage #4-1510)
X655	32.0	Bridge on Waterman Rd.
X668	37.1	Caro State Hospital sewage treatment plant
X670	38.0	Bridge on Walk Rd.
X678	41.6	Caro sewage treatment plant
X680	42.1	Bridge on M-24 in Caro
X682	46.0	Bridge on Deckerville Rd.
X684	50.3	Bridge on Hurds Corner Rd.
X686	54.8	Bridge on N. Dodge Rd.
X689	58.9	Cass City sewage treatment plant
X688	59.2	Bridge on Seeger St. (Cemetery Rd.) (USGS gage #4-1505 at Cass City)

TABLE 2. CASS RIVER SAMPLING STATIONS
(cont'd)

Tributary Stations

Station	Mile Point	On Tributary	Confluence Mile Point	Location
X642	.1	Perry Creek	22.7	Bridge on Loren Rd. near Tuscola
X649	1.0	Goodings Creek	27.0	Bridge on Vassar Rd.
X681	1.6	Sucker Creek	43.2	Bridge on Albin Rd.
X683	.8	White Creek	47.6	Bridge on Murray Rd.
X695	3.9	South Branch	59.3	4.2 mi. southeast of Cass City off Cable Corner. Enter on Lamton Rd. 1.5 mi. north of Severence Rd. (USGS gage #4-1500)

WATER USE

Municipal Water Supply

The Cass River Basin has a population served by public water supplies of approximately 20,000 people. Except for the City of Frankenmuth (1,700), which obtains its water from the Cass River, all of this water comes from local wells.

Total municipal water use in the basin is approximately 3.0 million gallons per day (MGD). Projected water use is expected to be 12 MGD in the year 2020. Table 3 lists the present water supplies and source. Projected municipal water uses for the years 1990 and 2020 are shown in Table 4.

Industrial Water Use

Michigan Sugar Company is the only large water user in the basin, and uses approximately 4.0 MGD from the Cass River during the late fall and winter season. The projected industrial water use shown in Table 4 is based on this use, but is intended to imply the expansion of water-using industries in general; not necessarily this single industry.

Water-Related Recreation

Water-related recreation resource base in the Cass River Basin is limited by the nature of the basin and the fact that population corridors do not at present cross the basin. The river is narrow and shallow except behind the lowhead dams at Frankenmuth and Caro. There are no large impoundments or natural lakes in the basin. Water quality of the river is impaired. These factors limit the amount of boating, swimming,

and water skiing activity. The number of boats registered in the basin was 2,000 in 1965, most of which were under 20 feet in length. Most of the length of the Cass River has been designated a canoe trail by the Michigan Department of Conservation and Michigan Tourist Council. Fishing upstream of Frankenmuth has been described as good for warm-water gamefish although the less desirable fish are also taken. Downstream from Frankenmuth, degraded water quality limits fishing. In addition to the four State Game areas, there are a number of local and private recreation areas. The local areas which provide boating, fishing, and picnicking range in size from 20 to 60 acres. Particularly in Frankenmuth, the levee system, utilized for flood control purposes, provides an excellent vantage point for picnicking, family outings, and esthetic enjoyment of the river. A more detailed discussion of basin recreation is contained in the Bureau of Outdoor Recreation publication "Water-Oriented Outdoor Recreation Lake Huron Basin (1967)."

TABLE 3. MUNICIPAL WATER SUPPLIES*
CASS RIVER BASIN

Municipality	1960 Pop.	Owner**	Source	Treatment**
Bridgeport Twp.	4,000	T	Wells in rock 116' to 140' deep and in drift 63' to 71' deep	-
Frankenmuth	1,728	M	Cass River 50' of 10" intake 8' deep	2 & 6
Millington	1,159	M	Wells in rock 370' to 390' deep	-
Vassar	2,680	P	Wells in rock 260' to 270' deep	-
Mayville	896	M	Wells in rock 272' to 327' deep	-
Caro	3,534	M	Wells in rock 120' to 166' deep, wells in rock 226' to 250' deep	-
Cass City	1,945	M	Wells in rock	3
Gagetown	376	M	Wells in rock 85' to 185' deep	-
Indianfields Twp.		S	Wells in drift 77' to 80' deep, wells in rock 300' deep	-
Kingston	456	M	Wells in rock 215' to 331' deep	-
Marlette	1,640	M	Wells in rock 170' to 300' deep	-
Ubly	819	M	Wells in rock 150' to 175' deep	-

* Taken from "Data on Public Water Supplies in Michigan," Engineering Bulletin No. 4 by the Michigan Department of Public Health.
** See Owner and Treatment Code page 23.

OWNER AND TREATMENT CODE

Owner Code:

M = City or Village

T = Township

P = Private

D = District

C = County

S = State

U.S. = Federal

Treatment Code:

1 Std. Filtration*

2 Lime softening**

3 Zeolite softening

4 Iron removal

5 Chlorination

6 Fluoridation

* Implies at least chlorination, chemical coagulation, and rapid sand filtration.

** Lime softening includes filtration.

TABLE 4. PROJECTED WATER USE
(million gallons per day)
Cass River Basin

	1965	1990	2020
Municipal*	3	7	12
Industrial	4	9	16
Total	7	16	28

* Includes water used by small industries.

SOURCES AND CHARACTERISTICS OF WASTES

Municipal

The Cass River has seven sewage treatment plants along its length that contribute a flow of 3 MGD from approximately 18,000 people. The areas served by municipal sewage treatment plants are Bridgeport, Frankenmuth, Caro, Caro State Hospital, Vassar, Cass City, and Marlette.

Millington, with 1,160 people in Tuscola County, has sewers but no treatment facilities. Plans are underway for a waste stabilization lagoon. Mayville, also in Tuscola County, has neither collection nor treatment system for its 900 residents but is expected to have facilities by 1970. Marlette sewage treatment plant has a sand filter that is used during the period of low stream flow and substantially reduces the BOD_5 load to the stream. The yearly average effluent BOD_5 was 14 mg/l, but during the period the sand filter was in operation, the effluent BOD_5 averaged less than 3 mg/l. Caro State Hospital plant has been plagued with equipment problems. This plant is currently being improved. The Frankenmuth sewage treatment plant was constructed in 1955 as a trickling filter-type plant which proved to be unsatisfactory for handling the waste from the 1,700 residents and two breweries. The plant was converted to activated sludge in 1961, installing mechanical aerators. These aerators were replaced in 1965. Operation is still not fully satisfactory. The city is working on the problem. The major problem is created by the Carling Brewing Company which discharges a waste with a population equivalent of approximately 30,000 people based on BOD_5. This waste load fluctuates in volume and strength which makes treatment difficult.

Chemical data on this plant are not readily available due to continuously changing procedures in an effort to obtain an efficient operation.

Municipal waste treatment plants are described in Table 5. The information is based on 1965 records of the Michigan Department of Public Health. Prior to January 1967, all plants were required to practice disinfection from May 15 to September 15. Since that date, continuous year-round disinfection is required by Department of Public Health regulation. Effluent characteristics based on the 1965 plant operating records are also listed in Table 5 and outfall locations are shown on Figure 11.

Industrial

The Cass River drains a rich farming area. The only large industry in this basin, other than the brewery wastes handled by the Frankenmuth sewage treatment plant, is the Michigan Sugar Company. The industries are rated annually by the Michigan Water Resources Commission on adequacy of treatment.

Outfall locations for the industrial plants are shown on Figure 11. Industrial waste inventory information is shown on Table 6.

The W.N. Clark Company in Caro operates a cannery which has a waste flow of 0.1 MGD. This flow is not discharged to the river but is spray irrigated.

The Michigan Sugar Company in Caro processes sugar beets into sugar. The waste flow is 4 MGD during the fall and winter processing season and contains BOD_5 and solids. Treatment consists of screens and lagoons, with the lagoon discharge controlled so that no waste enters the river during low-flow conditions.

The Crown Foods, Inc., Division of Vlasic Foods is located in Bridgeport. The waste containing BOD_5, suspended solids, acids, and chlorides is placed in a controlled-discharge lagoon.

The Nestles Company, Inc. in Ubly is a milk processing plant which has a waste flow of 0.3 MGD containing milk waste.

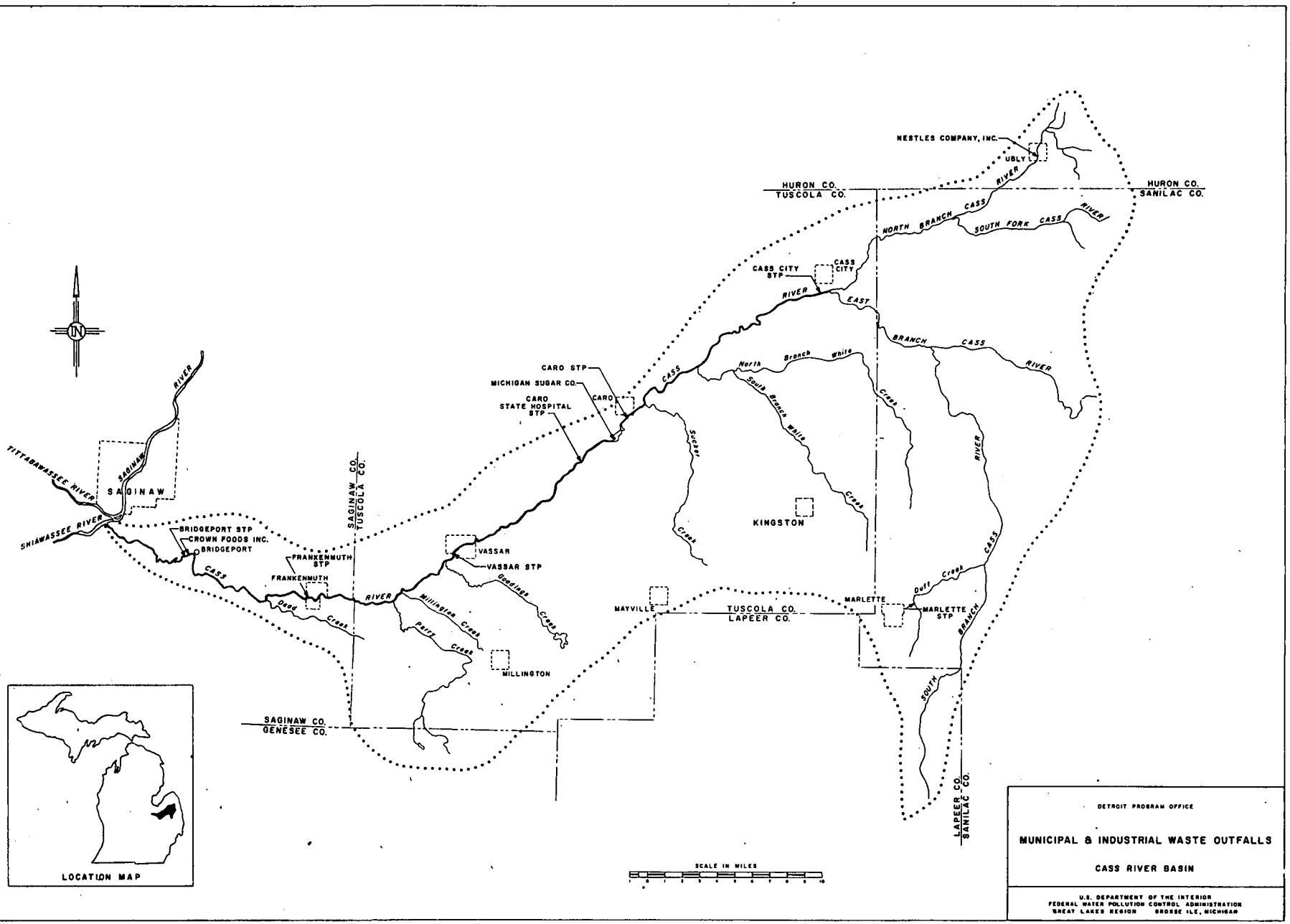

NESTLES COMPANY, INC.
UBLY
HURON CO.
TUSCOLA CO.
HURON CO.
SANILAC CO.
CASS RIVER
NORTH BRANCH CASS RIVER
SOUTH FORK CASS RIVER
CASS CITY STP
CASS CITY
EAST BRANCH CASS RIVER
CARO STP
MICHIGAN SUGAR CO.
CARO
CARO STATE HOSPITAL STP
North Branch White Creek
South Branch White Creek
Sucker Creek
KINGSTON
TITTABAWASSEE RIVER
SAGINAW RIVER
SAGINAW
SHIAWASSEE RIVER
BRIDGEPORT STP
CROWN FOODS INC.
BRIDGEPORT
SAGINAW CO.
TUSCOLA CO.
FRANKENMUTH STP
FRANKENMUTH
VASSAR
VASSAR STP
CASS RIVER
Dead Creek
Millington Creek
Pats Creek
Goodings Creek
MILLINGTON
MAYVILLE
TUSCOLA CO.
LAPEER CO.
MARLETTE
MARLETTE STP
Duff Creek
SOUTH BRANCH CASS RIVER
SAGINAW CO.
GENESEE CO.
LAPEER CO.
SANILAC CO.
LOCATION MAP
SCALE IN MILES
0 1 2 3 4 5 6 7 8 9 10
DETROIT PROGRAM OFFICE
MUNICIPAL & INDUSTRIAL WASTE OUTFALLS
CASS RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION BROSSE ILE, MICHIGAN

FIGURE 11

TABLE 5. MUNICIPAL WASTE TREATMENT PLANTS
1965 EFFLUENT CHARACTERISTICS*
CASS RIVER BASIN

Community	Type	Percent Removal	Pop. Served	Flow (MGD) Avg.	Flow (MGD) Max.	Flow (MGD) Min.	Temp. °F.	BOD_5 (mg/l) Avg.	BOD_5 (mg/l) Max.	BOD_5 (mg/l) Min.	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	pH
Bridgeport	secondary	85	5,000	0.41	0.67	0.27	-	37	43	30	-	-	-
Frankenmuth	secondary	90	1,700	1.10	-	-	-	-	-	-	-	-	-
Vassar	secondary	73	2,700	0.35	-	-	-	57	74	40	27	22	7.3
Caro	secondary	75	3,500	0.23	-	-	60	56	92	35	58	48	7.8
Caro State Hospital	secondary	70		0.20	-	-	68	146	300	78	86	70	7.1
Cass City	secondary	90	1,900	0.22	0.26	0.18	69	23	55	6	19	16	7.6
Marlette	secondary	87	1,500	0.36	-	-	58	14	-	-	21	11	7.5
Millington	**		1,160										
Mayville	***												

* Based on monthly averages of daily plant operation records submitted by plants to Michigan Department of Public Health
** Sewers but no treatment
*** No collection or treatment

TABLE 6. INDUSTRIAL WASTE INVENTORY
Cass River Basin

Industry	Location	Receiving Stream	Waste Constituents	Waste Flow (MGD)	Treatment Provided
W. N. Clark Company	Caro	ground water	general cannery	0.1	spray irrigation
Michigan Sugar Company	Caro	Cass River	BOD_5, solids	4	screens & lagoons
Crown Foods, Inc., Div. of Vlasic Foods	Bridgeport	Cass River	BOD_5, SS, acids, chlorides		lagoon
Nestles Company, Inc.	Ubly	Cass River	milk wastes	0.3	-

POPULATION AND WASTELOAD PROJECTIONS

Demographic studies were conducted by the Great Lakes-Illinois River Basins Project, Chicago, Illinois for the Lake Huron Basin. Population trends on a national, regional, and county basis were analyzed, and population projections were developed for the various areas of the Lake Huron Basin. In 1960, approximately 1.2 million persons lived in the U.S. portion of the Lake Huron Basin - double the 1920 population. By the year 2020, it is estimated that the population of this watershed will be approximately 3.2 million.

The areas of Marlette, Caro, Cass City, Frankenmuth, Vassar, and Bridgeport were analyzed separately, assuming that by 2020 each area will be urbanized and served by water and sewer systems. Then data from the individual areas were added together to yield the total population served for the basin. The 1965 population served by sewerage systems was estimated to be 18,400, and projected to be 28,500 by 1990 and 40,100 by the year 2020. These projections are for population served and do not necessarily represent the total population figures for the basin.

Table 7 and Figure 12 show the estimated waste flow in MGD for the Cass River Basin.

BOD_5 projections were based on present-day inventory information obtained from the Michigan Water Resources Commission, Michigan Department of Public Health, and the U.S. Public Health Service. Municipal and industrial water use growth rates and BOD_5 production in terms of population equivalents were determined from studies on Lake Michigan Basin and applied to the inventory data obtained for the Cass River Basin.

The results of these projections are shown on Table 8. For example, in 1965 a total of 16,900 pounds per day of BOD5 was produced in the basin, of which 72 percent was removed by treatment leaving 6,350 pounds of BOD5 discharged to the river. By the year 2020 with the same percentage of treatment, 21,800 pounds would reach the river. In order to show an improvement over present water quality, 90 percent removal will be necessary at that time.

TABLE 7. WASTE FLOW PROJECTIONS
(MGD)
Cass River Basin

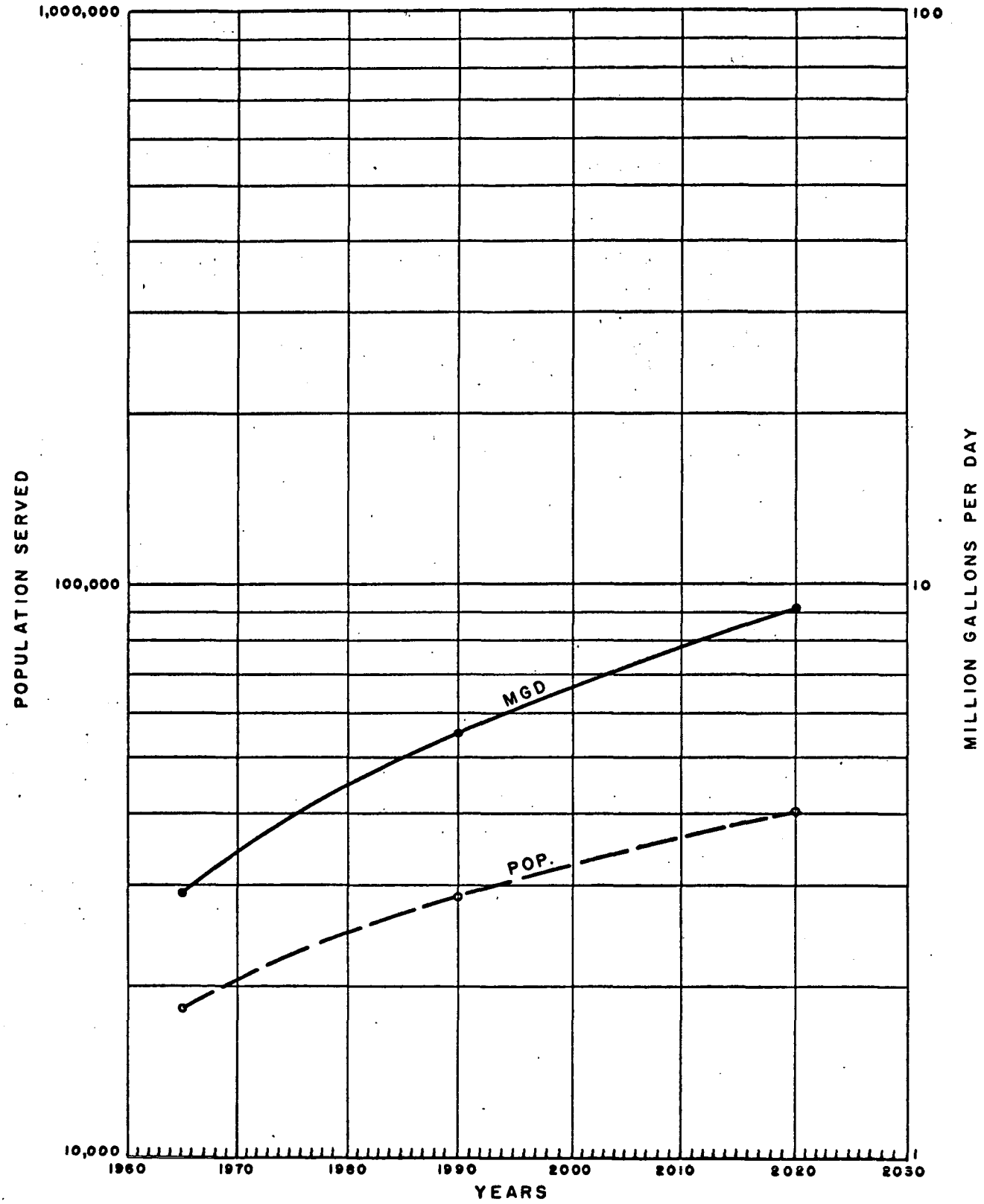
	1965	1990	2020
Municipal			
Residential	2.3	4.8	8.1
Industrial	0.6	0.7	1.0
Total	2.9	5.5	9.1
Industrial (direct to river)	4.1	9.0	15.6
Total to River	7.0	14.5	24.7

TABLE 8. BOD_5 PROJECTIONS
(#/day)
Cass River Basin

	1965	1990	2020
Municipal			
Residential	3,583	5,090	7,872
Industrial	6,171	8,030	10,800
Total	9,754	13,120	18,672
With present removal	1,349	1,913	2,783
With 90% removal	976	1,312	1,867
With 95% removal	487	656	933
With 99% removal	98	131	187
Industrial			
(direct to river)	7,140	15,700	27,100
With present 30% removal	5,000	11,000	19,000
With 90% removal	714	1,570	2,710
With 95% removal	357	785	1,355
With 99% removal	71	157	271
Total in the Basin	16,894	28,820	45,772
Total to the river			
With present removal	6,349	12,913	21,783
With 90% removal	1,690	2,882	4,577
With 95% removal	844	1,441	2,288
With 99% removal	169	288	458

FIGURE 12

POPULATION AND MUNICIPAL WASTE FLOW PROJECTIONS FOR THE CASS RIVER BASIN



WATER QUALITY DATA

The Detroit Program Office conducted surveys of the Cass River during 1965 to determine the quality of this watercourse. Station locations are shown on Figure 10 and described in Table 2.

A reconnaissance survey was conducted on January 26-28, 1965. Single grab samples were collected at many locations and analyzed for alkalinity, chlorides, conductivity, dissolved oxygen, pH, and total coliform concentrations.

On the basis of this survey, a location was selected for routine sampling which was conducted approximately twice a month. A second location was also sampled during the latter part of the year. Samples collected were analyzed for physical, chemical, microbiological and biological parameters.

An intensive survey was conducted August 4-5, 1965 to determine the effect of waste loading on the 60 miles of river from Cass City to the confluence with the Saginaw River. Thirteen locations at 5-mile intervals along the river were sampled every 4 hours for 24 hours. Tributaries were also sampled. DO and temperature were determined on each sample. Composites were prepared for other parameters and analyzed. Samples for bacteriological analysis were collected on one of the six runs. Samples of waste effluents were collected and analyzed.

As part of the Lake Huron Program, special studies were conducted on the East Branch of the Cass River to determine the characteristics of runoff in the rural area.

The results of the various surveys are described in the following sections. Data tabulations and graphical presentations for the surveys are included on Tables 9 to 17 and Figures 13 to 17.

Reconnaissance Survey

The survey of the Cass River from Cass City to Bridgeport (Table 9) indicated that bacterial pollution occurred below the many municipal sources: Cass City, Caro, Vassar, Frankenmuth, and Bridgeport. Below Frankenmuth, the levels indicated gross contamination with all samples in excess of 200,000 coliform organisms/100 ml. These levels reached a maximum of 510,000 org/100 ml below Bridgeport. DO levels varied throughout the stream with minor depressions below the various communities. Below Frankenmuth, the depression was significant, reaching a minimum DO level of 2.6 mg/l. Chloride concentration increased below the confluence of the East Branch Cass River which receives the waste from Marlette sewage treatment plant. Levels varied through the remainder of the stream, decreasing below the various tributaries - White and Sucker Creeks - and increasing below the waste treatment plants. Below Frankenmuth, the chloride level indicated a moderate amount of pollution.

Regular Tributary Sampling

One location on the Cass River, X610 at Bridgeport ten miles below the Frankenmuth sewage treatment plant outfall, was sampled on a periodic basis during 1965. A second location, X670 below Caro, was similarly sampled during the latter part of the year. The stations are described on Table 2 and located on Figure 10. Tables 10 to 14 list the water quality data obtained during 1965.

Dissolved oxygen (DO) concentration at Bridgeport averaged 8.9 mg/l throughout the regular sampling period. Minimum level was 3.4 mg/l with a maximum of 12.6 mg/l (Table 10). These results were exclusive of diurnal values obtained during the intensive DO profile study. Seasonal variation (Table 11) indicated a significant decrease in percent saturation during the summer months. Levels below Caro, observed during the fall season, were similar to the levels at Bridgeport for the same time period. The levels at Bridgeport indicated supersaturation does not occur and active oxidation of organic matter occurred in this stream reach.

Organic matter expressed in terms of 5-day BOD and ammonia and organic nitrogen (Table 10) was not extremely high with average yearly concentration of 4 mg/l BOD_5, 0.56 mg/l ammonia, and 0.27 mg/l organic nitrogen. Maximum levels were 6 mg/l, 0.93 mg/l, and 0.70 mg/l, respectively. As indicated in Table 11, there was only minor seasonal variation. As also indicated by the low dissolved oxygen levels at this location, rapid oxidation of organic wastes occurred in the 10-mile stream reach from the Frankenmuth outfall. Levels of organic matter below Caro were similar to this location during the latter part of the year.

Nutrient levels expressed in terms of nitrate-nitrogen and total and soluble phosphorous as phosphate (Table 10) were indicative of moderate pollution. Nitrate-nitrogen averaged 1.0 mg/l and total phosphate was 0.5 mg/l. There was significant seasonal variation (Table 12) with the nitrate low in the summer season and phosphate levels doubled during this season. Nitrate levels below Caro were one-third the levels at Bridgeport during the fall season although phosphate was the same.

Chloride and other dissolved solids indicated a moderate amount of municipal pollution in the Cass River. Average chloride level below Frankenmuth was 41 mg/l (Table 10) and total solids level was 470 mg/l. Seasonal variation was apparent (Table 11) with the summer chloride level at 72 mg/l - nearly triple the spring level (26 mg/l). The fall level (58 mg/l) was considerably higher than the spring level but less than the summer level. This parameter appeared to be most influenced by stream flow, being lowest in spring floods and highest during summer droughts. Maximum yearly levels of both total solids and chlorides occurred during unusually low flow of the intensive DO profile study. These levels were 630 mg/l and 131 mg/l, respectively.

Bacterial quality of the Cass River at Bridgeport indicated severe degradation with a median value of 64,000 total coliform organisms/100 ml (Table 10). Median fecal coliform density was 1,400 org/100 ml. Maximum levels of total and fecal coliforms were greater than 3,000,000 org/100ml and 28,000 org/100 ml. These maximum levels occurred on the same day during the summer disinfection season. Maximum levels during the non-disinfection season were 94,000 total coliform org/100 ml and 3,600 fecal coliform org/100 ml. With the exception of the unusually high values on the single day, seasonal variation (Table 13) indicated that bacterial quality was considerably better during the disinfection period. Median summer levels were 9,000 total coliform org/100 ml and 600 fecal coliform org/100 ml compared with median spring and fall levels of 64,000 org/100 ml and 2,000 org/100 ml, respectively, total and fecal coliforms. The bacterial quality below Caro during the fall season was considerably

better than that at Bridgeport with maximum levels of 7,800 total coliform org/100 ml and 400 fecal coliform org/100 ml; median levels of 245 total coliform org/100 ml and 60 fecal coliform org/100 ml. These regular locations were not the points of highest density as indicated by the reconnaissance and intensive surveys.

The other parameters listed on the tables confirm the quality of the basin waters as indicated in the previous discussion. Suspended and volatile suspended solids and phenols indicated moderate amounts of pollution. The suspended solids levels were higher during the spring high-flow period. The water quality below Caro was similar during the fall season.

Radiochemistry data based on the 1965 regular tributary sampling program is listed on Table 14 for the Cass River. The data are listed in picocuries per liter of water sample. The sample was reported in terms of suspended (non-filtrable) and dissolved (filtrable) portions. Alpha emitters and beta emitters were measured. Composites of regular tributary samples were analyzed in most cases rather than the individual sample. Also included is the result of analysis at a rural runoff station on the East Branch Cass River below Marlette. Maximum levels of alpha emitters were 3.60 pc/l dissolved and 0.60 pc/l suspended. Maximum levels of beta emitters were 14.0 pc/l dissolved and 2.4 pc/l suspended. For most samples, the standard counting error exceeded the level of the sample indicating a very low level of radioactivity in the sample.

Cass River Dissolved Oxygen Profile Study

Data collected during the intensive survey on August 4-5, 1965 are listed on Table 15 and shown on Figures 13 to 17. During this survey, water quality differed from the average annual water quality, indicating a greater amount of pollution for most parameters except coliform densities.

DO profile (Figure 13) indicated a highly varied oxygen level throughout the stream. Above Frankenmuth, the level was high with minimum levels greater than 5 mg/l and an average level greater than 8 mg/l. Maximum levels at many locations exceeded 10 mg/l, indicating supersaturation. Below Frankenmuth, DO level changed dramatically with zero levels found 2 miles below the sewage treatment plant outfall. For ten miles below the outfall, the average level remained below 5 mg/l. Five miles further downstream, the minimum level increased to near saturation with a maximum level of 21.7 mg/l or 256 percent of saturation.

Diurnal variation throughout the stream was high. Maximum variation above Frankenmuth was 7.5 mg/l or 88 percent of saturation above the Vassar sewage treatment plant outfall. Minimum variation of 1.4 mg/l or 17 percent of saturation occurred just above the Frankenmuth sewage treatment plant outfall. Below the outfall, the minimum variation was 1.7 mg/l (0.0 mg/l to 1.7 mg/l) or 20 percent saturation (0 to 20 percent). At this location, 5 of 6 samples were less than 1 mg/l and 2 were 0 mg/l. Maximum variation occurred fifteen miles below the outfall and two miles above the confluence of the Cass River with the Saginaw River. Variation was 13.2 mg/l or 163 percent of saturation (93 to 256 percent). Table 16 lists the diurnal variation at a number of locations in the Cass River.

Included are the results obtained during studies of the Saginaw River which indicated diurnal variation on a seasonal basis. Diurnal variation was not as significant during the cooler season and no supersaturation was observed in the fall.

Organic matter expressed as 5-day BOD (Figure 13), and organic and ammonia nitrogen were at moderate levels above Frankenmuth. These levels increased below the waste source - then gradually declined. Maximum 5-day BOD level was 5 mg/l with an average level of 3 mg/l. Maximum ammonia level was 0.47 mg/l with an average of .2 mg/l. Below the Frankenmuth sewage treatment plant outfall, BOD_5 level increased to 13 mg/l. Ammonia nitrogen increased to a maximum of 1.74 mg/l. These levels were indicative of high organic pollution. The stream levels declined, increasing again below the Bridgeport sewage treatment plant outfall. Rapid oxidation of these organic materials was indicated by the change in level of the parameters and the severe DO depression (anaerobic conditions were noted). The intensive survey levels were similar to the average annual concentration.

Nutrient levels in terms of phosphates and nitrate-nitrogen (Figures 14 and 15) were indicative of moderate pollution. Nitrate-nitrogen above Frankenmuth ranged from 0.1 mg/l to 0.2 mg/l. Below Frankenmuth, the level increased to 0.4 mg/l. Phosphate level was 1.0 mg/l near the confluence of the East Branch Cass River (which carries residual wastes from the Marlette sewage treatment plant) increasing to 1.8 mg/l below Cass City sewage treatment plant. The level declined to 0.4 mg/l increasing in the Frankenmuth area. There was a considerable increase below the Frankenmuth sewage treatment plant with level

in excess of 1 mg/l throughout the remainder of the stream. The nutrient levels were similar to annual average levels, although below Frankenmuth the phosphate level was the annual maximum level and the nitrate level was near the minimum level.

Chloride and dissolved solids levels (Figure 16) indicated moderate residual pollution below the Cass City sewage treatment plant and below the confluence with the East Branch which carries the wastes from the Marlette sewage treatment plant. These levels, especially chlorides, decreased noticeably as more tributaries entered the Cass River downstream. At Frankenmuth the chloride level increased from 48 mg/l to 142 mg/l below the sewage treatment plant then decreased to 121 mg/l near the confluence with the Saginaw River. Dissolved solids followed a similar pattern although the change was not as great. Chlorides and dissolved solids levels were near the maximum of the annual values; below Frankenmuth the intensive survey levels were the maximum recorded for the year.

Total coliform densities (Figure 17) indicated moderate to minor pollution above Frankenmuth with levels of less than 1,000 org/100 ml at all but one location. Median density was 560 org/100 ml in this reach. Densities increased below the Frankenmuth sewage treatment plant outfall to 370,000 org/100 ml and then rapidly decreased to 1,000 org/100 ml. Intensive survey levels were the minimum measured for the year at the two areas sampled on an annual basis.

The levels of the other parameters indicated moderate to minor pollution above Frankenmuth with major pollution occurring in the Frankenmuth area. During this special study, the flow at the U.S. Geological

Survey gage at Frankenmuth was extremely low - less than one-day low flow with a recurrence of ten years.

Rural Runoff Studies

As part of the Lake Huron Basin comprehensive studies, locations throughout the basin were sampled on a monthly basis during the summer and fall of 1965 to determine the characteristics of rural runoff. One location was in the Cass River Basin on the South Branch of the Cass River 24 miles downstream from the community of Marlette at the U.S. Geological Survey gaging station (X695). The drainage area is 251 square miles. Mean flow was 90.1 cfs and yield was .359 cfsm during calendar year 1965 which was 25 percent less than the average yearly flow of the preceding 18 years. Stream flows preceding the sampling dates were constant and considerably lower than the mean yearly flow except for the late spring sample in May.

As indicated on Table 17, data for this location reflects the residual pollution of the conservative and semi-conservative wastes from the Marlette sewage treatment plant. Little correlation was evident among the various samples although chloride concentrations were considerably lower during the high flow period. Suspended solids were higher during this period. The mineral concentrations in general followed the chloride levels. Nutrient levels indicated a minor amount of pollution.

NOTES
FOR
WATER QUALITY TABLES

NS - Number of Samples

Chemical Parameters

Cl	-	Chloride	Mg	-	Magnesium
Fe	-	Iron	Na	-	Sodium
SO_4	-	Sulfate	K	-	Potassium
Si	-	Silica	CO_3	-	Carbonate
Ca	-	Calcium	HCO_3		Bicarbonate

Total hardness: reported as $CaCO_3$

Nitrogens: ammonia (NH_3), organic, nitrates (NO_3), and nitrites (NO_2) reported as nitrogen equivalent (N)

Phosphates: reported as PO_4

Total phosphates include: ortho, poly, biological, and organic.
Total soluble phosphates include: soluble ortho, soluble poly, and soluble organic.

pH: reported in standard units

All results recorded in milligrams per liter (mg/l) except:

phenols and iron - micrograms per liter (µg/l)
conductivity - micromhos per centimeter (µmhos/cm)

Microbiological Parameters

Total Coliform)
Fecal Coliform) reported as organisms(MF)/100 ml
Fecal Streptococcus)

Total Plate Count: number of bacteria/ml

Median value is used for "average" statistic except as noted.

- -

Indeterminate values (less than < or greater than >) not used in calculating average.

TABLE 9. WATER QUALITY DATA - RECONNAISSANCE SURVEY
CASS RIVER

January 26-28, 1965

Station	River Mile*	Alkalinity	Dissolved Oxygen	pH	Total Coliform	Conductivity	Chloride
X690	62.3	265	-	7.4	100	820	19
X688	59.2	254	8.0	7.7	250	1,000	50
X687	57.0	267	6.7	7.5	24,000	960	38
X686	54.8	246	8.1	7.8	2,800	840	39
X684	50.3	238	7.6	7.6	480	820	41
X682	46.0	224	8.3	7.6	340	760	25
X680	42.1	193	11.1	7.8	1,400	600	18
X670	38.0	220	9.9	7.8	16,000	750	26
X665	36.4	207	8.0	7.6	1,400	720	28
X660	34.2	234	10.2	7.9	490	620	20
X655	32.1	174	8.6	7.0	2,100	660	29
X650	28.1	198	5.6	7.6	210	700	37
X645	24.7	194	8.7	7.7	6,700	670	36
X640	22.4	194	7.7	7.6	5,400	680	41

*Miles above confluence with Saginaw River.

TABLE 9. WATER QUALITY DATA - RECONNAISSANCE SURVEY (cont.)
CASS RIVER

January 26-28, 1965

Station	River Mile *	Alkalinity	Dissolved Oxygen	pH	Coliform	Conductivity	Chloride
X630	17.3	195	7.5	7.6	2,400	690	41
X620	15.2	195	9.8	7.5	230,000	740	55
X615	11.7	222	7.3	7.5	390,000	800	60
X610	7.8	180	5.4	7.4	210,000	820	-
X608	5.7	194	2.6	7.4	510,000	740	53
X605	2.3	200	4.9	7.5	240,000	750	52

* Miles above confluence with Saginaw River.

TABLE 10. WATER QUALITY
CASS RIVER
1965

Parameters	X695 East Branch				X670 below Caro				X610 at Bridgeport			
	NS	Avg.	Low	High	NS	Avg.	Low	High	NS	Avg.	Low	High
Dissolved Oxygen	0	-	-	-	6	10.2	5.8	14.7	10	8.9	3.4	12.6
5-day BOD	0	-	-	-	6	6	4	11	7	4	2	6
NH_3-N	4	0.20	0.07	0.34	6	0.59	0.00	1.10	12	0.56	0.19	0.93
Org-N	4	0.27	0.13	0.66	5	0.47	0.19	0.66	12	0.27	0.07	0.70
NO_3-N	5	0.1	0.0	0.3	6	0.3	0.1	0.6	13	1.0	0.2	1.6
NO_2-N	4	0.01	0.00	0.02	1	0.01	-	-	9	0.02	0.01	0.04
Total PO_4	5	-	< 0.1	1.0	6	0.4	0.3	0.5	13	0.5	0.2	1.3
Total Sol. PO_4	5	-	< 0.1	0.9	6	0.3	0.2	0.4	13	0.4	0.1	1.2
Total Solids	4	593	514	667	6	460	430	493	13	469	218	584
Suspended Solids	5	4	0	12	6	11	5	17	13	35	8	124
Vol. Susp. Solids	2	2	0	4	6	5	0	9	12	9	2	29
Chlorides	5	52	28	76	6	41	37	43	15	41	7	91
Phenol	0	-	-	-	6	4	3	7	14	4	1	8
pH	5	7.9	7.3	8.6	6	8.0	7.8	8.2	15	7.8	7.4	8.4
Temperature	5	19.0	8.0	24.0	7	7.5	1.0	19.0	16	7.5	0.0	23.5
% Saturation	0	-	-	-	7	84	56	135	10	73	35	110

TABLE 10. WATER QUALITY (cont.)
CASS RIVER
1965

Parameters	X695 East Branch				X670 below Caro				X610 at Bridgeport			
	NS	Avg.	Low	High	NS	Avg.	Low	High	NS	Avg.	Low	High
Total Iron	1	100	-	-	6	-	100	200	13	2,200	100	10,800
Sodium	2	30	19	41	4	25	8	32	11	32	4	82
Potassium	2	10	7	12	4	10	8	10	11	10	5	16
Calcium	2	84	76	92	6	76	64	90	13	73	30	94
Magnesium	3	30	20	38	6	25	17	29	13	23	6	36
Sulfate	4	176	140	220	6	73	50	90	13	82	20	135
Total Hardness	0	-	-	-	6	292	248	324	14	279	94	368
Conductivity	5	840	740	920	6	650	600	720	16	600	200	830
Total Coliform	0	-	-	-	6	245	180	7,800	14	64,000	900	>3,000,000
Fecal Coliform	0	-	-	-	6	60	10	400	12	1,350	100	28,000
Fecal Strep	0	-	-	-	6	90	<5	260	12	250	20	19,000

TABLE 11. CASS RIVER WATER QUALITY
1965 SEASONAL VARIATION

Season/ Location	Dissolved Oxygen			BOD_5	NH_3-N	Org-N	NO_3-N	Tot. PO_4	Tot. Sol. PO_4	Solids			Cl.	Phenol
	Avg.	Max.	Min.							Total	Susp.	Vol. Susp.		
Jan.-April														
X610	10.4	12.6	5.4	-	0.70	0.22	1.4	0.43	0.30	392	51	12	26	5
May-Sept.														
X610	4.7	8.0	3.3	3	0.49	0.30	0.4	0.82	0.63	584	23	7	72	2
Oct.-Dec.														
X610	10.4	12.1	9.1	4	0.40	0.32	0.9	0.40	0.33	479	17	5	58	4
Annual														
X610	6.4	12.6	3.3	3	0.56	0.27	1.0	0.56	0.42	479	34	9	46	4

TABLE 11. CASS RIVER WATER QUALITY (cont.)
1965 SEASONAL VARIATION

Season/ Location	Total Iron	Sodium	Potassium	Calcium	Magnesium	Sulfate	Total Hardness
Jan.-April X610	4,050	27	10	67	20	95	232
May-Sept. X610	1,040	41	8	84	31	85	328
Oct.-Dec. X610	170	35	11	74	20	53	289
Annual X610	2,140	32	10	73	23	82	279

TABLE 12. CASS RIVER WATER QUALITY
1965 SEASONAL NUTRIENT VARIATION

Season/ Location	Nitrate-Nitrogen			Total Phosphate			Soluble Phosphate		
	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
Jan.-April									
X610	1.4	1.6	1.1	0.43	0.90	0.20	0.30	0.50	0.20
May-Sept.									
X610	0.4	0.9	0.2	0.82	1.30	0.30	0.63	1.20	0.10
Oct.-Dec.									
X610	0.9	1.5	.04	0.40	0.50	0.20	0.33	0.40	0.20
Annual									
X610	1.0	1.6	0.2	0.56	1.30	0.20	0.42	1.20	0.10

TABLE 13. CASS RIVER WATER QUALITY
1965 SEASONAL COLIFORM VARIATION

Season/ Location	Total Coliform			Fecal Coliform		
	Median	Low	High	Median	Low	High
Jan.-April						
X610	64,000	4,600	940,000	2,000	480	3,600
May-Sept.						
X610	9,000	900	>3,000,000	600	100	28,000
Oct.-Dec.						
X610	110,000	32,000	180,000	590	180	1,000
Annual						
X610	62,000	900	>3,000,000	1,400	100	28,000

TABLE 14. CASS RIVER BASIN WATER QUALITY
1965 RADIOACTIVITY

Parameter	X610 NS	X610 Avg.	X610 Low	X610 High	X695 NS	X695 Avg.	X695 Low	X695 High
Dissolved								
ALPHA	7(2)	1.83	<0.05	3.60	2(1)	<0.05	-	-
Error	7(2)	2.8	2.8	2.8	2(1)	2.5	-	-
BETA	7(2)	5.6	3.8	7.3	2(1)	14.0	-	-
Error	7(2)	4.9	3 8	6.0	2(1)	3.5	-	-
Suspended								
ALPHA	7(2)	0.33	<0.05	0.60	2(1)	<0.05	-	-
Error	7(2)	1.1	0.6	1.5	2(1)	0.8	-	-
BETA	7(2)	2.0	1.5	2.4	2(1)	1.5	-	-
Error	7(2)	3.2	2.0	4.4	2(1)	1.9	-	-

TABLE 15. INTENSIVE DISSOLVED OXYGEN SURVEY
CASS RIVER BASIN

August 4-5, 1965

Station	Avg. Temp. (°C)	Dissolved Oxygen			Percent Saturation			BOD_5	Nitrogen			Phosphates	
		Avg.	Max.	Min.	Avg.	Max.	Min.		NH_3	Org.	NO_3	Total	Soluble
X680	20	6.4	7.9	5.0	70	87	56	3	0.21	.42	.1	1.00	0.90
X686	20	8.5	12.2	5.2	94	138	55	2	0.47	.01	.1	-	-
X684	20	7.9	9.6	6.4	87	108	68	1	0.14	.14	.2	1.84	1.04
X680	21	11.8	15.9	9.6	134	185	106	5	0.17	.13	.1	0.40	0.30
X670	20	6.9	8.9	5.2	77	99	57	5	0.17	.18	.2	0.40	0.40
X655	20	9.2	13.3	6.7	103	155	72	5	0.19	.13	.2	0.40	0.30
X650	21	9.2	11.1	3.6	103	128	40	3	0.17	.19	.2	0.90	0.68
X640	21	9.2	10.8	8.2	104	126	93	2	0.43	.05	.2	0.30	0.30
X630	21	6.7	7.4	6.0	75	84	67	2	0.30	.09	.1	1.60	0.20
X620	22	0.6	1.7	0.0	8	20	0	13	1.26	.19	.1	6.70	1.20
X615	21	2.7	4.2	1.4	30	48	16	5	1.74	.15	.1	1.12	0.70
X610	20	4.1	5.5	3.3	46	62	36	3	-	-	.3	1.28	0.84
X605	21	15.3	21.7	8.5	176	256	93	6	0.25	.17	.4	1.00	0.80

TABLE 15. INTENSIVE DISSOLVED OXYGEN SURVEY (cont.)
CASS RIVER BASIN

August 4-5, 1965

Station	Solids			Chlorides	Conductivity	Alkalinity	pH	Iron	Total Coliform
	Total	Suspended	Volatile						
X688	579	3	2	60	880	160	8.1	0.7	990
X686	576	3	2	62	840	180	8.2	2.0	810
X684	545	4	2	75	800	186	8.3	0.7	510
X680	454	3	3	41	660	182	8.4	0.7	140
X670	475	6	4	40	670	216	8.2	1.1	170
X655	419	1	1	37	620	190	8.3	1.1	560
X650	420	6	4	47	620	174	8.2	2.4	800
X640	396	1	0	48	760	182	8.3	1.5	1,300
X630	512	8	7	78	620	194	8.1	1.4	2,900
X620	665	12	12	142	960	206	7.7	1.2	370,000
X615	670	12	3	142	1,080	212	8.0	2.5	1,000
X610	626	16	6	131	880	222	8.1	1.3	3,000
X605	608	27	7	121	960	198	8.4	2.1	1,000

TABLE 16. DIURNAL DISSOLVED OXYGEN FLUCTUATION
CASS RIVER BASIN

Station	Date 1965	Time	Temp. (°C)	DO (mg/l)	Percent Saturation
X605	7/20	0805	21	10.7	121
		1211	23	13.6	160
		1612	24	17.2	205
		2015	23	19.5	227
	7/21	0125	21	13.0	147
		0510	21	12.1	137
	7/21	1017	22	13.0	148
		1420	27	13.7	173
		1815	26	19.3	241
		2215	23	16.0	189
	7/22	0320	22	12.2	140
		0725	25	11.2	137
	8/04	1210	22	17.4	200
		1535	23	16.5	195
		2025	23	21.7	256
		2400	20	12.4	138
	8/05	0430	20	-	-
		0800	19	8.5	93
	10/26	0905	8	8.2	69
		1300	9	8.6	75
		1705	9	8.6	75
		2125	8	8.1	68
	10/27	0120	7	7.9	65
		0515	7	8.1	66
	10/27	1145	7	9.7	80
		1600	8	9.8	82
		1950	8	9.6	80
		2340	7	9.3	76
	10/28	0325	7	8.9	73
		0726	6	8.9	71

TABLE 16. DIURNAL DISSOLVED OXYGEN FLUCTUATION (cont.)
Cass River Basin

Station	Date 1965	Time	Temp. (°C)	DO (mg/l)	Percent Saturation
X620	8/4	1135	23	1.7	20
		1500	22	0.8	9
		1915	23	0.9	11
		2315	21	0.5	6
	8/5	0325	21	0.0	0
		0705	20	0.0	0
X610	8/4	-	-	-	-
		1520	21	5.5	62
		-	-	-	-
		2345	20	4.2	47
	8/5	0400	21	3.4	38
		0730	19	3.3	36
X670	8/4	0945	19	6.2	68
		1335	20	6.4	71
		1710	23	7.5	87
		2110	20	8.9	99
	8/5	0130	21	7.6	81
		0515	19	5.2	57

TABLE 17. 1965 RURAL RUNOFF
CASS RIVER BASIN
Station X695

Date	Flow (cfs)	Temp. (°C)	Solids			Conductivity	Chlorides	pH	Iron
			Dissolved	Suspended	Volatile				
5/27	37.0	22	660	12	-	880	28	7.3	-
7/06	5.2	24	-	0	-	860	52	8.6	-
8/24	2.8	19	510	1	0	740	52	8.0	100
9/22	6.6	22	560	5	4	800	53	7.8	-
11/08	5.0	8	620	4	-	920	76	8.0	-
Average	11.3	19	590	4	2	840	52	7.9	100

Date	Nitrogen				Phosphate		Minerals					
	NO_3	NO_2	NH_3	Org.	Total	Soluble	Na	K	Ca	Mg	SO_4	SiO_2
5/27	.3	.02	.24	.13	<.1	.1	19	7	-	38	192	1.1
7/06	.1	.00	.34	.16	<.1	<.1	-	-	-	-	220	-
8/24	.0	.00	-	-	1.0	.9	-	-	-	-	-	-
9/22	.1	.00	.07	.66	.1	.2	41	12	76	20	>150	2.7
11/08	.1	-	.13	.14	.3	.2	-	-	92	33	140	3.8
Average	.1	<.01	.20	.27	.3	.3	30	10	84	30	176	2.5

CASS RIVER
DISSOLVED OXYGEN AND 5-DAY BOD
AUGUST 4-5, 1965 SURVEY

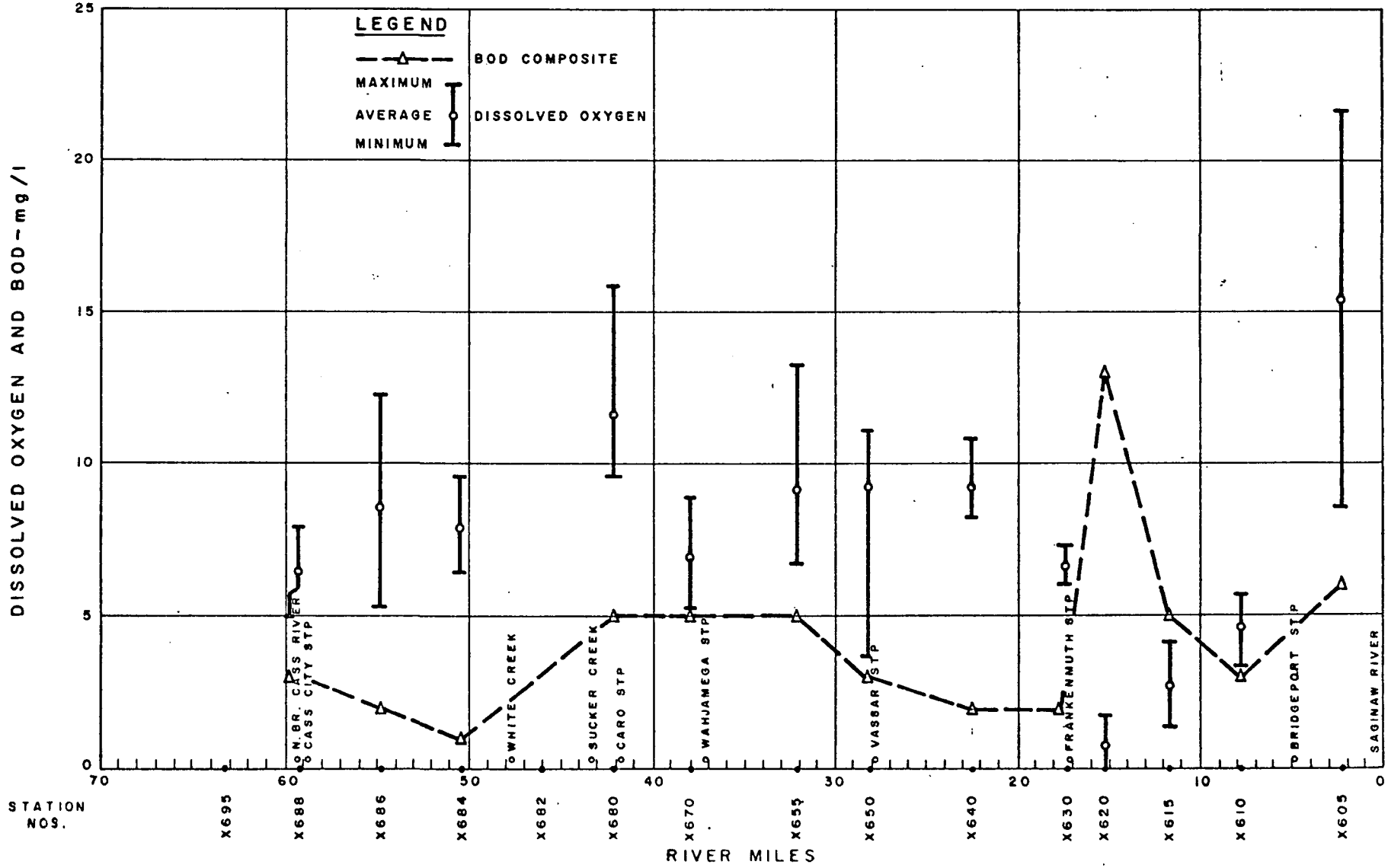


FIGURE 13

CASS RIVER
NITRATE CONCENTRATION
AUGUST 4-5, 1965 SURVEY

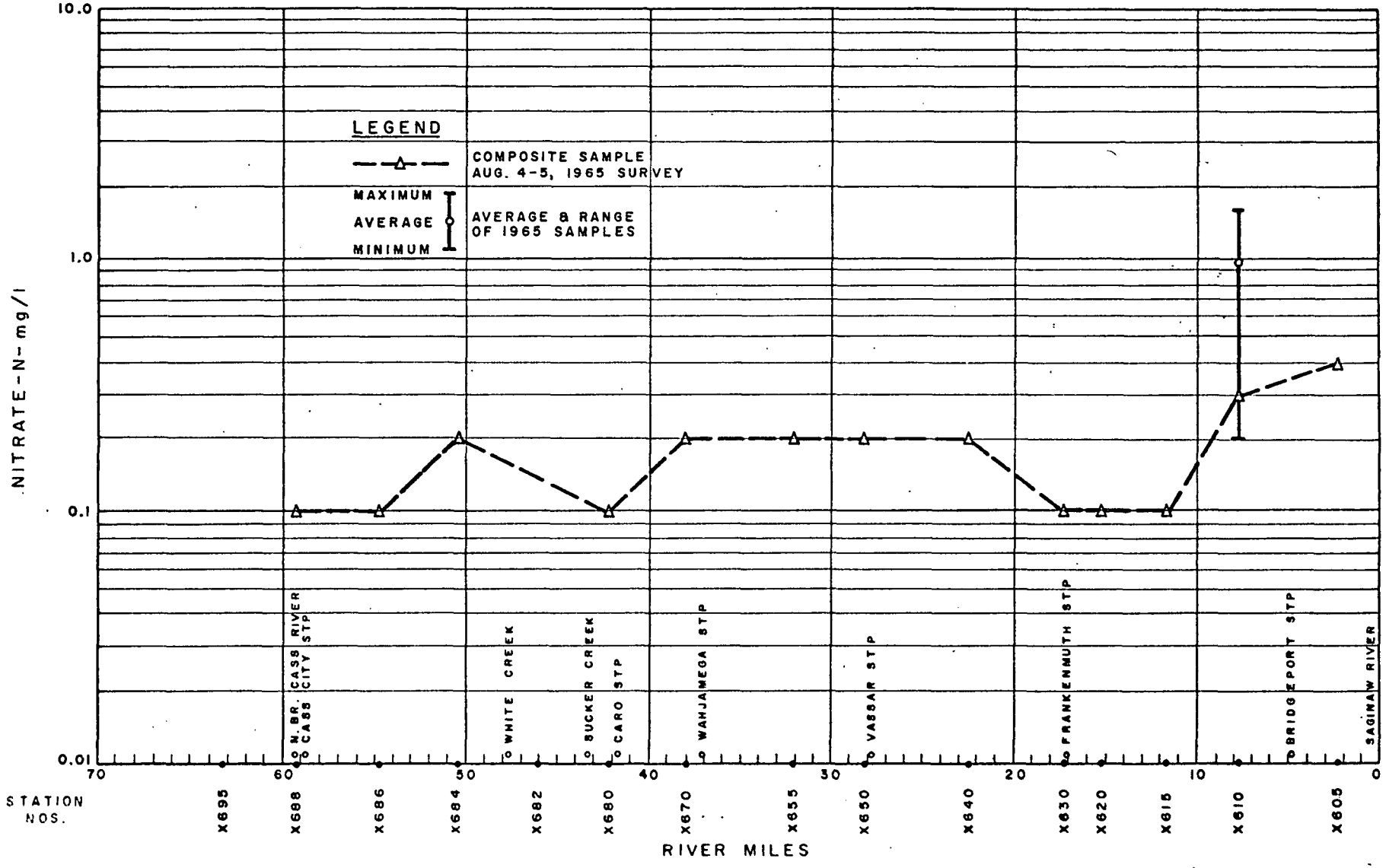


FIGURE 14

CASS RIVER
TOTAL PHOSPHATE
AUGUST 4-5, 1965 SURVEY

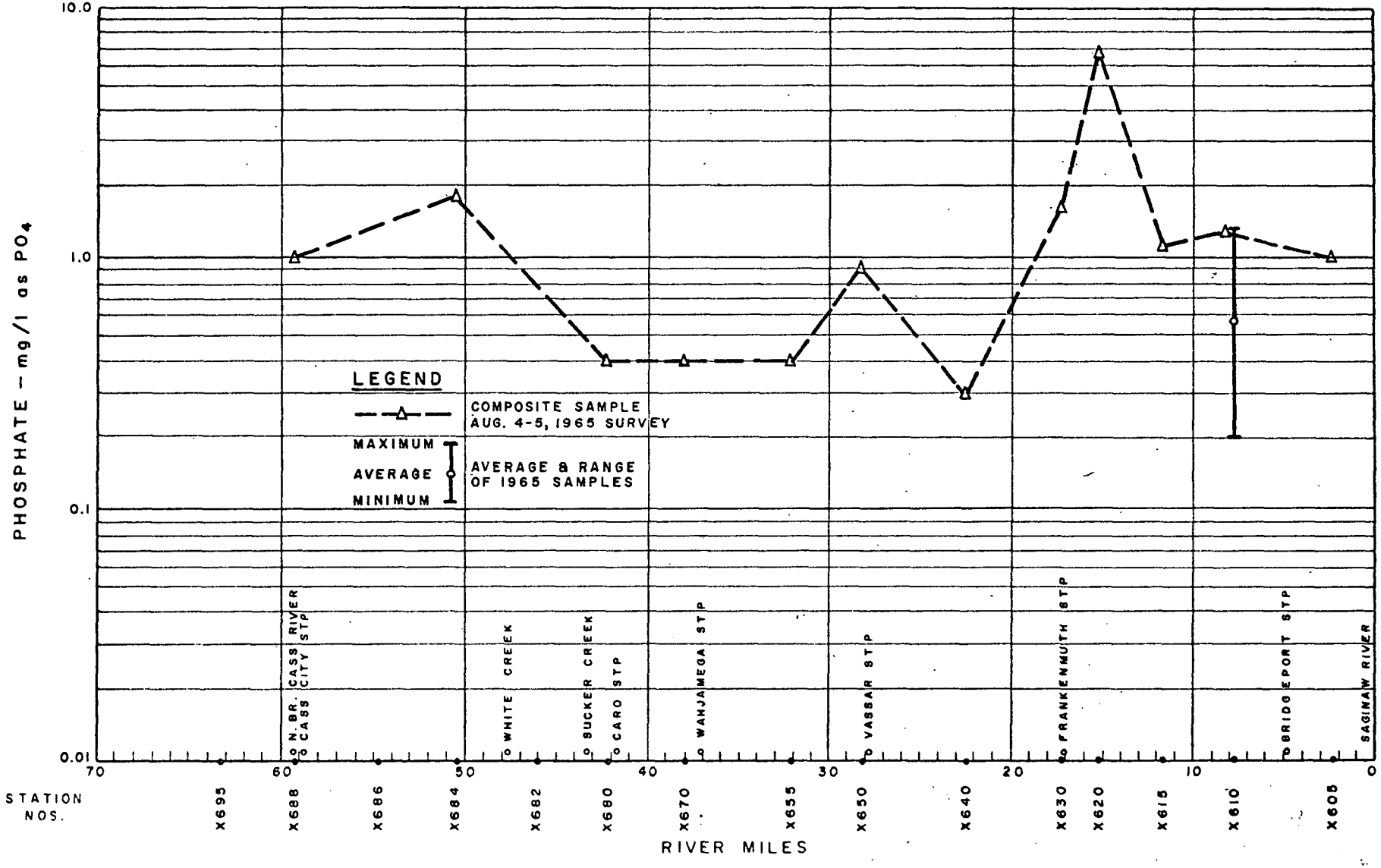


FIGURE 15

CASS RIVER
TOTAL SOLIDS AND CHLORIDES
AUGUST 4-5, 1965 SURVEY

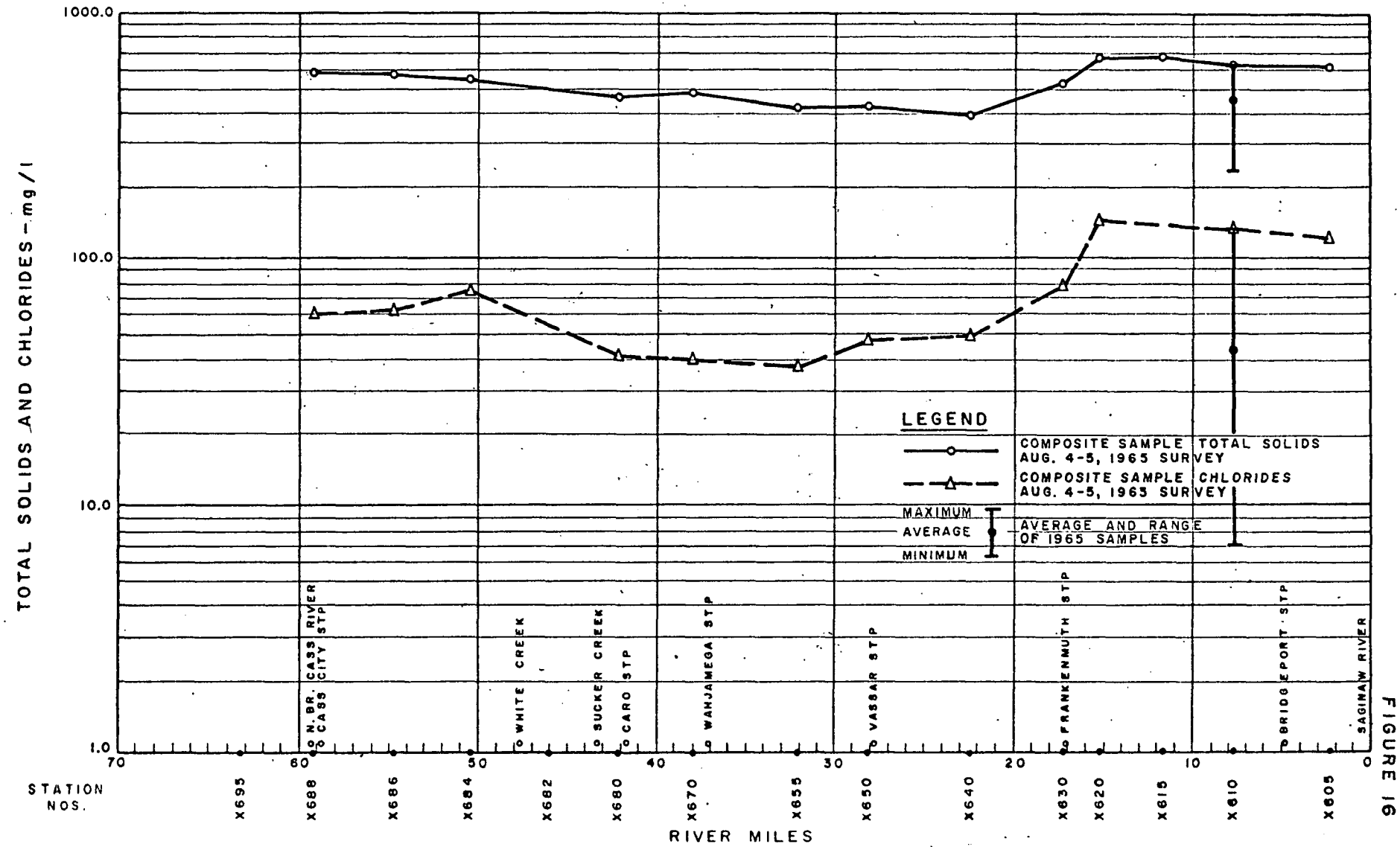


FIGURE 16

CASS RIVER
TOTAL COLIFORM DENSITIES
AUGUST 4-5, 1965 SURVEY

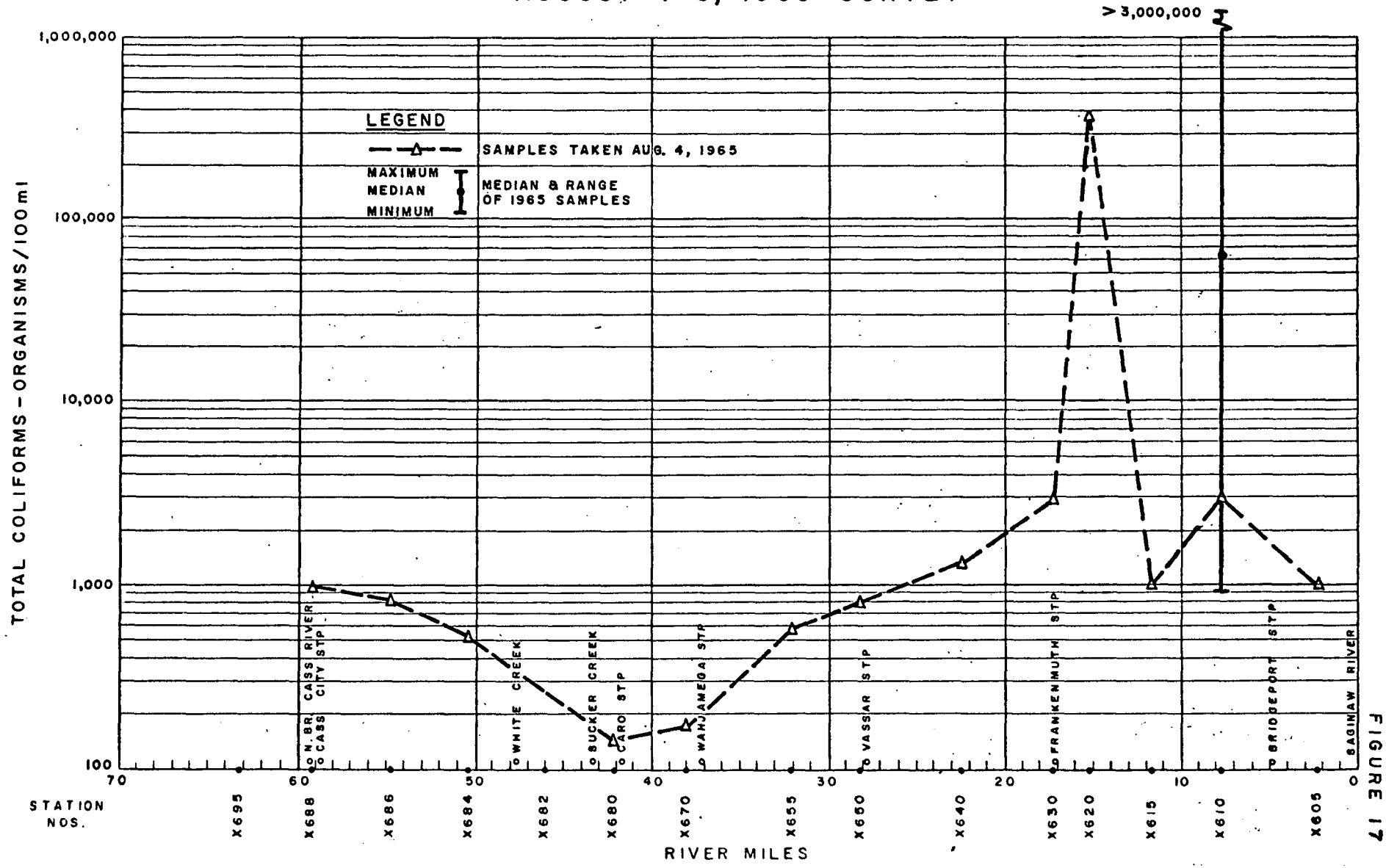


FIGURE 17

Biology

Biological investigations of the Cass River were conducted from October 1964 through November 1965, as part of a comprehensive study of the Lake Huron Basin. Three stations were sampled; X605, X610, and X670 (Figure 10). Three elements of the biota were sampled; benthic fauna, planktonic algae and attached algae. Water and bottom sediment conditions and water transparencies were routinely recorded.

Physical observations in the Cass River are listed in Table 18. Transparency, as measured with a secchi disc, was always low and never exceeded 1.5 feet. The water appeared very dark and turbid at all times. No rooted aquatics were observed; probably being inhibited by the high turbidity which prevents light from penetrating to the bottom.

The bottom materials showed the Cass River to be degraded. Ooze, a soft, black, nongranular slimy bottom material, and silt, mixed with sand, was the bottom type at stations S605 and X610. Sewage odors were present at station X610. This is characteristic of decomposing organic material and indicates a degraded condition.

Table 19 shows the kinds and numbers of animals found in the Cass River. The predominant forms were the bloodworms (Tendipedidae) and sludgeworms (Tubificidae). Both are examples of pollution-tolerant forms that exist in the decaying organic sediment which builds up from the settleable organic solids present in most waste discharges.

The benthic fauna reflected part of the biological degradation of the Cass River. None of the pollution-sensitive snails, caddisflies, mayflies, or scuds were found at any of the stations sampled. Non-

quantitative samples revealed some beatles, water-bugs, crayfish, soldier flies, and mosquitoes. Shallower depths, higher levels of oxygen, and a more suitable bottom type near the edges of the river were apparently responsible for the presence of these organisms.

The Cass River algal population was predominated by centric diatoms and green and brown flagellates (Table 20). These algae are the common forms in many nutrient-enriched midwestern streams. Blooms of filamentous blue-green algae in February and August 1965, followed by rapidly changing algal types, are indicative of a troubled ecosystem. Soluble phosphate and organic nitrogen concentrations in the Cass River were well in excess of those recognized as limiting to algal growth.

The nutrients that support planktonic algae were only found on two occasions. Their infrequent occurrence could be related to the limited light penetration through the turbid water.

Benthic fauna and phytoplankton analyses indicated degradation was in progress in the Cass River. Over half of the bottom-dwelling animals were pollution-tolerant, although some pollution-sensitive forms could still be found. Dense standing crops of phytoplankton reflected the high levels of phosphate and inorganic nitrogen in the river. The low transparency values were probably a reflection of the high phytoplankton counts in addition to waste discharges.

TABLE 18. PHYSICAL OBSERVATIONS
CASS RIVER
OCTOBER 1965-NOVEMBER 1965

Station	Date	Depth (ft.)	Secchi Disc (ft.)	Bottom		Remarks
				Type	Odor	
X605	10/8/64	3	1	ooze, silt	normal	turbid water and low, no aquatic vegetation
	10/20/64	3	1.5	silt, sand	normal	water dark and slow, oscillatoria on mud
X610	4/26/65	4	1.5	sand	sewage	no vegetation
	7/8/65	1.5	to bottom	silt, sand	sewage	Spirogyra along shore, virtually no flow
	9/17/65	3	1.5	silt, sand	normal	moderately turbid, no flow, no emergent vegetation

TABLE 19. BENTHIC MACROINVERTEBRATES
CASS RIVER
OCTOBER 1964-SEPTEMBER 1965

Station	Date	Tubificidae (sludgeworms)	Tendipedidae (bloodworms)	Diptera	Ceratopo-gonidae	Corixidae	Coleoptera	Trich-optera	Total
X605	10/20/64	27	2	9	-	-	-	-	38
X610	4/6/65	35	71	x	2	x	-	-	108
	7/8/65	7	31	-	-	x	x	-	38
	9/17/65	44	8	x	-	x	x	x	52

x - present in nonquantitative samples

TABLE 20. PHYTOPLANKTON
CASS RIVER
OCTOBER 1964-NOVEMBER 1965

Station	Date	Average Number per Milliliter								Predominant Genera* (10% or more)
		Centric Diatoms	Pennate Diatoms	Green Coccoids	Blue-Green Coccoids	Blue-Green Filamentous	Green Flagellates	Brown Flagellates	Total	
X605	10/20/64	1,958	1,034	352	-	-	924	-	4,268	a,c
X610	2/23/65	63	63	21	21	1,785	147	-	2,100	h
	3/8/65	132	110	-	-	11	-	-	253	a,b
	4/5/65	105	21	21	-	21	945	-	1,113	j
	4/26/65	315	273	-	-	42	1,113	-	1,743	a,j
	6/2/65	700	280	1,820	-	-	3,080	-	5,880	a,f,d,j
	7/8/65	1,890	350	1,750	-	-	1,820	-	5,810	a,j
	9/8/65	210	210	336	-	-	798	-	1,554	a,j
	10/6/65	3,990	70	630	-	-	630	-	5,320	a
	11/2/65	350	210	1,610	-	-	2,450	3,710	8,330	l,j,k
	11/30/65	840	-	420	-	-	140	1,610	3,010	a,d,k
X670	8/4/65	882	252	714	-	9,366	126	1,218	12,558	g,k
	9/23/65	2,730	840	3,850	-	-	280	6,580	14,280	a,e,k
	10/13/65	840	-	560	-	-	910	5,390	7,700	a,i,k
	11/9/65	420	210	280	-	-	-	5,390	6,300	k
	11/30/65	210	70	210	70	70	-	420	1,050	a,d,k

* See explanation list on page 70.

EXPLANATION LIST
FOR
PREDOMINANT PHYTOPLANKTON GENERA (Table 20)

Centric Diatoms

a. Cyclo-Stephanodiscus

Pennate Diatoms

b. Navicula

c. Nitzchia

Greens

d. Ankistrodesmus

e. Oocystis

f. Selenastrum

Blue-Greens

g. Aphanizomenon

h. Oscillatoria

Green Flagellates

i. Trachelomonas

j. Unidentified green flagellates

Brown Flagellates

k. Synura

WATER QUALITY PROBLEMS

In the Cass River below Frankenmuth, the DO level was low due to the effect of the Frankenmuth sewage treatment plant (STP) which was overloaded by industrial wastes. High levels of chlorides were observed in the South Branch of the Cass River below Marlette, and high bacterial levels were observed in the river below the municipalities. Phosphates were high in certain locations and moderate throughout the rest of the stream. The data indicated that there were moderate amounts of pollution in the stream with the exception of the river below Frankenmuth where levels were excessive.

Moderate pollution existed in the Cass River above Frankenmuth due to the residual effects of the secondary treatment plants at Marlette, Cass City, Caro, Caro State Hospital, and Vassar, and the industrial waste effluent of Michigan Sugar Company at Caro and Nestles Company, Inc. at Ubly. Bacterial pollution below the municipal sources was moderately high during the non-disinfection period. Chloride and nutrient levels indicated residual pollution in the East Branch Cass River below Marlette and the entire Cass River below the confluence of the East Branch. Minor DO depletion with significant diurnal variation indicated excess algal populations caused by the residual nutrients from the waste sources.

Below the City of Frankenmuth STP outfall, there was gross pollution caused by inadequate treatment of the overloading brewery wastes. Although this municipal plant is designed as a secondary plant, the effluent contains more pollutants than raw sewage. Anaerobic conditions occurred below the outfall caused by the high concentration of organic wastes.